basell
Polyolefins

In honour of

Giulio Natta

For the Centenary of his Birth
1903 - 2003
and
the Fortieth Anniversary of the
Nobel Prize Award in Chemistry
1963 - 2003

Proceedings of the "Giulio Natta" celebration conference

June 12th - 13th, 2003
Teatro Comunale di Ferrara
C.so Martiri della Libertà, 5

Giulio Natta

"Fatto il polipropilene". This is what Giulio Natta hand-wrote on his diary in March 1954 when, with the financial support of Montecatini (a Basell predecessor company), he extended the research conducted by Ziegler on organometallic catalysts to the stereospecific polymerisation of propylene, thus discovering new classes of polymers with a sterically ordered structure. Both scientists were awarded with the Nobel Prize in Chemistry in 1963 for their revolutionary breakthrough. These studies led to the industrialisation of thermoplastic material, isotactic polypropylene, which Montecatini was the first to produce in Ferrara in 1957.

Born at Imperia P.to Maurizio on February 26th, 1903, Giulio Natta graduated with a degree in Chemical Engineering at the Politecnico di Milano in 1924, where he eventually became a full professor and director of the Department of Industrial Chemistry. He held these positions for nearly 35 years.

Giulio Natta died in 1979.

Giulio Natta special celebration conference

Ferrara, Teatro Comunale - June 13th, 2003

Programme

Friday, June 13th, 2003

08.45 Registration

Welcome and opening remarks

09.15 **Gaetano Sateriale** - Mayor of Ferrara
Werner Breuers - President, Technology Business, Basell Polyolefins
Gian Guido Balandi - Pro-Rector, Università degli Studi di Ferrara

The industrialisation of Giulio Natta's discovery

Chairman: **Nello Pasquini** - V. President, International R&D JV's Interface, Basell Polyolefins

Part 1
Creating the polypropylene business chain

09.45 *Polypropylene, a technology-driven history*
Paolo Galli - Honorary Chairman, Basell Technology
Nello Pasquini - V. President, International R&D JV's Interface, Basell Polyolefins

10.15 *The unique case of polypropylene growth and development in Japan*
Norio Kashiwa - Senior Research Fellow, Mitsui Chemicals

10.35 *Polypropylene, a business without frontiers. The geographical expansion and Basell's role in its growth*
Randy Woelfel - President, Basell International

10.55 *The engineering company, a key player in the industrialisation step*
Paolo Bigi - Commercial Director, Petrochemicals, Tecnimont S.p.A.

11.05 Coffee break

11.30 *The inroad of polypropylene into the rigid packaging industry*
Marco Bergaglio - Sales Manager, Piberplast

11.50 *Polypropylene & compression technology: a successful case history*
Dario Beltrandi - General Manager, SACMI Beverage & Packaging

Part 2
Future perspectives. Drivers for business sustainability. Final remarks

12.10 *Polyolefins global industry situation and future challenges*
Brian P. Gersh - Principal, Charles River Associates

12.30 *The technological challenge continues*
Anton De Vries - President, Research & Development, Basell Polyolefins

12.50 **Panel and Q&A session**
Participants: D. Beltrandi, M. Bergaglio, P. Bigi, W. Breuers, A. De Vries, P. Galli, B.P. Gersh, N. Kashiwa, N. Pasquini, G. Rossi, V. Trautz, R. Woelfel

13.30 Buffet

Basell R&D Centre and plants visit

14.30 Transfer to Basell site and tour

17.00 End of the visit

Parallel programme

"Giulio Natta and Nicolò Copernico" Awards Ceremony

15.00 *Awards ceremony*
Chaired by the President of the Committee Prof. **Pietro Dalpiaz** - Physics Department of the Università degli Studi di Ferrara

17.00 Conclusion and cocktail party

Paolo Galli
Basell Senior Advisor

Education:

After graduating in Industrial Chemistry from the University of Padua, he was taken on as a researcher at the Istituto Ricerche Idrocarburi, Montecatini, Ferrara on July 1st, 1962.
From March 1977 to November 1983 he worked as Director of the "Giulio Natta" Research Centre in Ferrara.
From November 1983 to April 1985 he was appointed Managing Director of Dutral SpA, the Montedison special materials company.
From May 1986 to July 1989 he was appointed Vice President of Technology for Himont Incorporated.
On July 1st, 1989, he became Managing Director of Montedison Research, while continuing as Vice President of Technology, Himont.
From May 1st, 1996 to April 30th, 1999 he was President of the Montell Technology Company b.v. with headquarters in Hoofddorp, the Netherlands.

Additional information:

He made fundamental contributions to the research and understanding of heterogeneous Ziegler-Natta catalysis, particularly in the discovery of "delta" $MgCl_2$ active support, in 1968, revolutionising the polymerisation of ethylene and propylene monomers.
He contributed to the technological innovations in the Montedison group, in both high-yield production processes and in the development of polymers, copolymers, alloys and polyolefin-based materials.
He gave the main contribution to the understanding and control of the replication phenomenon of the parent catalyst by the generated polymer that led to the implementation of the Fourth Generation Ziegler-Natta super-active catalysts, giving rise to the Reactor Granule Technology.
Prof. P. Galli appears as inventor in many patents concerned with high-yield Ziegler-Natta catalysts, catalyst supports, spherical form polyolefins by synthesis, elastomer, alloys and polymerisation processes.
Prof. P. Galli has had a dual career, both as an industrial researcher at Montedison and as an academic scientist at Ferrara University.
Since 1968 he has presented many technical and scientific papers at the Conferences throughout the world.
His expertise and important scientific contributions in the area of polyolefin technology are recognised through his many publications and review articles.
As a basis for scientific research he has always applied his personal belief that " Knowing why " is the foundation for "Knowing how".

Nello Pasquini – V.P. International R&D - J.V.s -Interface, Basell Polyolefins

Education:
Graduation in Chemistry, Ferrara University
MBA Bocconi University, Milano

Additional information:
Joined Montedison in 1969, initially working for a few years in the area of Polyolefins Product/Application Development.
In the mid 70's he was given the responsibility to lead a Business Unit called "Special Polyolefins".
In this position he strongly contributed to the development and commercialization of the Polypropylene based materials for the Automotive industry.
With the formation of Himont in 1983, he was transferred to Wilmington (Delaware ,USA) as Director "New Business world-wide".
One of the most important achievements of those years, besides the market development of new polymers from Spheripol technology was the "Blue Book". It was a comprehensive study concerning the Polypropylene market which was broken down into a few tens of segments representing the customers' business. The study was considered a major mile-stone by the company that used it to establish its future successful Marketing strategy. For the first time in the plastics industry the commercial activity was organized by market sector and the leading Polypropylene supplier initiated a close cooperation with the customer to jointly develop competitive solutions.
Back to Milano in 1986 as Director Marketing Europe, he moved to Brussels in 1990 .
The new challenge was called "Catalloy " the recently developed process to make Advanced Polyolefins.
With a team of young engineers, in a couple of years the Ferrara plant was fully utilized and the new Advanced Polyolefins Business established in the market.
After 28 years he returned to Ferrara as V.P. Technology for Product and Application Development. He is currently responsible for transferring innovation to the Basell Join Ventures world-wide.
He cooperates with the MaSTeM project (Master of Science, Technology and Management) providing lessons on Business Management.
Recently he was granted a Carrier Award by the Ferrara journalists' community.

Paolo Galli
Basell Senior Advisor

Nello Pasquini
V.P. International R&D J.V.'s Interface, Basell Polyolefins

Polypropylene, a Technology Driven History

Giulio Natta Celebration
Ferrara, Italy - 13 June 2003

Abstract

The need for a continuous and dramatic process and product improvement has been a main driving force behind the entire innovation and growth of polypropylene. This need has pushed scientific research on catalyst systems and material structure property relationships to new levels and is ultimately responsible for the dynamic and continuous growth of the market.
When polypropylene was born and in the early stages of commercialisation, it appeared affected by two main limitations that threatened its commercial success:

1) a complex production process that was difficult to operate consistently, produced unreliable quality and which had limited flexibility or versatility and

2) products that had almost no utility since they apparently had limited properties that were of practical use. This latter element was further complicated by a lack of knowledge on how to control and use these materials and basic structure-property relationships.

Those two critical issues are in fact strictly interconnected but they were in practice kept separated by a deep lack of understanding of the basic chemistry underlying production process technology and the relationships between process and material property requirements of the market.
In summary, the first generation processes were complicated, expensive, and inflexible with undesirable byproducts and high pollution risks for the various operations.
Attempts to improve or to generate new product properties were barred by the process complexity, rigidity and system constraints.
However since the potential was recognised by the scientists early in its life cycle these difficulties did not get the upper hand!
On the contrary; the polypropylene story really represents a uniqueness in material development. Fueled by a tremendous commitment to understanding the basic phenomena involved in propylene polymerisation and associated polypropylene product processing technology, the problems were tackled with a spirit of innovation, creativity and a professionalism that quickly turned by-products into highly desirable materials of commerce.
At the same time the difficult challenges catalysed a reaction, no pun intended, that has become the main driving force for the development of entire families ofpolyolefins and which crystallized into a strong robust industry over the last half century. The second part of the lecture focuses on polypropylene as a business, analysing the role the technological breakthrougs (*Spheripol* and *Catalloy* processes) have played world-wide after the 1982-1983.
The revolutionary properties envelope expansion required a new way of marketing the new polymers.
Market segmentation and "value in use" have become more and more familiar within the commercial organisations, whit Marketing experts driving the challenge with the other plastic and traditional materials.
Automotive, Fibres, Packaging and Consumer sectors have enjoyed the greatest PP penetration allowing the "monomaterial" strategy in most of the applications.

Polypropylene, a Technology - Driven History

REVISTING THE PAST (P. Galli)

Let us see what has happened since the very beginning of the PP technology commercialisation and what has been the rationale for the intensive R&D developments of the following years.

The bright promises of the early period:

I remember well the very beginning and early period of the novel Ziegler-Natta technology. We were all shocked, admired, full of trust and enthusiasm for the potential of the novel, revolutionary catalysts, able to generate new materials like polyethylene (PE) and PP (PP) with a new, convenient, apparently easy technology and with a new gamut of properties.

There was a lot of enthusiasm for the novelty of the catalytic system, which was able to operate in mild, easy conditions. There was also a deep curiosity for the new materials and their set of properties, a strong expectation to have good and low cost materials, driven by readily available monomers and the expected low cost processes.
The enthusiasm and the push were on the scientists' part, and also the top management of several companies. In November 1955, in Montecatini, a large-scale pilot plant for the polymerisation of ethylene and propylene started operating in the Ferrara plant in Italy.
In January 1957, a very first multipurpose BATCH polymerisation plant for the production of the first high-density injection moulding PE (*Moplen* RO) and PP started operating (Fig. 1).

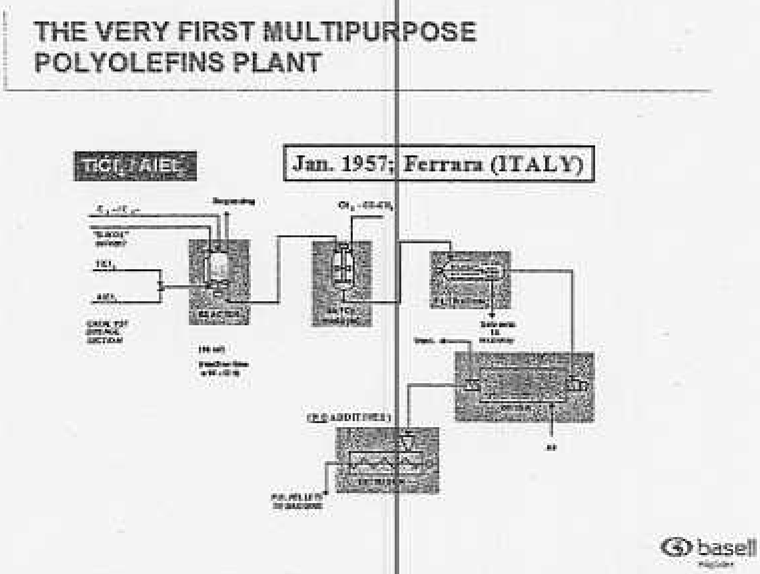


Fig. 1 – The first multipurpose P.O. plant

It was mainly dedicated to the production of PE; a larger scale, more sophisticated plant fully dedicated to PP started operating in Ferrara in November 1957. (Fig. 2)

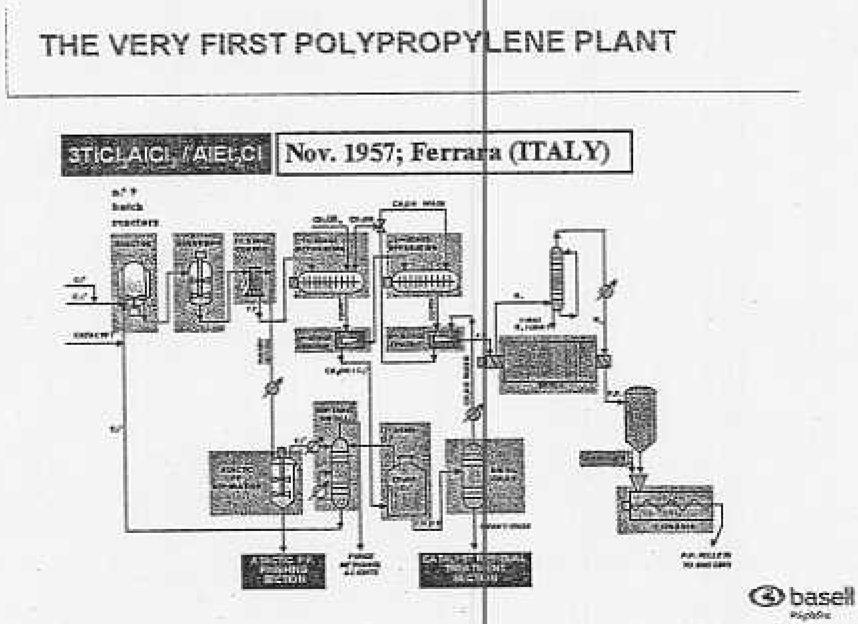


Fig. 2 – The first PP plant

Those plants were projected, built and started up in an extremely short time at the cost of tremendous efforts, in terms of commitment, on the researchers' and management's part.
They all made great sacrifices, pushed and supported by the great enthusiasm based on the trust of the fluttering promises of the new family of catalysts and materials.

The bitter, tough commercial reality:

In spite of the bright expectations, the commercial reality very soon turned out to be completely different:
The catalyst activity and selectivity were very poor, polymer morphology did not even exist at a concept level, the commercial plants were a real nightmare to operate, the production costs very high, the properties at best simple and poor and consequently the selling price ……….low.
In other words, as a business it was a downright disaster!
After many efforts in several different directions to dramatically improve the process technology, it was clear that the only answer had to come from a fundamental scientific understanding and development approach.
In particular, we did not recognise that the key to the main commercial plant issues was a largely ignored and misunderstood principle of polymer morphology control which affected all the commercial plants,

heavily spoiling all cosmetic efforts made in order to improve quality and cost.
The situation was at a dead end because the solution had to resolve an impossible compromise between two conflicting needs to make the polymer purification step effectual and to make the commercial plant operability reliable, fast and cost efficient. (Fig. 3)

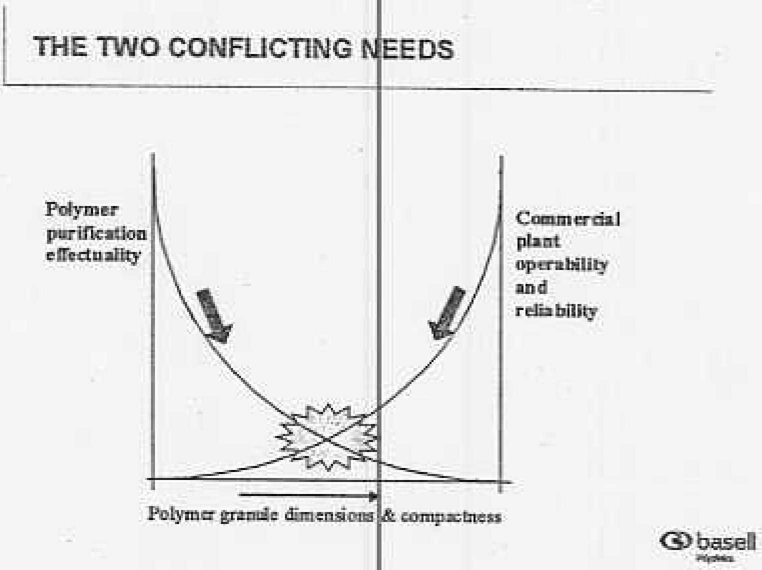


Fig. 3 – The two conflicting needs

The life of the industrial plant was an adventure, or more accurately, a nightmare, in a continuous precarious balance between conflicting needs, such as product quality or plant operability. The plants always had to live under "Damocles' sword", regarding the alternative to have to shift in between a total plugging of the lines or not to be able to achieve a decent quality of the materials in terms of purification from the catalyst residual and undesired polymerisation by- products.

1. To make the overall operability of the commercial plant manageable, reliable and cost efficient:
   a. it meant, and means, to obtain medium or large size and compact morphology polymer granules. The granule porosity was a big issue because it meant high polymer fragility during the plant operations, which generated large amounts of very fine and irregular polymers, creating fouling issues.
   b. it meant to perform the extraction in the same way as all the other operations in an economically and sustainable short time.

2. To make the polymer purification step effectual, manageable and easy;

   a. it meant to extract and remove the catalyst residuals and the polymer by-products in a practical low cost and time efficient way.

(By-products were waxes and low molecular weight polymers, and specifically, in the case of PP, the atactic and syndiotactic polymers).

b. it needed to produce polymer granules of very small dimensions and /or very high porosity in the polymerisation step, in order to allow an easy and manageable mass transfer process in and out of the polymer granules, as specified in the previous point a).

The main difficulties encountered in the commercialisation of the process were directly connected to the low catalyst activity and poor selectivity and the inconstant, unpredictable and unmanageable morphology of the polymer generated during the polymerisation.
Those two drawbacks were in fact the cause of the following main consequences:
The totally unpredictable, random, polymer morphology (such as fine particles, extra fines, or vice-versa, very big, porous, fibre like or popcorn like etc.,) (Fig. 4) created insurmountable obstacles to the smooth running of industrial operations, such as discharge from the reactors, slurry or powder, transportation, filtration, purification, centrifugation, drying etc.

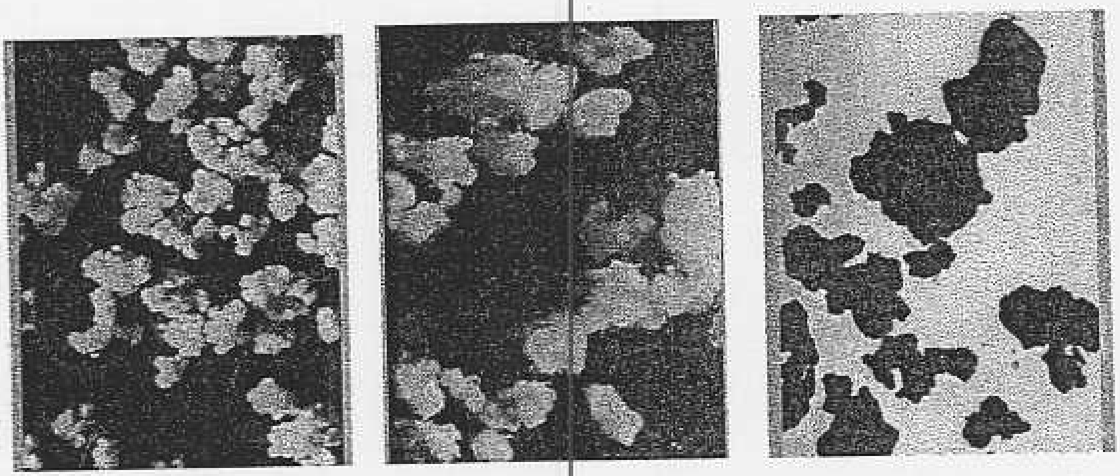


Fig. 4 - Examples of bad polymer morphology

Small morphology was very favourable, for example in the polymer depuration step, it made the extraction easier for both the catalyst residuals and for the polymeric by-products, waxes, atactic PP etc. but it was a nightmare in all polymer transfers, from one step to another, in the filtration, centrifugation, drying etc. Big polymer particle morphology acted in the opposite way and worst of all and not infrequently was to deal with the irregular random mix of very small fines and big particles together.

To compound an already difficult situation, was the total unpredictability of the phenomenon in the commercial plant and the lack of any possibility to react to or control the issue!

There was no simple and elegant solution for the issue if we tried to cope with it in a direct way. The real, unique, definitive and only solution was, and is, to increase the catalyst activity and selectivity in order to make all the operations of chemical material removal from the granule unnecessary. Easier said than done! It meant to be able to achieve a breakthrough in the Ziegler-Natta catalysis.

THE PROACTIVE TECHNOLOGY REACTION

The Catalyst System Development

To cope with, and to solve such a difficult and "dead end" situation, a revolutionary jump in catalyst understanding had to be achieved in order to obtain a major breakthrough in catalyst science. The heavy commitment on the part of many companies all over the world in that field obtained the result.
The intensive efforts in basic research on the catalysts in the 70s, aimed at the understanding of the chemical and physical-mechanical phenomenon linked to polymerisation, brought about the achievement of two major breakthroughs in the catalyst activity and architecture. This had a tremendous impact on polymer quality and morphology, culminating in the discovery of the current 4th generation Ziegler-Natta catalysts. Most important, it was the beginning of a <u>new way</u> of thinking and conceiving the catalyst. It was realised that it was mandatory to look for a catalyst showing an <u>entire, complete, all embracing set of properties.</u> Just <u>one</u>, even if an outstanding property, such as activity or selectivity, was not at all enough! It appeared that it was not possible to achieve a complete success just by operating empirically, looking at the new catalyst properties, one by one.

It became necessary to elaborate and to develop the research in line with a <u>MODEL</u> for the catalyst to achieve.
The Model for the " new dream", the all-embracing ideal catalyst, was imagined and called "the extreme target: the ideal catalyst", a catalyst, that in addition to processing a very high catalytic activity and great selectivity, would have imparted the desired proper morphological structure to the appropriate product, whether this was a polymer, a copolymer or a polymer alloy. (Fig. 5)

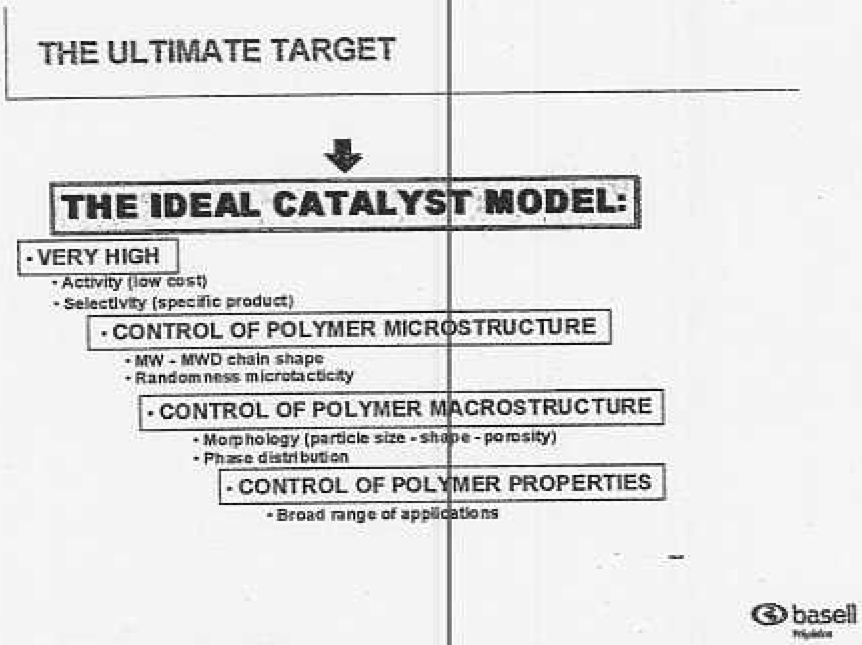


Fig. 5 – The "ideal catalyst " model

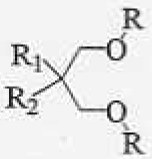
The discovery of the high activity "δ" $MgCl_2$ – supported catalyst for the olefins polymerisation in 1968, became the first of the two major breakthroughs which have revolutionised the development of the Polyolefin technologies in the following 30 years.
It brought about the elimination of the need of the removal of the catalyst residues. This resulted in a significant simplification of the polymerisation processes but did not satisfy the other parameters for an Ideal system.

Nevertheless, in order to fully achieve the first target, eliminating all the constraints generated by the catalytic system, it was apparent that much better catalyst selectivity was necessary.
The target was achieved in 1975, with the introduction of the 3rd generation catalyst that gave for the first time high yield and high selectivity.
These high-activity Ziegler-Natta catalysts comprise $MgCl_2$ $TiCl_4$ and an "internal" electron donor and are typically used in combination with an aluminium alkyl co-catalyst such as $AlEt_3$ and an "external" electron donor added in polymerisation.

Additional and impressive progress has been made over the years to understand the function of donors and their structure has been designed accordingly. As a result, catalyst performances have been largely improved, starting first from activity and stereoselectivity, by displacing the first generation of internal/external donors (ethylbenzoate/aromatic esters) with the couple diisobutyl phthalate/alkoxysilane and, more

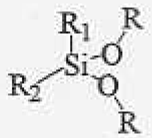
recently, with the introduction of diethers, typically a 2,2-disubstituted-1,3-dimethoxypropane, used without or in combination with an alkoxysilane. But in addition to activity and stereo-control, other catalyst attributes exist that need fine-tuning to drive product innovation and, in particular: hydrogen response and control of polymer molecular weight distribution (MWD). In this respect, phthalate-based catalysts are characterised by high isospecificity, medium hydrogen sensitivity and provide medium MWD PP, diether-based catalysts are characterised by very high activity, medium-high isospecificity, high hydrogen sensitivity and are able to provide narrow MWD polymers. And the progress is not at an end!
Quite recently, a very new catalyst system has been patented, based on a particular family of internal donors, namely succinates, which looks particularly interesting since it was found to provide both high polymer stereoregularity and broad polymer MWD.

Phthalate



Diether

Succinate



Silane

Fig. 6 - General formula of internal and external donors

Thus, as a function of donor structure (Fig. 6), it is possible to modulate both catalyst performances and polymer structure. Actually three families of catalyst systems have been developed that are complementary to one another offering the best choices in terms of both production plant performances and final product property envelope finely tuned towards the most demanding commercial needs (Table 1).

Table 1. General performances of different electron-donor classes

Cat. 1	I.D. 2	E.D. 3	Yield (KgPP/gCat)	X.I. (%)	mmmm (%)	Mw/Mn	H_2 response
A	Phthalate	Silane	70-40	96-99	94-99	6.5-8	medium/low
B	Diether	Absent	130-100	96-98	95-97	5-5.5	excellent
B	Diether	Silane	100-70	98-99	97-99	4.5-5	excellent/high
C	Succinate	Silane	70-40	96-99	95-99	10-15	medium/low

I.D. = Internal Donor; E.D. = External Donor
The ranges are mainly function of the structure of I.D. and E.D. employed.
Bulk polymerisation at 70°C for 2 h, $[AlEt_3]$ = 2.5 mM, Al/E.D. = 20 molar, $[H_2]$ = as needed to obtain an intrinsic viscosity of 2 dl/g

In conclusion, the benefits achieved eventually brought about the elimination of the need of the removal of all the catalyst residuals and the atactic fraction. This made a significant simplification of the polymerisation processes. The elimination of these constraints allowed a remarkable reduction in investment costs and brought about several new degrees of freedom. (Fig. 7)

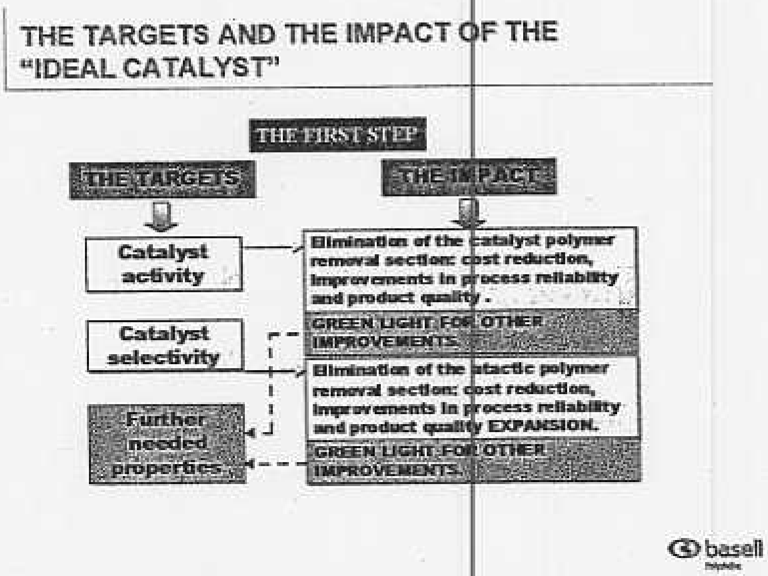


Fig. 7 - The first step in the way towards the achievement of the ideal catalyst.

From these discoveries, the "dream" of the "Ideal Catalyst" as the extreme target in the heterogeneous catalysis started appearing as an achievable reality.

The elimination of the need of the removal of the catalyst residues and to a large extent, of the atactic polymer fractions, were not such important facts in themselves, but mostly because they became the starting point and the base for all the future revolutionary developments.

As a matter of fact, the most important event for all the future scientific, technological and commercial development was not just the increase in the catalyst activity and selectivity. It was the green light to conceive, with a total freedom from any process constraints, the "IDEAL CATALYST" system.

It enabled us to maximise the technology versatility so as to have a significant expansion of the product property envelope. (Fig. 8)

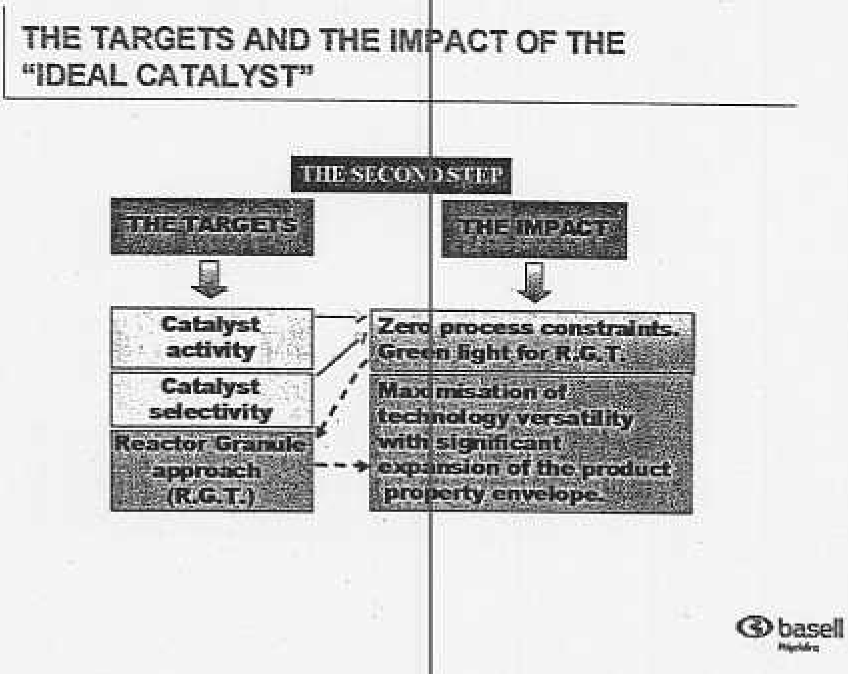


Fig. 8 – The targets and the impact of the "Ideal Catalyst"

This fundamental research led to **the second breakthrough**: discovery and development **of a new dimension** in heterogeneous catalysis and of the "Reactor Granule Technology" (R.G.T.). (Fig. 9)

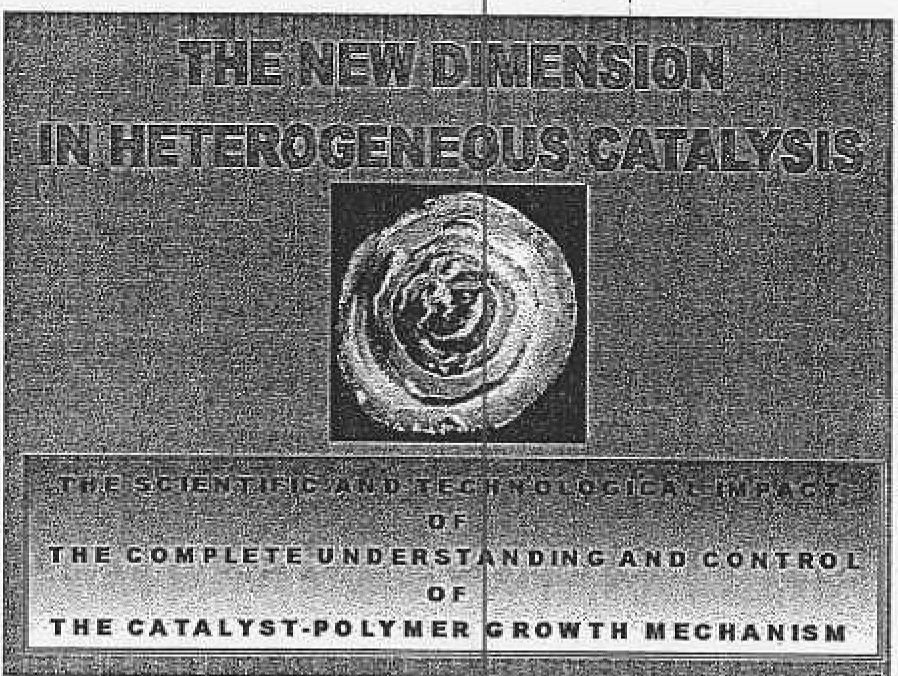


Fig. 9 – The new dimension in heterogeneous catalysis

Its discovery and understanding brought about the complete control of the catalyst-polymer granule genesis and growth: The R.G.T represents a key breakthrough result in the Science of structural versatility in the polymerisation technology (Fig.10) and a fundamental milestone in the entire history of the process and product development (Fig. 11).

REACTOR GRANULE TECHNOLOGY:
"THE SCIENCE OF STRUCTURAL VERSATILITY"

MAIN ACHIEVEMENTS:

- **Complete scientific understanding and control of the polymer growth mechanism in order to exploit the polymer/catalyst replication phenomenon.**
- **Tuning the tri-dimensional architecture of the catalyst granule, capable of producing a controlled fragmentation in extremely fine, regular particles, in order to generate spherical polymer particles having controlled size, porosity and mechanical strength.**
- **Selecting the most appropriate polymerization conditions in order to give the polymer granule its original integrity/identity during the polymerization.**
- **Set up the best polymerization process, or better, catalyst-process combination, taking advantages of the above scientific conquestes, thus maximizing both plant operability and polymer performance.**
- **Improve and expand the polymer properties envelope towards new and specialty materials.**
- **Open the way for the generation of novel materials, different material combinations and multimaterial alloys.**

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Fig.10 – Reactor Granule Technology, the main achievements

THE STRINGENT AND AMBITIOUS TECHNICAL AND ECONOMICAL GOALS OF THE REACTOR GRANULE TECHNOLOGY

- **Maximize the operability and productivity of commercial plants:**
  - **Improving slurry or gas flow reactor behaviour.**
  - **Decreasing tendency to plug.**
  - **Increasing the reactor's polymer content.**
- **Optimize the quality and consistency of the polymers.**
- **Eliminate the expensive pelletization step, which damages integrity and quality of the polymer.**
- **Eliminate all the extruder connected constraints and related polymer property limitations.**
- **Eliminate all the bounderies among the different polyolefin families: PE - PP - EPR**
- **Create feasible specialty polymers and novel alloys unachievable by conventional methods or mechanical blending.**
- **Dramatically extend the property envelope of polyolefinic materials.**

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Fig.11 – Reactor Granule Technology, technical an economic achievements

The role of the CATALYST THREE DIMENTIONAL ARCHITECTURE in the controlled expansion of the polymer granule was deeply explored, so as to reach an optimum equilibrium between the mechanical strength of the growing granule and the catalyst polymerisation activity.
In the first step the catalyst has been combined and optimised with a unique process designed to capitalise and exploit the full potential of the catalyst.
Catalysts with controlled spherical morphology were developed allowing the full control of particle size and compactness of the related spherical form polymers (Fig.12).

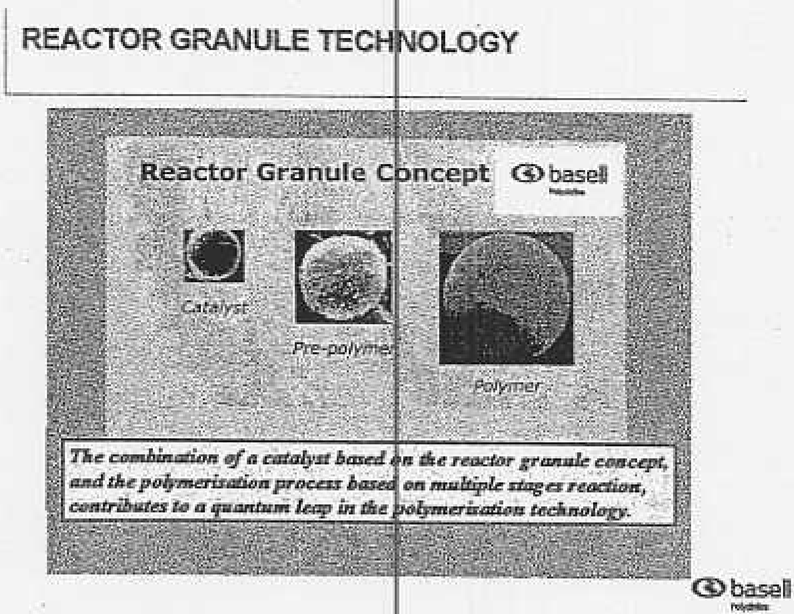


Fig. 12 – "Replication" phenomenon during the polymerisation

As a second step, under appropriate polymerisation conditions, polymer particles with an internal morphology ranging from compact to porous can be obtained (Fig.13).

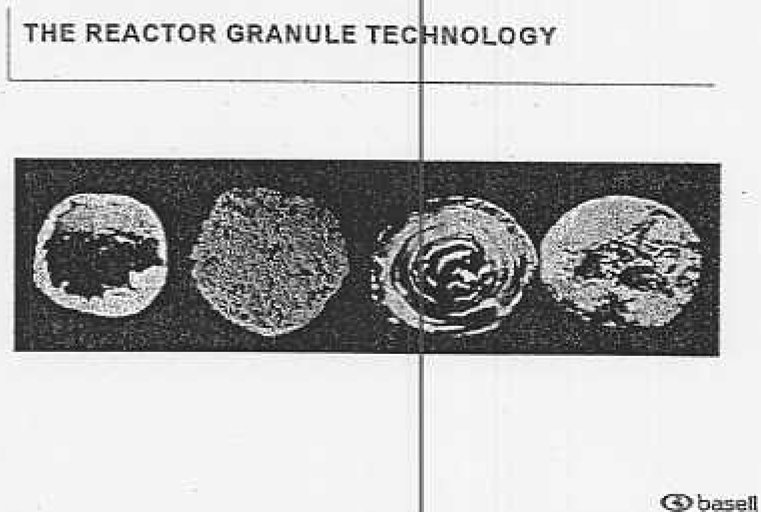


Fig.13 – Different polymer morphologies from R.G.T.

The polymer particle becomes the reactor itself in which polymerisation occurs, and by changing monomer it is possible to obtain another polymer intimately dispersed within the mass of the solid granule of the matrix. It became the basis to the "Reactor Granule Technology" fully exploiting the potential of the Spherical Form Catalyst to generate alloys, thanks to the capability of building different polymers components **inside** the same granule.

The most important fact is that now it is possible to achieve an IDEAL mixing of different and even very different components inside the same granule, overcoming the difficulties of their mixing via the blending technology. In many cases, even the difficulty, or impossibility, of handling incompatible products, that cannot be processed alone because of their M.W. (either too low or too high) sticky or oily products is overcome (Fig. 14).

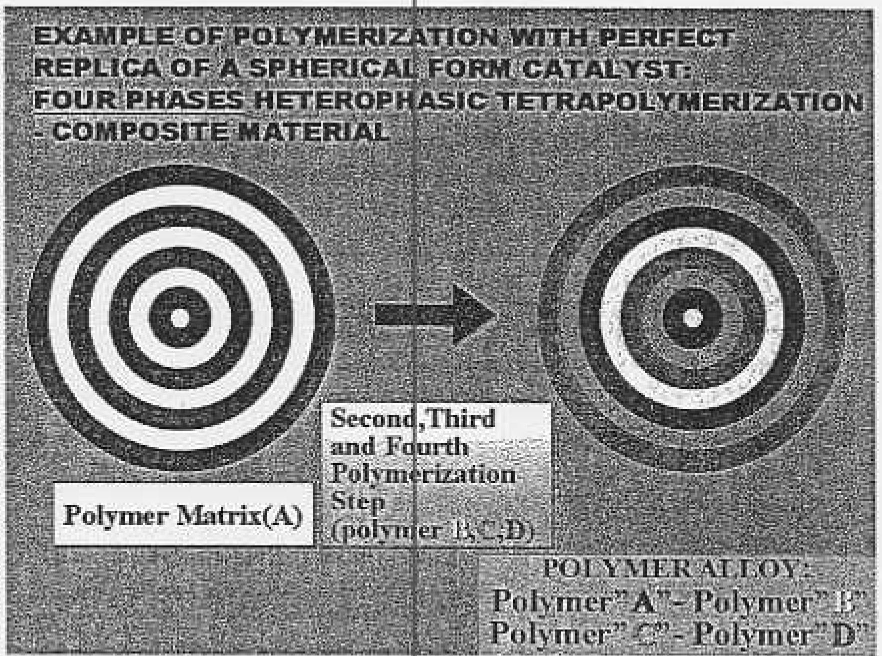


Fig. 14 - Four phases polymer alloy achievement

In this way, we have now generated a novel possibility of overcoming the difficulties of miscibility of the different polymer phases, with a degree of freedom clearly superior to the one we may have via the mechanical blending of the different polymer components and phases.
We are now approaching this new frontier, just entering the exciting future of the full exploitation of such a tremendous potential.
In the development of the polyolefin technology, the discovery and implementation of the "R.G.T." is today considered, together with the discovery of the high yield catalyst, based on active $MgCl_2$, a fundamental milestone in the Polyolefin technology development.

The process development

The different catalyst generations developed from the 1st to the current 4th have allowed, or better still, have driven the development of a family of new and novel processes taking full advantage of the new virtuosity made available by the various generations of catalyst families. This made a complete revolution in the process concept, the polymer properties and the market development.
All the new and most successful revolutionary generations of production processes are based on the adaptation of the "cascade reactor" technology; the fundamental prerequisite for that technology being a good and reliable R.G.T. type catalyst.
The cascade reactor processes currently are based on the use of the fourth generation catalyst. The most successful and famous is certainly the *Spheripol* process, eventually followed by the *Catalloy* process, specifically conceived in order to further expand the polymer property envelop. These make it possible to generate multipolymers, multiphase alloys and blends directly in synthesis, thus achieving materials not achievable with traditional technologies.
All that, made it possible to expand the PP and polyolefin properties obtainable in polymerisation from the straight homopolymers or slightly modified copolymers, to highly modified copolymers, and to real polymer alloys without boundaries in the ratios between the different comonomer introduced, number and type of phases and final compositions.

The **first impact** of RGT is well represented by the implementation of the first modern technology: the *Spheripol* process (Fig. 15). We may take it as the first and very likely best example among all the PP production processes.

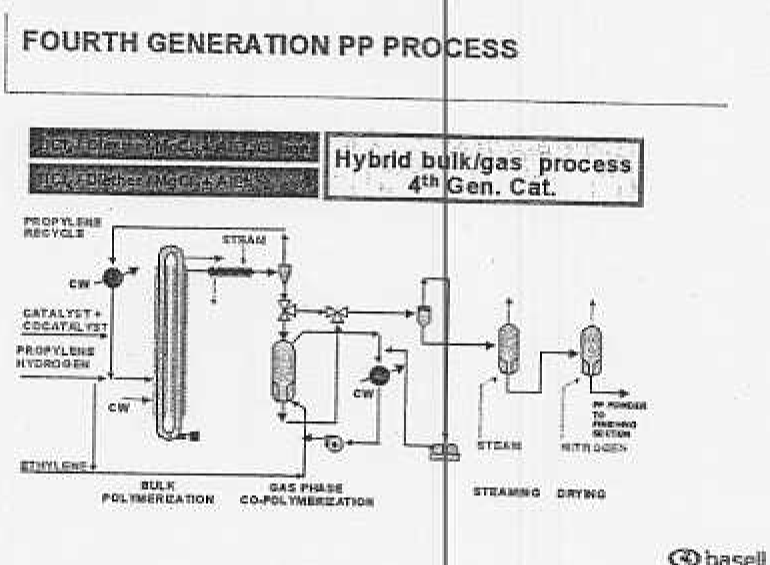


Fig. 15 - The fourth generation PP process

The *Spheripol* process, the first modern, most known and utilised PP process, has been designed to increase and exploit to the maximum the efficiency of the catalytic system in the production of PP homopolymers as well as random and heterophasic copolymers.
It is a two-stage hybrid process as it consists in the combination of the bulk technology in liquid monomer for the production of homo and random copolymers and of the gas-phase technology for the production of heterophasic copolymers.

Compared with the previous processes, the *Spheripol* process is dramatically simpler and more versatile in terms of products achievable. This is thanks to the elimination of several redundant reaction steps with the consequent reduction of investment and running costs, optimisation of economics and, above all, the complete elimination of environmental risks due to the complete absence of effluents.
The progressive simplifications of the process technology brought about a dramatic reduction of both: the CAPITAL COSTS (Fig. 16) and .the PRODUCTION COSTS connected, first of all, to the dramatic energy savings (Fig. 17).

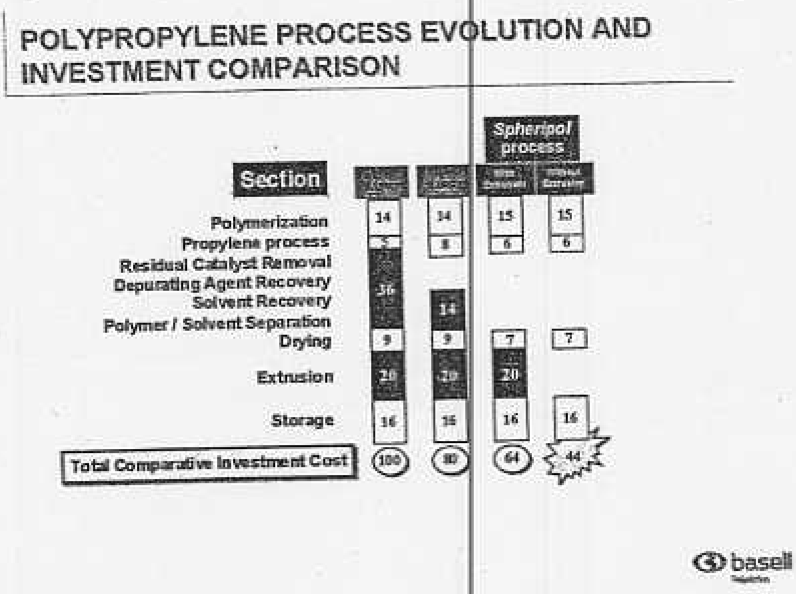
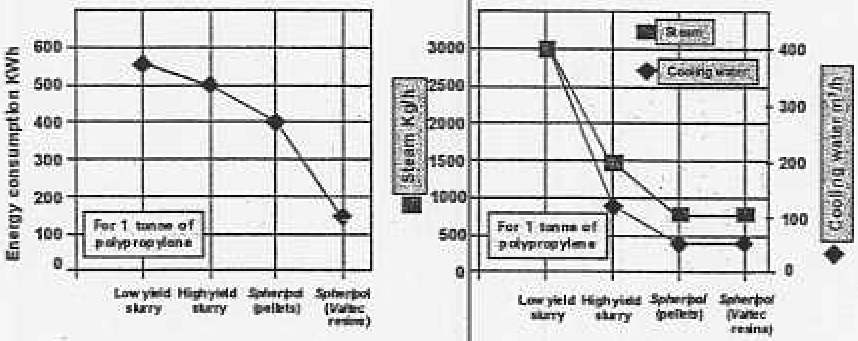


Fig. 16 - Investment cost comparison



basell

Fig. 17 - Evolution of PP process in terms of energy saving.

But, certainly most important is the dynamic expansion of the PROCESS VERSATILITY with the sharp and endless broadening of the POLYMER PROPERTY ENVELOPE. This concept has brought about the development of the *Catalloy* technology.

The *Catalloy* Process represents the most recent advance: in the achievement of a new family of POLYOLEFIN ALLOYS

The *Catalloy* process was designed to make maximum use of the Reactor Granule Technology, allowing the repeated introduction of different monomers during propylene polymerisation to generate a multiphase multipolymer alloy directly in the reactor. The spherical free-flowing resins obtained are fit for the subsequent conversion and are provided with an extremely wide range of properties, which cannot be obtained with any other process for PP.

The *Catalloy* process is a multistage, highly flexible, mainly gas-phase technology.

The Reactor Granule, based on the catalytic system used, permits the incorporation of multiple polymer structures within a single particle moving through the multistage process.

Also in this case the growing particle itself becomes the polymerisation reaction medium thus, eliminating all the previous process constraints and allowing the production of unique reactor-made resins with properties no longer limited from mechanical considerations of the process.

THE TWO PHASES OF PP LIFE CYCLE (N. Pasquini)

Introduction

As a consequence of the technological evolution, the life cycle of PP as a business can be broken down into two distinct phases:

- Before and after 1982/1983.

In spite of its interesting intrinsic properties, such as stiffness, temperature resistance, stretchability, moisture barrier, chemical resistance, the technical limitations already mentioned in previous paragraphs, prevented PP from a real commercial success during the first two decades of its life.
The perspective completely changed with the advent of the *Spheripol* and *Catalloy* (1990) processes (1982/1983)
Actually the most impressive fact brought by the RGT-based Cascade Reactor Technology, has been the revolutionary expansion of the polymer properties envelope.
The new profile has not just satisfied the existing market needs, but much more widely expanded the boundaries generating a new wave of applications and markets.
Outstanding performances were reached by the new products in terms of rigidity, impact and processability as shown in Fig. 18 and 19 when compared with products from traditional technology.

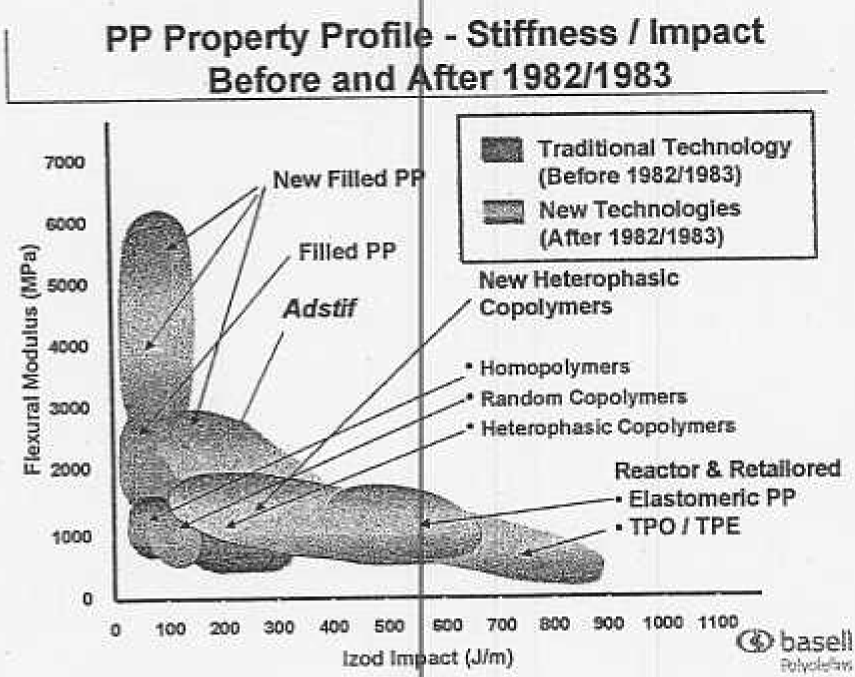


Fig. 18

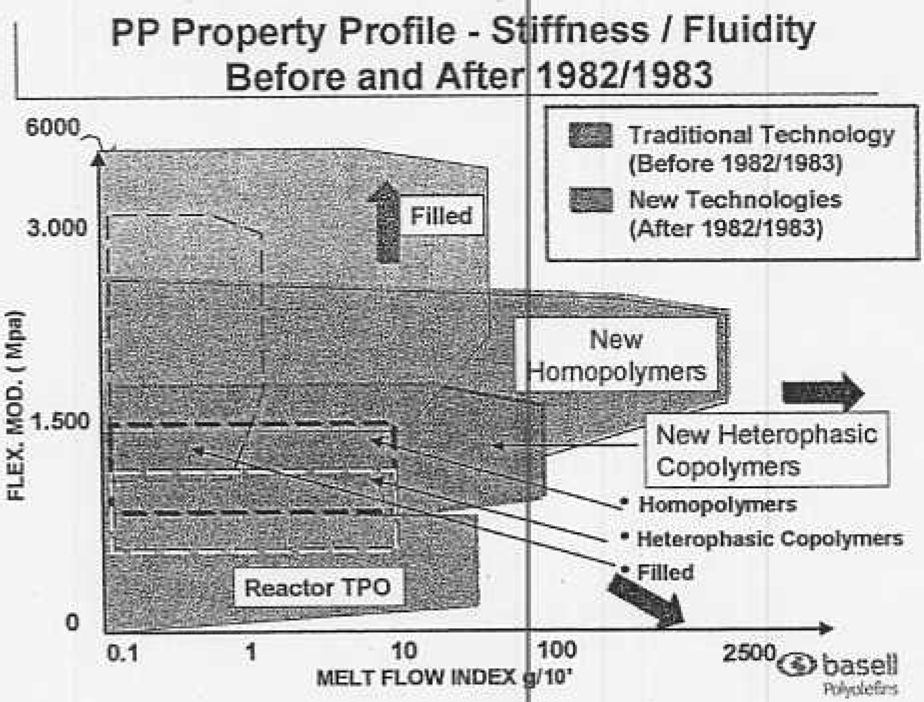


Fig. 19

It is amazing to realise that a strict correlation exists between the expansion of PP property profile and its growth rate in the market. Fig. 20 shows the demand of PP in the USA where two different trends are evident in the two time periods under consideration.

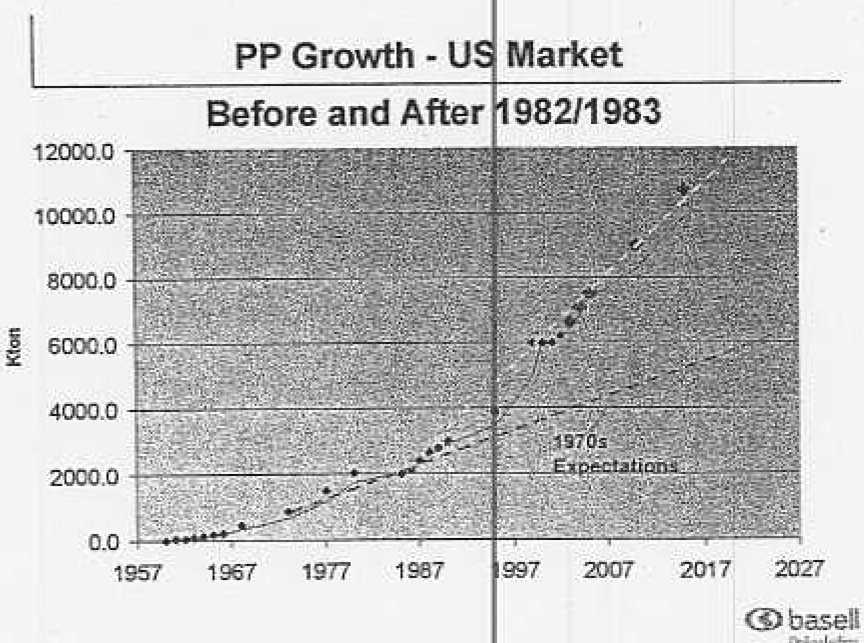


Fig. 20

We would like to support this statement by quoting.
Peter Bins and Ken Sinclair, who say in their last interesting multi-client study on PP "ULTIMATE PP MARKET POTENTIAL":
"The new technologies were not of themselves valuable, their value had to be developed through and from the market. Leaders of the 1979/1983 revolution such as Himont (then Montell now Basell) therefore devoted particular attention to the identification and satisfaction of real market needs.
The growth of PP from its commercial introduction in 1957 provides one of the best examples of market response to the introduction of new technology. Demand growth expressed in Kg / capita for the first 25 years of the industry from 1957/58 to about 1982/83 could be fit quite well in a logistics curve moving toward a fixed target of ultimate per-capita consumption. As illustrated in the chart below, (fig. 21) indications in 1983 were that the market was maturing – approaching an upper limit of per capita consumption—and that future growth was trending toward growth in the economy in general. Expectations of medium term growth were in the region of 4-5% per year.

Fig. 21

These expectations, however, failed to take into account the structural changes in PP's life cycle brought about by technological innovations, particularly the development in the late 1970s of high-yield, highly stereo selecting, (HY/HS) catalysts.
These boosted PP demand in virtually all markets world-wide. This led to a global consumption growth of more than 10% per year through the 80s. It became apparent that growth in all categories was following a new logistics curve with an ultimate per capita consumption two to three times the previous target".

Marketing and Market Segmentation

A more sophisticated "commercial" approach was needed to sell the value the new products were potentially able to offer to the market.
The concept of "value in use" became the new way to promote the new polymers (Fig. 22) and a more advanced Marketing organisation was needed to manage the innovation process. Market segmentation was a necessary step to better understand the business of the customers and that of their customers.

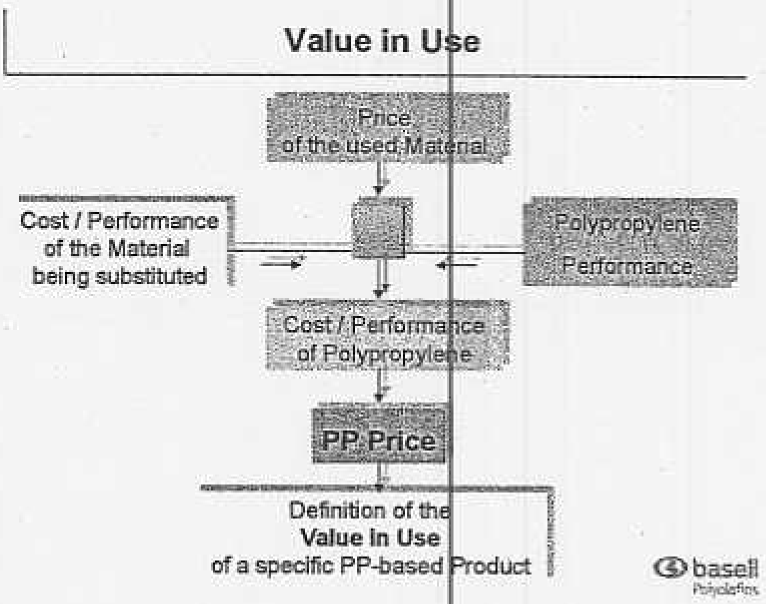


Fig. 22

It was important to identify which markets could become addressable to the new polymers.
Polyolefins and plastics in general had been sold without really knowing the role they played within the customers' business .
In other words, PO suppliers had been more concerned about their internal production related issues than being involved with the

applications development of their products which was almost interely left in the hands of customers.
With the introduction of the *Spheripol* technology, it was understood that this approach could not be suitable anymore for the future.
Specialised marketing teams had to be appointed and trained; this process required several years and it represented a major investment for the predecessors of Basell.
Today we are happy to say that the marketing teams organised by market segments and integrated with the R&D group (Fig 23) have, been the real key success factors able to convert a major technological breakthrough into a world-wide commercial reality.

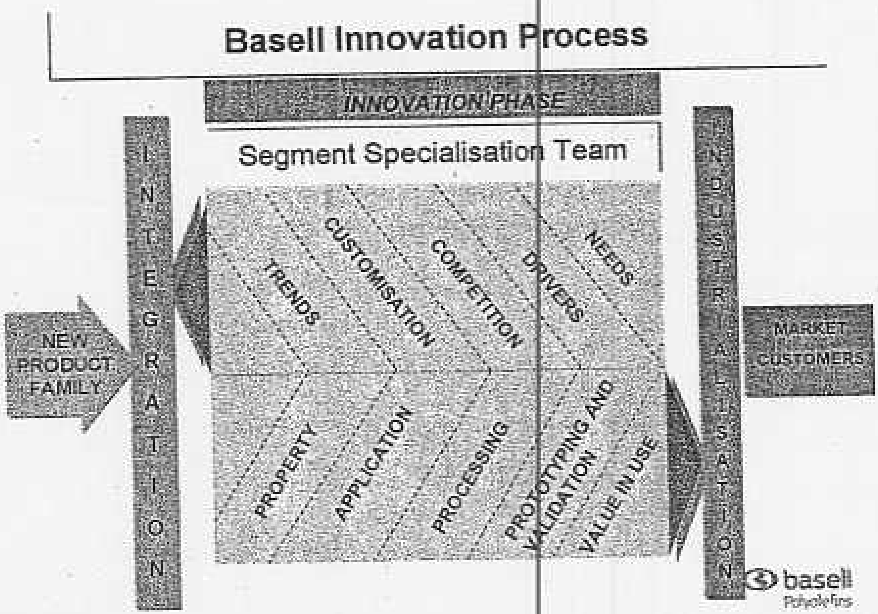


Fig. 23

The PP business was broken down into 5 strategic segments and several tens of sub-segments (Fig. 24) representing customers business with common features. Each segment (and more specifically each sub-segment) is characterised by specific requirements in terms of raw materials: automotive needs completely different from those of packaging and fibres and vice-versa.

Example of Basell Market Segmentation

CONSUMER	Battery Cases	FIBRES	Staple Fibres
	Crates		Spunbond, Melt blown
	Furniture		BCF / CF
	Housewares		Raffia (Cordage, netting, slit tape)
	Luggage		Strappig
	Other Consumer		Other Textile
	Sport /Leisure / Toys		
RIGID PACKAGING	Containers	FLEXIBLE PACKAGING	BOPP
	Thin Wall Moulding Technical		Cast
	Thin Wall Moulding Food		Blown Film
	Blow Moulding		Extrusion Coating
	Thermoforming		Other Film
	Medical	AUTOMOTIVE	Bumper
	Caps & Closures		Exterior Trims
	Corrugated Board		Instrument Panel
	Foram Sheet		Interior Trims
	Other Packaging		Under the Hood

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Fig. 24

The broadening of the key product properties made available by *Spheripol* and *Catalloy* technologies with respect to the previous generations is clearly visible in fig. 25)

Spheripol and *Catalloy* Process Versatility Producer Perspective / Opportunity

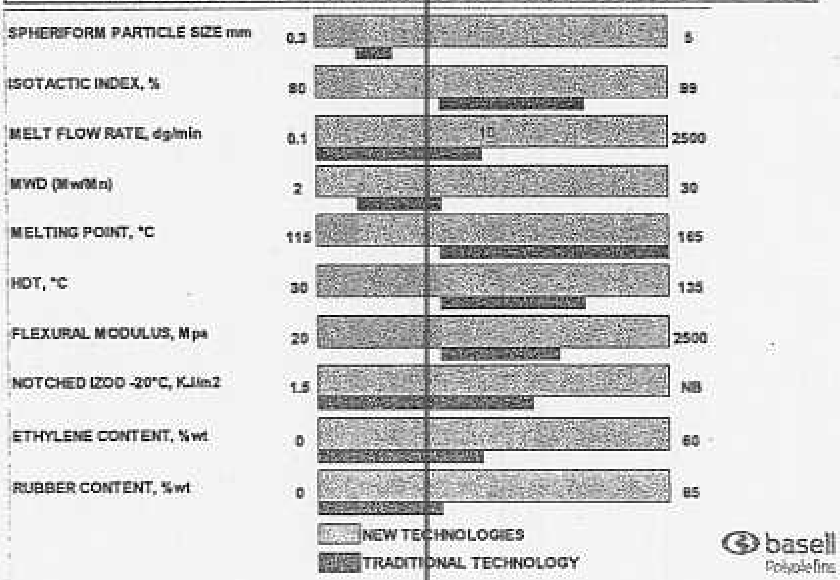

Fig. 25

Thanks to the new integrated working approach between Marketing and R&D, it was possible to fully capitalise on the versatility of the new processes. The improved structural, molecular and rheological properties were translated into application and market benefits (fig 26).

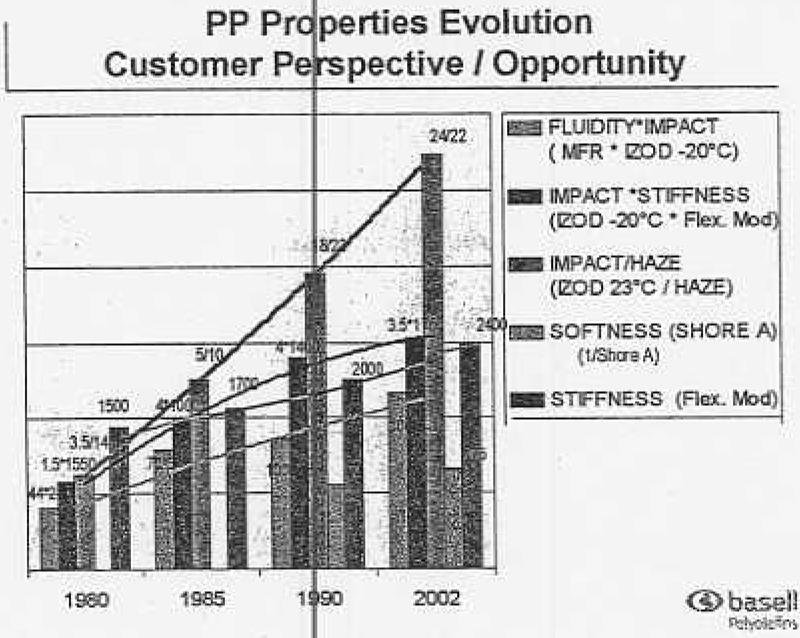

Fig. 26

The new capability of tailoring products for specific applications thanks to the combinations of catalyst, process and product design, has been increasingly exploited over the years providing Basell and its predecessors with a strong competitive advantage.
In fig. 27 a few relevant sentences extracted from the Himont annual report of the year 1987 are reported which confirm that the company was moving towards the right direction.

The Initial Phase of Innovation

HIMONT 1987 ANNUAL REPORT

"Fiscal 1987 was the first full year of HIMONT's global **segmentation strategy.** Two factors made it possible for us to develop and implement this strategy.

- First, polypropylene - unlike other large-volume plastic resins - is used in a broad range of markets. Within each of these **diverse markets** are a wide range of **individuals segments** for which HIMONT has identified unique **properties needs.**
- Second, the **versatility** of the Company's ***SPHERIPOL*** process allows HIMONT to produce precisely the properties and the **performance** characteristics each of these segments requires. **During fiscal 1987, sales of specialty grades reached 43.1% of product mix. As a result, revenues increased over 20% on a physical volume increase of 9.2%.**"

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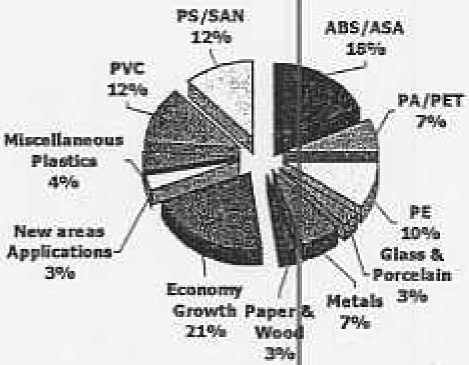
Fig. 27

The renewed capability of PP to replace other materials, is shown in Fig. 28: more than 75% of the two additional million tons of PP sold in the period 1988/1998 was coming from of intermaterial competition.

1988-1998

Polypropylene Source of Growth

Western Europe



Total 2 million Tons

ECN 1999

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Fig. 28

Contribution came from all the strategic segments: Automotive, Packaging, Consumer and Fibres. The perfect fit between the new and improved properties and the requirements/trends typical of these segments, (Fig. 29, 30, 31 and 32) made it possible to stimulate a major material replacement process over the last two decades

Automotive

PRODUCT		APPLICATION	
PRODUCER	CUSTOMER	BENEFITS MATCHING CONVERTER / END USER REQUIREMENTS	
MFR, MW	Fluidity	Productivity, easier moulding of thin wall section with long flow path.	THE COMBINATION PROVIDES: • Technical performance and functionality, • Innovative design • Safety, • Reduced environmental impact: –Lighter parts, –Fuel efficiency, –Easier reciclying (mono-material PO)
ISOTACTIC INDEX, MWD	Stiffness	Downgauging, high-speed, heat-resistance, Eco tax reduction, lower waste management concern	
RUBBER CONTENT, COMPOSITION AND VISCOSITY	Impact resistance	Increased safety	
RUBBER CONTENT AND COMPOSITION	Shrinkage, CLTE	Dimensional stability, Zero-gap design	
HDT, VICAT	Thermal Properties	Durability, Scratch resistance	
RUBBER COMPOSITION AND VISCOSITY	Aesthetics	Paintability, soft touch, comfort	

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Fig. 29

Packaging

PRODUCT		APPLICATION	
PRODUCER	CUSTOMER	BENEFITS MATCHING CONVERTER / END USER REQUIREMENTS	
MFR, MW	Fluidity	Productivity, easier moulding of thin wall section with long flow path.	THE COMBINATION PROVIDES: • Reduced environmental impact • Lighter parts, • Easier reciclying (mono-material PO) • easy and safe transportation, • secondary packaging elimination, • multiple size options, • design freedom, • attractive design opportunity for product differentiation
ISOTACTIC INDEX, MWD	Stiffness	Downgauging, high-speed, automated operations, hot fill capability,tamper-evident pack, heat-resistance, top-load, Eco tax reduction, lower waste management concern	
RUBBER CONTENT, COMPOSITION AND VISCOSITY	Impact resistance	Chilled goods storage and frozed food pack.	
ETHYLENE CONTENT, RUBBER COMPOSITION AND VISCOSITY	Aesthetics	Product appeal, transparency, gloss, low stress whitening.	

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Fig. 30

Consumer

PRODUCT		APPLICATION	
PRODUCER	CUSTOMER	BENEFITS MATCHING CONVERTER / END USER REQUIREMENTS	
MFR, MW	Fluidity	Productivity, easier moulding of thin wall section with long flow path.	THE COMBINATION PROVIDES: • Lighter parts, • no brittle fractures, • multiple size options, • design freedom, • attractive design opportunity • colour options, • Easier reciclying (mono-material PO)
ISOTACTIC INDEX, MWD	Stiffness	Downgauging, high-speed, automated operations, heat-resistance, top-load	
RUBBER CONTENT, COMPOSITION AND VISCOSITY	Impact resistance, shrinkage	Chilled goods storage, from freezer to microwave, safety.	
ETHYLENE CONTENT, RUBBER COMPOSITION AND VISCOSITY	Aesthetics	Product appeal, transparency, gloss, low stress whitening, colouring.	

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Fig. 31

Fibres

PRODUCT		APPLICATION	
PRODUCER	CUSTOMER	BENEFITS MATCHING CONVERTER/END USER REQUIREMENTS	
MFR, MW	Fluidity	Productivity, processability, spinnability	THE COMBINATION PROVIDES: • Options for optimal balance between productivity and fibre and fabric performances • Quality consistency, • Inter-material competition opportunities
MWD	Tenacity/elongation	Spinnability, low titre, mechanical properties,softness	
ISOTACTIC INDEX (Xylene soluble)	Tenacity, Purity	Filament and fabric strength	
ETHYLENE CONTENT	Thermal bonding	Productivity/Performances, Processability/Mechanical properties/ Softness	
MELTING POINT	Lower Temperature Processing	Processability / Softness	

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Fig. 32

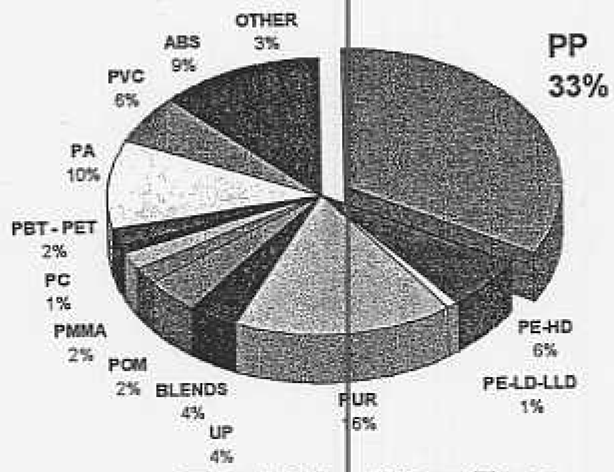
Fig. 33, 34, 35 and 36 report current PP European market share in these segments compared with all other plastics.

SETTORE AUTOMOBILISTICO

Automotive

Current PP Market Share - Western Europe

Year 2000



Total 2.7 million Tons

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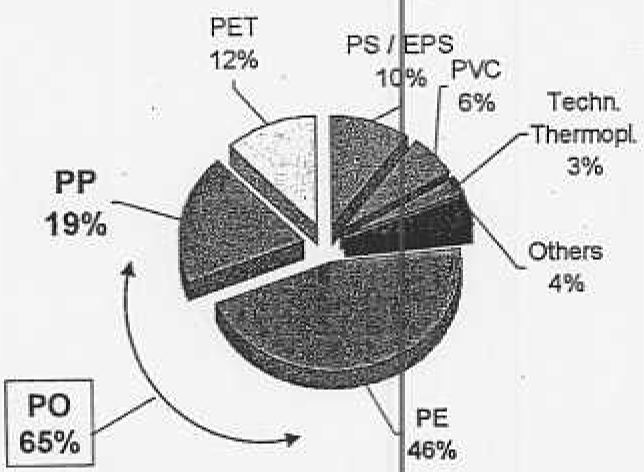
BASF Marktforschung Kunststoffe 2001

Fig. 33

Packaging

Current PP Market Share - Western Europe

Year 2001



Total 17 million Tons

APME

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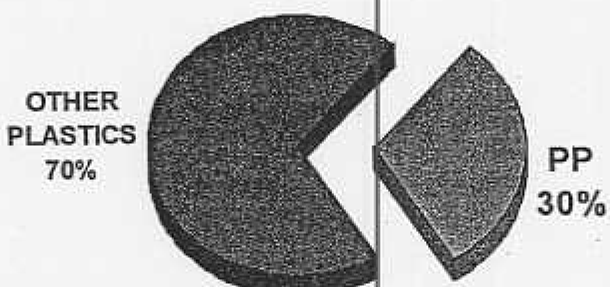
Fig. 34

Consumer

Current PP Market Share - Western Europe

Year 2000



Total 3.5 million Tons

Basell

Fig.35

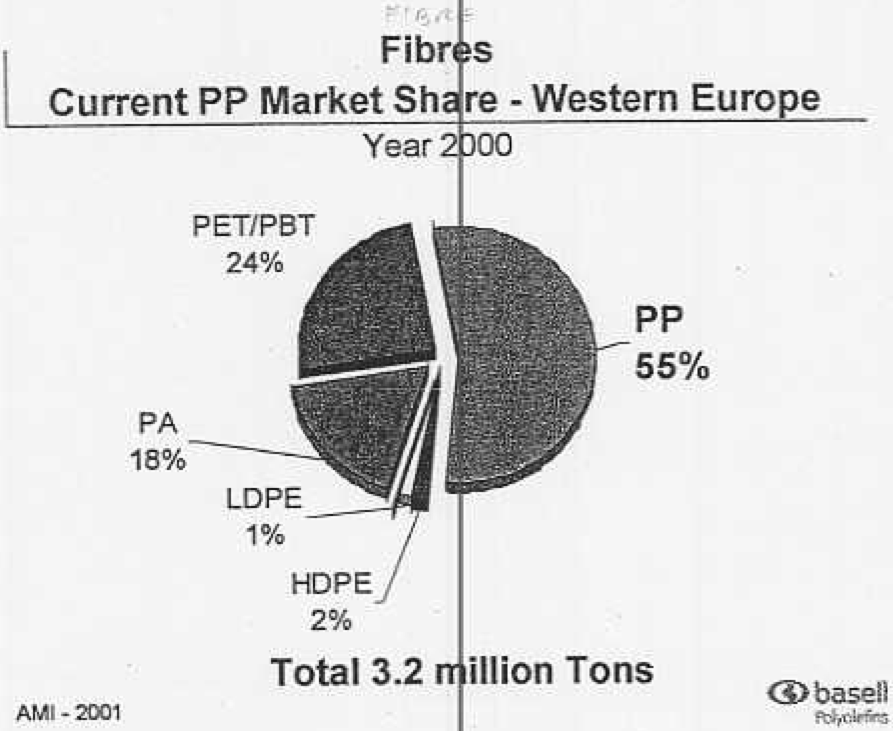


Fig. 36

Fig 37 shows the evolution since 1982/83.
The superior cost/performance advantages has made PP the material of choice.

Evolution of PP Positioning vs. Other Plastics Western Europe

SEGMENTS	PP MARKET SHARE (%)	
	BEFORE 1982/1983	CURRENT
AUTOMOTIVE	21	33
PACKAGING	8	19
CONSUMER	13	30
FIBRES	25	55

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Fig. 37

The example of the Automotive sector

Continuous improvements in mechanical properties of bumper materials have enabled progressive reduction of wall thickness and thus significant material saving for manufacturers, lighter components and thus lower fuel consumption for the end users.
Improved processability in terms of optimised melt flow characteristics has translated to significant reduction in cycle time. The story of exterior and interior trims and instrument panels has followed the same path as bumpers.
Fig. 38 clearly shows the impact of the advanced PP products on the Automotive sector: with the exception of structural parts, PP is strongly present in all the other applications. This trend continues to be driven by the “monomaterial strategy” in which the reciclability factor has a fundamental importance.

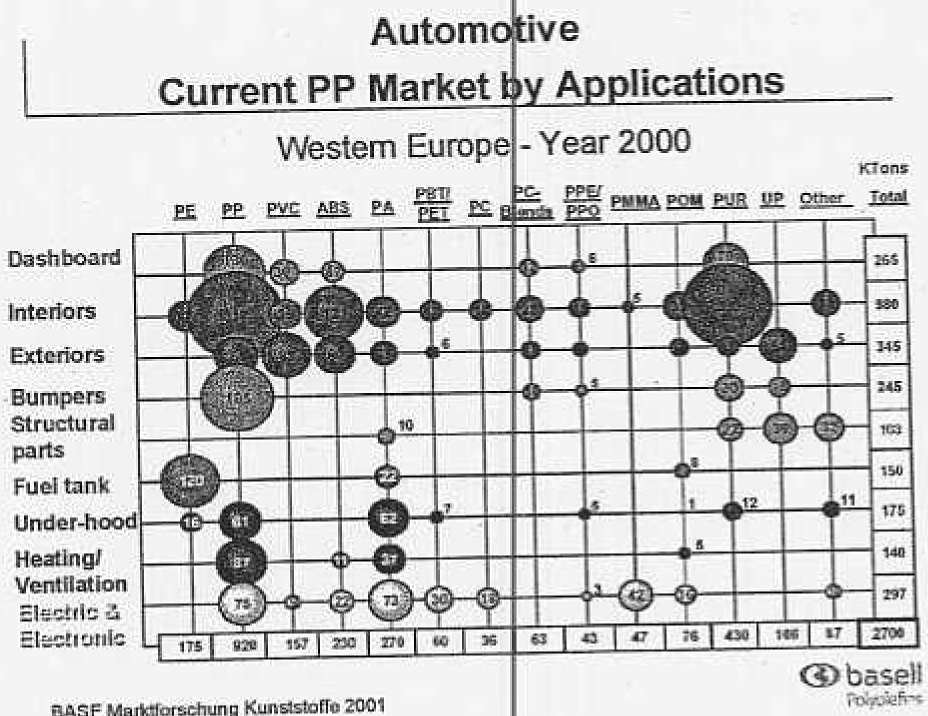
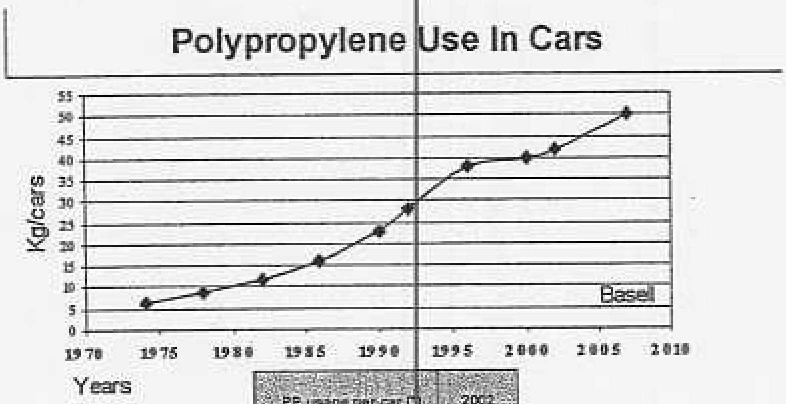


Fig. 38

The Automotive industry has been under increasing pressure from government regulation and public opinion to minimise the environmental impact.

It is no coincidence that there has been a corresponding growth of PP-based materials from just a few Kg/ cars in the late 70s to 22 Kg in 1990 to over 40 Kg in 2000. Current estimates indicate 50 Kg by 2007. (Fig. 39)



PP usage per car (*)	2002
Region	kg/car
AFRICA	29
ASIA PACIFIC	26
EASTERN EUROPE	26
JAPAN	50
NAFTA	40
SOUTH AMERICA	49
WESTERN EUROPE	49
Total	42

* Polypropylene Annual Report - 2001 from PTAI

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Fig. 39

Conclusion

The importance of G. Natta discovery is well understood by all of us: the 30 million tons of PP and 100 million of PO used today world-wide are visible to everybody and our imagination can help us "to see " the huge up and down stream business associated with those volumes. The history of PP could be summarised with a simple slogan "from the ideal catalyst to the ideal material". As a matter of fact the exceptional set of properties (mechanical, physical and processabiliy) combined with the environmental superiority have made PP the material of choice in most of the applications within the modern society. However we would like to underline an additional contribution of PP, in this case to the world of business management: the PP business has become part of teaching programs in a few qualified business schools. Very much appreciated as an excellent case study has been the unique portfolio of management dimensions that PP offered to Basell and to the other PP suppliers:

Business dimensions	PP featuring
Products	Extremely versatile and tailoring
Market	Very broad portfolio of applications
Technology	Continuous advances
Organisation	Evolution to fit with the PP life cycle
Human resources	Multicultural
Customers	PP seen as asset
Pricing	Cost /performance superiority
Innovation	Successful record: from inventions to commercial realities
Market pull / technology push	Unique example of a balanced approach
Licensing	Supporting PP growth
Competition	Direct (PP- indirect other materials)
Marketing/Market segmentation	The first example in the plastics industry

This unique combination makes the PP business an unparalleled example for all the business management experts.

Norio Kashiwa

Senior Research Fellow

R&D Center, Mitsui Chemicals Inc.580-32 Nagaura,Sodegaura, Chiba 299-0265, Japan

Education: 1964 Bachelor of Engineering (Osaka University)
1966 Master of Engineering (Osaka University)
1985 Ph.D. (Kyoto University)

Additional information:

Dr. Kashiwa is a global authority on R&D of olefin polymerization catalysts. Since his invention of $MgCl_2$-supported $TiCl_4$ catalysts for the first time in the world in 1968, he has been in the front line of olefin polymerization catalyst research including not only $MgCl_2$-supported $TiCl_4$ catalysts but also single-site catalysts such as metallocene and post-metallocene catalysts.

Especially, it should be noted that he had led the large team of Mitsui Petrochemical Industries for the collaborative research with Montedison (changed to Himont, Montell and Basell) for more than 20 years and contributed to the global production of polyolefins by developing the HY-HS catalysts.

Besides, he has studied on everything related to olefin polymerization for 37 years on the industry side, for example, polymer science, polymer application, polyolefin production process, R&D management and corporate management.

Now, various kinds of new polymers are being created at his laboratory.

Professional Appointments:

1966 Joining Mitsui Petrochemical Industries Ltd.
1993 Board Director & General Manager of Polymers Laboratory, Mitsui Petrochemical Industries Ltd.
1995 Managing Director, Mitsui Petrochemical Industries Ltd.
1997 Managing Director, Mitsui Chemicals Inc.
1999 Senior Research Fellow (current title), Mitsui Chemicals Inc.

Awards: 1985 The Chemical Society of Japan Award for Technical Development
1986 The Association of Chemical Engineers (Japan) Award.
2003 The Chemical Society of Japan Award for Technical Development.
2003 The Award by Japanese Minister of Education, Culture, Science and Technology

Norio Kashiwa, Mitsui Chemicals, Inc.

The unique case of Polypropylene growth and development in Japan

Abstract

General Aspect

Historically, Japanese has been admiring exquisite architectures. For example, it gave wooden temples that could last several centuries in old days and high quality cars or electric machines recently. It also brought about quality-oriented mindset to Japanese PP industry. For creating the exquisite architectures, Japan has adopted the latest technologies mainly from foreign countries and modified them into Japanese style.

The start of Japanese PP industry corresponded with the beginning of the incredibly rapid economic growth of Japan. Although many small players were born in the PP industry, all of them could survive owing to the protective and exclusive policies by Japanese government. These and geographic and climatic reasons made Japanese PP market quite unique.

Historical observations of the early stage

For starting the PP industry, many Japanese companies had rushed to visit Italy to become licensees of Montecatini and three companies could be licensed to produce PP with $TiCl_3$ catalyst systems. Then, these three companies had kept their positions as leaders of Japanese PP industry for 20 years since 1962. Although their initial expectation was to use PP in Fiber applications for textile use, the expectation declined rapidly due to low spinnability and poor dyability of PP in addition to climatic and cultural reasons. On the other hand, Injection applications grew rapidly by replacing metals and wood for daily use such as buckets or washbowls with competing with HDPE. Then, creation of "Impact-copolymer (block PP)" improved its impact strength at low temperatures to enhance its competitiveness with HDPE. It led to a turning point that was the first massive use of PP Injection as beer bottles crafts. After its success, PP started to be used as parts of household electric apparatus such as electric washing machines by increasing its MFR. Film applications were suitable for early Japanese PP industry to demonstrate the competitive power of PP especially in packing use.

Historical observations of the late stage

The catalyst innovation allowed Japanese PP industry to get into another stage. Its origin was in 1968 when Mitsui Petrochemicals (MPC) and Montedison independently applied patents about $MgCl_2$-supported $TiCl_4$ catalyst systems ($TiCl_4/MgCl_2$) in the same year (in our best knowledge; MPC: on 1 Aug. in Japan; Montedison: on 21 Nov. in Italy). Then, both companies started the collaborative research for new $TiCl_4/MgCl_2$ in the field of PP production. Introduction of electron donors such as ethyl benzoate led to highly stereospecific and highly active $TiCl_4/MgCl_2$ and subsequent studies established the current $TiCl_4/MgCl_2$ by using alkoxy silanes as electron donors. It gave process and product innovations such as the replacement of metal automobile bumpers by those made of block PP. This excellent collaborative project continued for more than 20 years and made MPC a leader in Japanese PP industry. Thus, the global standard in the PP production was established, although the details were different between both companies on the same platform in order to meet the Japanese PP market.

Now, long recession in Japan and globalization of main PP users such as automobile and electric appliances companies is forcing to change PP industry with still keeping the quality-oriented business style.

The unique case of Polypropylene growth and development in Japan

It has passed about 40 years since the beginning of Japanese polypropylene (PP) industry in 1962. This history can be classified into two stages that early 20 years and last 20 years. Through the two stages, Japanese PP growth has been said to be unique. We would like to discuss the uniqueness from general aspect and historical observations of the early stage and the late stage.

General Aspect

Historically, Japanese has been admiring exquisite architectures. For the examples, it gave wooden temples that could last several centuries or very expensive fragile antiques in old days and high quality cars and electric machines recently. It also brought about very quality-oriented mindset to Japanese PP industry. For creating the exquisite architectures, Japan has adopted the latest technologies mainly from foreign countries and modified them into Japanese style. A long time ago, Japan imported Kanji characters from China and combined them with Japanese letters, for example, or changed the governmental systems and national policies from the "Samurai" rules to the Western style in middle 19th century that made it one of the most modern nations within a short term. It could influence the developmental policies in Japanese PP industry. Significantly, all the progresses have been proceeded by specific groups called "Keiretsu" that is used even in English. It made relation between PP makers and customers quite unique.

Geographically, at the beginning of Japanese PP industry, Japan was too far from Western Europe and U.S.A. to import PP from these countries and there were no nations to compete with Japan economically in Asia. And Japanese climate is characteristic in high humidity and mild temperatures, compared with Western Europe and U.S.A.

Furthermore, the start of Japanese PP industry corresponded with the beginning of the incredibly rapid economic growth of Japan. Although many small players were born in the PP industry, all of them could survive owing to the protective and exclusive policies by Japanese Ministry of International Trade and Industry (MITI) who believed that their policies were inevitable to recover from the devastating defeat of World War II. It enhanced the specific relations between the makers and the customers constituted by Keiretsu.

Historical observations of the early stage

For starting the PP industry, many Japanese companies had rushed to visit Italy to become licensees of Montecatini and three companies that were Sumitomo, Mitsubishi and Mitsui-Toatsu could be licensed to produce PP with $TiCl_3$ catalyst systems. Then, these three companies had kept their positions as leaders of Japanese PP industry for 20 years since 1962. Their initial expectation was to use PP in Fiber applications for textile use and, in fact, Fiber applications accounted for 62% in the PP market in the starting year. Each PP marker had a respective textile company in their Keiretsu but they began to dislike low spinnability and poor dyability of PP. To make the matter worse, high humidity in Japanese climate did not allow PP to be used even as disposable clothes such as surgery wear and there was little use of carpets in Japanese houses that used Tatami-mat instead of the carpets. Thus, the Fiber applications declined rapidly to 10% in the PP market in 1972.

On the other hand, Injection applications that accounted for 27% of the PP market in 1962 grew rapidly to 39% in it in 1972. At the initial stage, PP Injection replaced metals and wood in such things for daily use as buckets or washbowls with competing with HDPE. PP demonstrated its advantages such as high processability and high gloss to HDPE but showed its disadvantages such as low impact strength at low temperatures to it. Then, creation of basic concept of "Impact-copolymer (block PP)" improved its impact strength at low temperatures to enhance its competitiveness with HDPE and allowed it to grow rapidly in the Injection applications with supported by the mind climate that winter is relatively warm. The first massive use of PP Injection was for beer bottles craft use that was turning point for the PP industry. At that time, there was a major beer company who was the dominant power in Japanese beer industry had converted the craft material from wood to HDPE. Creation of block PP enabled the beer company to replace HDPE by PP. From a viewpoint of Keiretsu, the leader of Japanese HDPE producers was Mitsui Petrochemicals (MPC) of Mitsui Group but Mitsubishi Group included the beer company and the PP producer that promoted the replacement. After its showing high potential of PP Injection, it could be used as parts of household electric apparatus such as electric washing machines by increasing its MFR to improve its melt-flowability.

The other Japanese companies than the Montecatini licensees had to develop their own PP production technologies or seek licensers other than Montecatini. Then, many small PP makers were born and all of them were protected by the policies of MITI. Although some of them had easy access to the resin users in their Keiretsu, their situations were generally very strict due to brick walls built by the ahead-going companies who were in the Three Major Groups leading Japanese economy. For such companies, Film applications were helpful. The Film applications were suitable for early Japanese PP industry to demonstrate the competitive power of PP to PE by high rigidity and transparency especially in packing use. And, from the viewpoint of Keiretsu, the film producers were too small to be included in the Three Major Groups. Namely, because the majority of them were in a cottage industry, even the PP makers that entered the market late could make their own Keiretsu by their investment. Thus-made tight and long-term relations between resin makers and resin users led to the situation that was suitable for producing the elaborate PP Film applications such as multi-layer films or films including silica or other additives in the precise manners. Thus, the Film applications that accounted for 7% of the PP market in 1962 grew rapidly to 23% in it in 1972.

Eventually, many small players survived and they produced a lot of the grades at small scales in accordance with favorites of their customers. Thus, the exclusive Japanese PP market formed, while its ineffective business system causing the high cost of production and trading was tolerated by the miraculous economic growth in Japan at this stage.

Historical observations of the late stage

The catalyst innovation allowed Japanese PP industry to get into another stage. It changed the competitive orders drastically from any aspects such as process technologies, product qualities or market controllability. Its origin was in 1968 when MPC and Montedison independently applied patents about $MgCl_2$-supported $TiCl_4$ catalyst systems ($TiCl_4/MgCl_2$) in the same year (in our best knowledge; MPC: on 1 Aug. in Japan; Montedison: on 21 Nov. in Italy). Then, both companies started the collaborative research for new $TiCl_4/MgCl_2$ in the field of PP production. Introduction of electron donors such as ethyl benzoate led to highly stereospecific and highly active $TiCl_4/MgCl_2$ and subsequent study established the current $TiCl_4/MgCl_2$ by using alkoxy silanes as electron donors. This catalyst system demonstrated several hundreds times higher activity and strikingly higher stereospecificity than those of $TiCl_3$ catalysts invented by Natta. Eventually, it gave birth to large and simplified PP production processes enabling us to cut the costs drastically by dispensing with the facilities for removal of catalyst residues and low stereoregular PP. Furthermore, it innovatively improved the PP properties to broaden the field of PP application by utilizing its enhanced stereospecificity and purified active site nature, as represented by the replacement of metal automobile bumpers by those made of block PP. This excellent collaborative project continued for more than 20 years and made MPC a leader in Japanese PP industry. Thus, the global standard in the PP production was established by using $TiCl_4/MgCl_2$ at continuous bulk-gas hybrid process, although the details such as the catalyst particle sizes and reactor design were different between MPC (which is now Mitsui Chemicals, Inc.) and Montedison (which is now Basell) on the same platform of $TiCl_4/MgCl_2$ technologies. Namely, MPC adopted vessel reactors that was suitable for the production of many PP grades at small quantities and the smaller size catalysts that were suitable for the vessel reactors and had the advantage in blending the silica or other additives with the PP powders.

Although the protective and exclusive policies by MITI were kept in the first half of this stage, the recent recession in Japan and globalization of main PP users such as automobile and electric appliances companies forced to change them with collapse of Keiretsu in their use. At last, Japanese PP makers have been drastically restructured with still keeping the quality-oriented business style.

The Unique Case of Polypropylene Growth and Development in Japan

Norio Kashiwa, Ph.D.
Mitsui Chemicals, Inc.

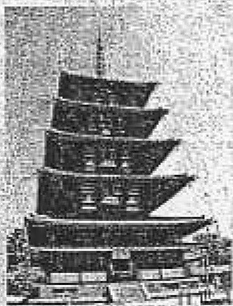
The Uniqueness of PP Growth and Development in Japan

from

- **General Aspect**
- **Historical Observation of the Early Stage**
- **Historical Observation of the Late Stage**

From General Aspect

Japanese has been admiring exquisite architectures historically.



6th Century

17th Century

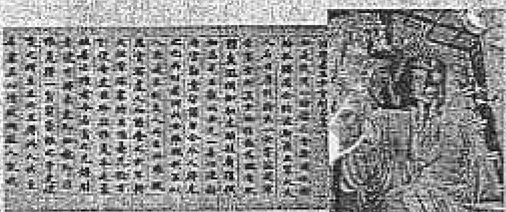
Recently

⇩

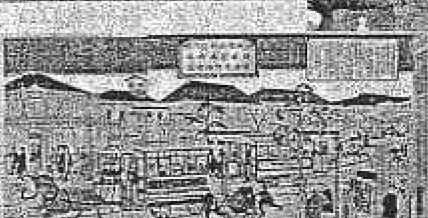
Quality-Oriented Mindset in Japanese PP Industry

From General Aspect

Japanese has adopted the latest technologies mainly from foreign countries and modified them into Japanese style.



By 9th Century
From China



Since 19th Century
From Western Countries

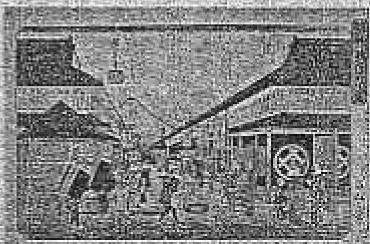
⇨ Influences on Developmental Policies in Japanese PP Industry

From General Aspect

"Keiretsu" worked.

The Three Major Group: Mitsui, Mitsubishi, Sumitomo
The Three Influential Group: Fuyoh, Sanwa, Ichikan

Mitsui (17th Century)



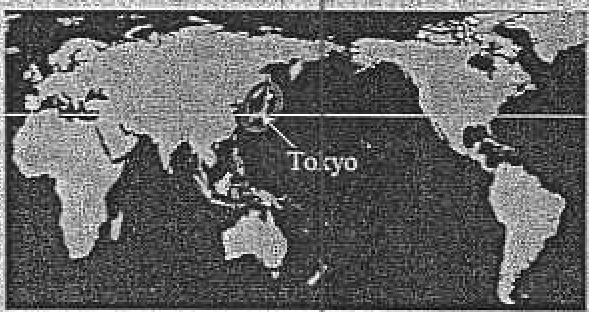
Mitsui (19th Century)

⇓

Unique Relation between Makers and Customers in Japanese PP Industry

From General Aspect

Geographically, Japan is far from Western Europe and U.S.A. and has high humidity and mild climate.



⇓

The Amount of Imported PP from Western Countries has been little in Japan.
The PP's disadvantage of Impact Strength at Low Temperatures in the comparison with HDPE tends not to matter.

From General Aspect

The Start of Japanese PP Industry corresponded with the Beginning of the Miraculous Economic Growth in Japan and No Nations competed with Japan Economically at that time in Asia.

Japanese Ministry of International Trade and Industry (MITI) carried out the Protective and Exclusive Policies.

⇓

Ineffective Business System in Japanese PP Industry was tolerated.

Many Small Players survived in Japanese PP Industry with Specific Relation with PP Users.

From General Aspect

Summary

- Quality-Oriented Mindset
- Adoption of the Latest Technologies
- Keiretsu
- Far from Western Countries
- High Humidity and Mild Climate
- PP Growth linked with Growth of Japanese Economy
- Little Competition in Asia
- Protective and Exclusive Policies by MITI

Historical Observation of the Early Stage

- (1954 Discovery of $TiCl_3$ Cat. by Natta)
- (1957 Commercialization of it by Montecatini)

Many Japanese Companies rushed to visit to Italy to became Montecatini Licensees

- **1962**

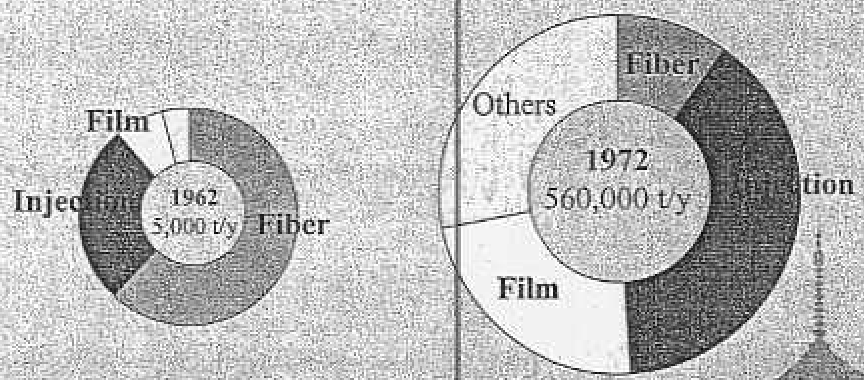
Start of Japanese PP Industry

by **Mitsui-Toatsu**, **Mitsubishi** Petrochemicals and **Sumitomo** Chemicals who succeeded to became Montecatini Licensees and had been the Leaders in Japan for the Early Stage.

Followed by Others than Montecatini Licensees :
Chisso (1963) ,
Mitsui Petrochemicals (MPC) (1968),
2 of the others (1969), - - - -

Historical Observation of the Early Stage

Changes of PP Market in Japan for the Initial 10 Years



Applications	in 1962	in 1972
Fiber	62%	10%
Injection	27%	39%
Film	7%	23%

Historical Observation of the Early Stage

- Fiber Applications -

Main Target at the Initial Stage

Development by Strong Tag Teams:

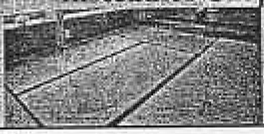
(PP company)	(Textile company)
Mitsui-Toatsu	Toray
Mitsubishi Petrochemicals	Mitsubishi Rayon
Sumitomo Chemicals	Toyobo

- High Humidity Climate

Disposable closes such as surgery wear did not become popular.

- Disliked low spinnability and poor dyability of PP

- Use of Tatami instead of Carpets



Rapid Decline

Historical Observation of the Early Stage

- Injection Applications -

Replacement of metal and wood in **Household Utensils**

Metal → PP Washbowls, Buckets etc.

Wood → PP Casks, Boxes etc.

Historical Observation of the Early Stage

- Injection Applications -

Beer Bottles Crafts

The First Use in Industry of PP Injection

Led to Mass Consumption of PP

HDPE had already replaced wood in this use.

HDPE	PP
High Impact Strength at Low Temperatures	High Processability, Good Appearance

- Creation of Impact-Copolymer (block PP)
- Mild Winter
- Keiretsu (The Major Beer Company: in Mitsubishi Group
  The Major HDPE Producer: in Mitsui Group.)

Replacement of HDPE by PP

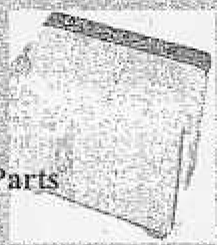
Historical Observation of the Early Stage

- Injection Applications -

Beer Bottles Crafts

Increase of MFR

Extension of the PP Market to Use
as **Household Electric Apparatus Parts**



The Three Leaders (Montecatini Licensees)
built brick walls in their Keiretsu and Local Communities.

Historical Observation of the Early Stage

- Film Applications -

- PP demonstrated the competitive power to PE.

  High Rigidity, High Transparency, etc.

- Keiretsu did not work.

Film producers — Too small to be members of the three major groups. Majority is in a cottage industry

⇩ Investment from PP makers

New Keiretsu was organized by PP makers.

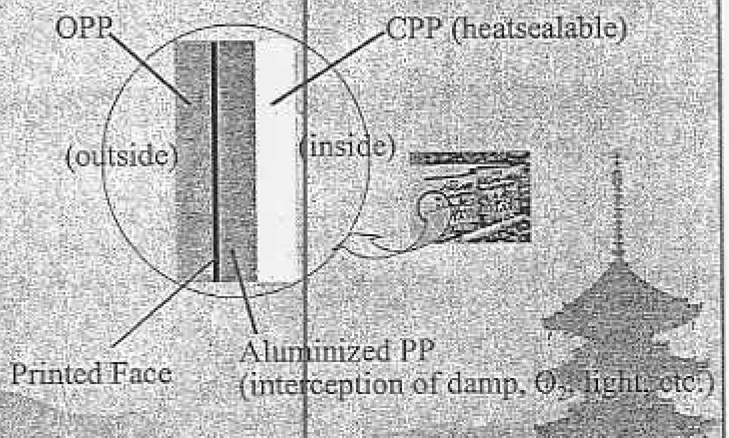
⇩

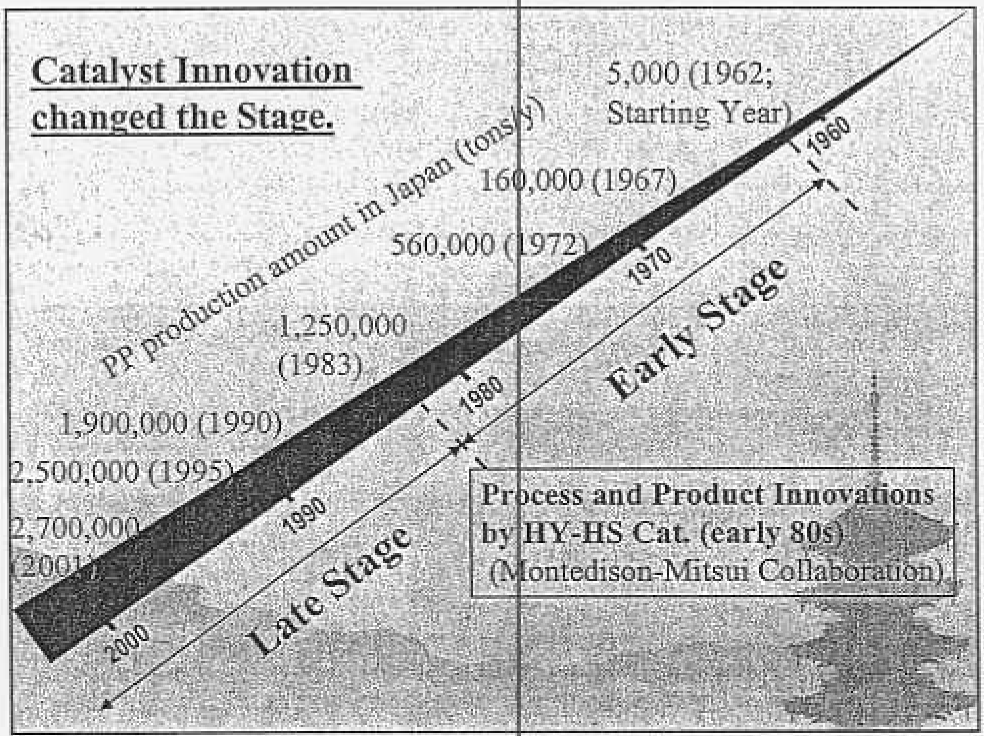
Many grades for elaborate PP films such as multi-layer films or films including silica or other additives

Historical Observation of the Early Stage

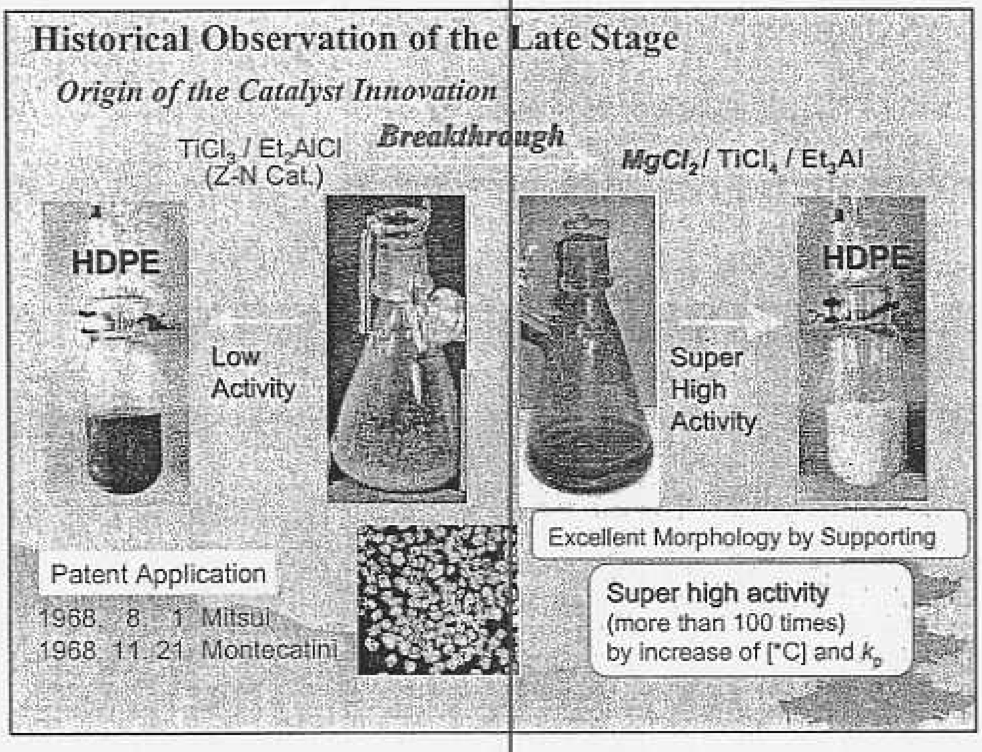
- Film Applications -

Example of PP usage in Japan





Catalyst Innovation changed the Stage.
PP production amount in Japan (tons/y)
5,000 (1962; Starting Year)
160,000 (1967)
560,000 (1972)
1,250,000 (1983)
1,900,000 (1990)
2,500,000 (1995)
2,700,000 (2001)
1960
1970
1980
1990
2000
Early Stage
Late Stage
Process and Product Innovations by HY-HS Cat. (early 80s)
(Montedison-Mitsui Collaboration)



Historical Observation of the Late Stage
Origin of the Catalyst Innovation
TiCl3 / Et2AlCl (Z-N Cat.)
Breakthrough
MgCl2 / TiCl4 / Et3Al
HDPE
Low Activity
Super High Activity
HDPE
Excellent Morphology by Supporting
Patent Application
1968. 8. 1 Mitsui
1968. 11. 21 Montecatini
Super high activity
(more than 100 times)
by increase of [*C] and kp

Historical Observation of the Late Stage

Catalyst Innovation

$MgCl_2/TiCl_4/Et_3Al$ → $ED/MgCl_2/TiCl_4/Et_3Al$

Atactic PP

Collaboration between Montedison and MPC since 1975

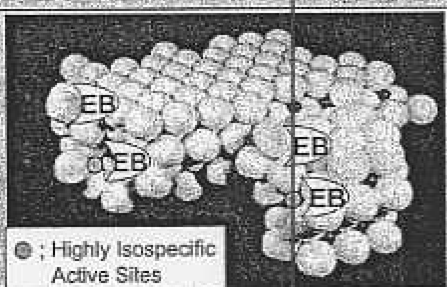
First Example of Catalyst Performance Control with Organic Compounds

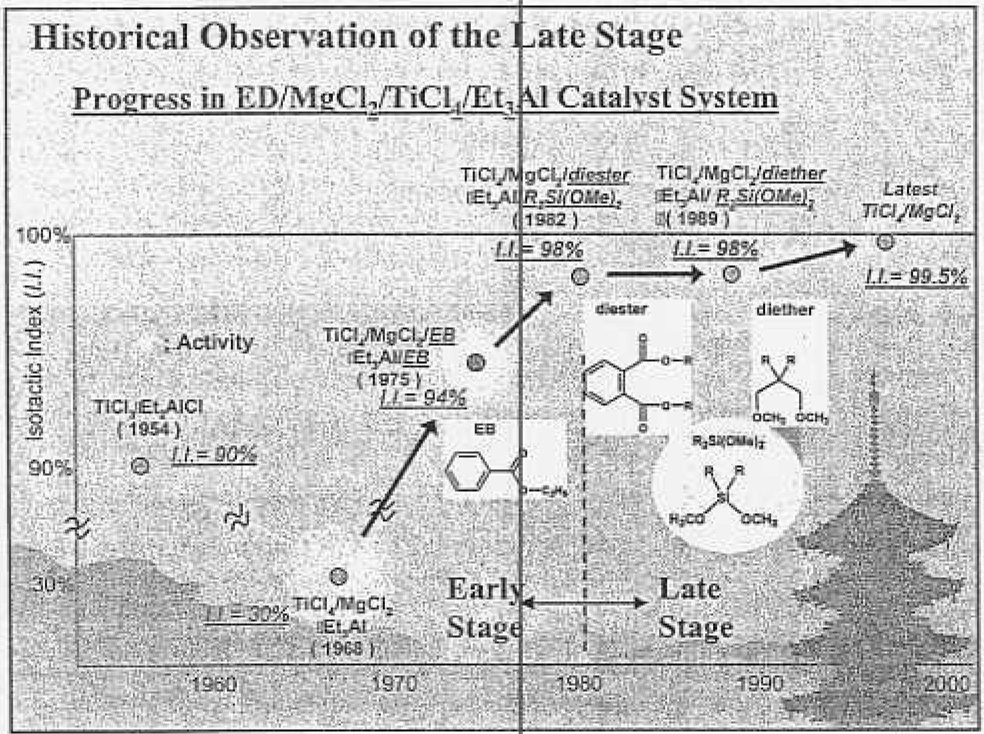
Isotactic PP

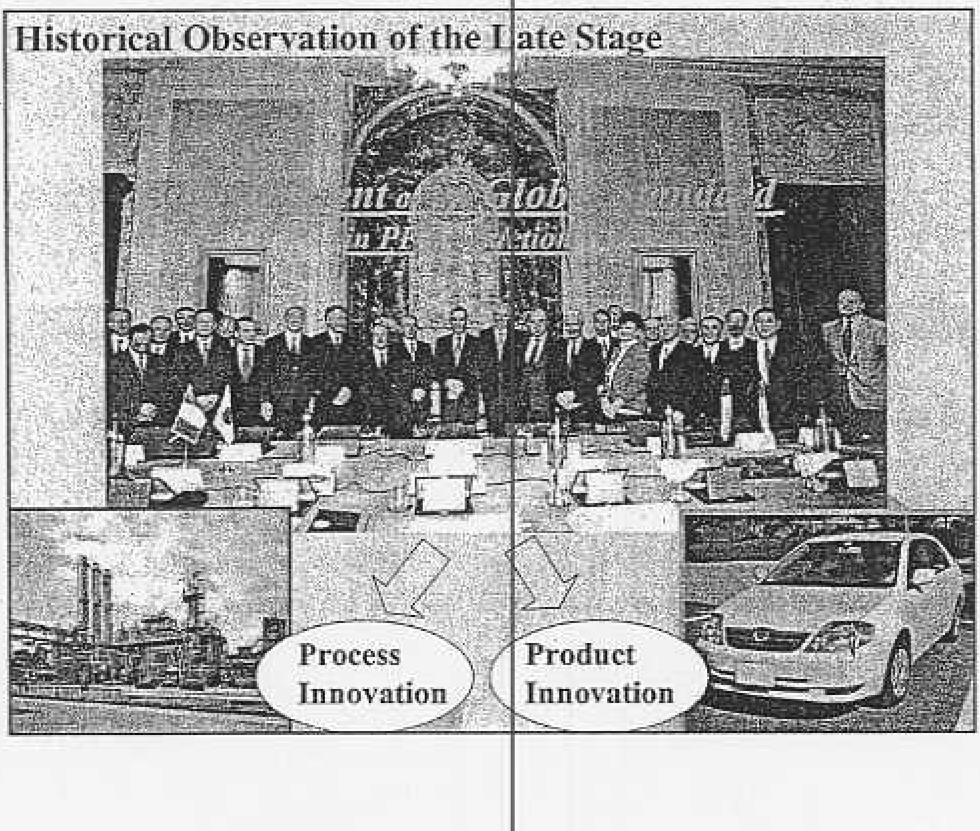
Historical Observation of the Late Stage

Effect of Electron Donor on the Active Sites

	$TiCl_3/Et_2AlCl$	$TiCl_4/MgCl_2$ /Et_3Al	$TiCl_4/MgCl_2/$*EB* /$Et_3Al/$*EB*
I.I.	90%	30%	94%
Specific Activity	1	250	140
Concentration of Active Sites [*C] (mol%[Ti])	0.2 - 0.63	**20 - 60**	**2.8**
Chain-Propagation Rate Constant k_p (L/mol/s)	2.5	**240 - 730**	**2700**



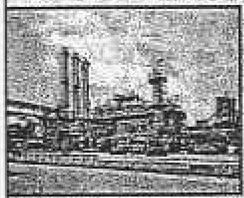

Historical Observation of the Late Stage
Progress in ED/MgCl2/TiCl4/Et3Al Catalyst System
TiCl4/MgCl2/diester /Et3Al/R2Si(OMe)2 (1982)
TiCl4/MgCl2/diether /Et3Al/ R2Si(OMe)2 (1989)
Latest TiCl4/MgCl2
100%
I.I.= 98%
I.I.= 98%
I.I.= 99.5%
Isotactic Index (I.I.)
: Activity
TiCl4/MgCl2/EB /Et3Al/EB (1975)
I.I.= 94%
diester
diether
TiCl3/Et2AlCl (1954)
I.I.= 90%
EB
R2Si(OMe)2
90%
30%
I.I.= 30%
TiCl4/MgCl2 /Et3Al (1968)
Early Stage
Late Stage
1960
1970
1980
1990
2000


Historical Observation of the Late Stage
Process Innovation
Product Innovation

Historical Observation of the Late Stage

Difference of MPC from Montedision

	same	different
Process	Continuous bulk-gas hybrid	Reactor design (Vessel reactors for many grades at small quantities)
Catalyst	$ED/MgCl_2/TiCl_4/Et_3Al$	Catalyst Particle Size (Smaller sizes for the process and well blending of PP powder with silica or other additives)



Japan is changing.

- Quality-Oriented Mindset
- Adoption of the Latest Technologies
- ~~Keiretsu~~
  Main PP users changed to global companies.
- Far from Western Countries
- High Humidity and Mild Climate
- ~~PP Growth linked with Growth of Japanese Economy~~
  Japanese Economy is in recession.
- ~~Little Competition in Asia~~
  Asian business is very Competitive.
- ~~Protective and Exclusive Policies by MITI~~
  MITI changed the policies.

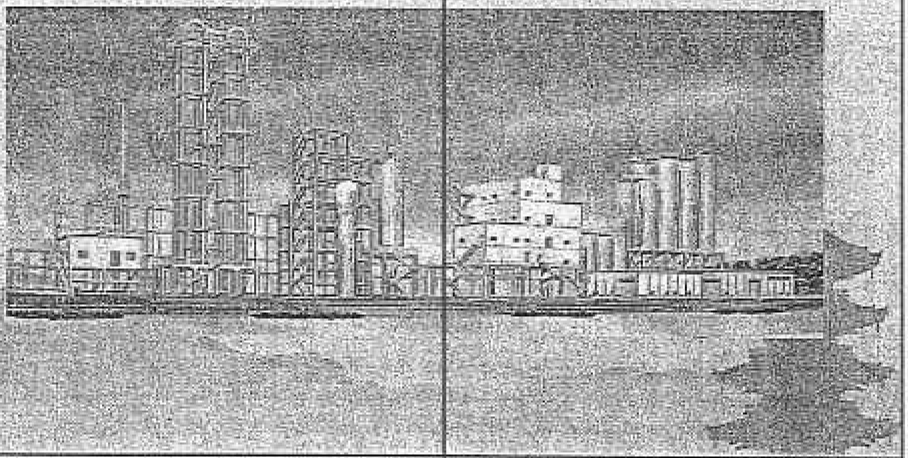
14 PP makers for 2.2 million t/y (1994)

⟶ 4 PP makers for 2.7 million t/y (2003)

Mitsui Chemicals is changing.

We are now constructing a **loop-type** PP plant in Japan.

300,000 t/y



Randy Woelfel,
President Basell International

Responsible for South America, Africa, Middle East and Asia-Pacific regions; Corporate strategy and development and Communications.

Randy's work in the polyolefins industry began in 1992 when he was assigned by Shell International Chemical Company, Ltd. as senior project manager of the multi-billion dollar merger project between Shell and Montedison.

For the merger, he managed all activities from conceptualisation to final implementation, including business plans and valuations through to launch communications and corporate identity development.

Montell (Basell's predecessor), the result of the Shell/Montedison "marriage", was launched in May 1995.

Randy then joined Montell International as SVP of Business Development where his team created five new polypropylene and advanced materials joint ventures that doubled Montell's business position in key international regions.

Following the formation of Basell in 2000, Randy was assigned to lead all of Basell's business and development activities in its international regions, and in 2003 he was given the additional responsibilities for Basell's corporate strategy and development and communications teams.

Prior to Montell, Randy worked in several positions for Shell Oil Company and Shell Chemical Company in the United Sates.

He began his Shell career in chemical technical sales (epoxy resins). Subsequent assignments included manufacturing management of a chemical intermediates area at Shell's Houston refinery/chemical complex, business management of a key chemical intermediates portfolio and leadership of planning activities for Shell USA in chemicals and oil products.

In the latter assignment, Randy became the team leader of a strategic review of the refining and oil products sector at Shell Oil in 1990. The recommendations of this broad-reaching study encompassed dramatic restructuring of Shell's business in the USA.

Just prior to the launch of the Montell merger project, Randy managed Shell's business development group.

Studies:
1981 - Master's degree in Management, Massachusetts Institute of Technology
MIT—Sloan School of Management. Boston, Massachusetts.

1977 - Bachelor's degree in Chemical Engineering, Rice University, Houston, Texas.

Randy Woelfel
President, Basell International

Polypropylene, a business without frontiers. The geographical expansion and Basell's role in its growth

Giulio Natta Celebration
Ferrara, Italy - 13 June 2003

Abstract

Basell and its predecessors have supported increasing world wide demand for polypropylene through the licensing of the company's proprietary *Spheripol* technology and the formation of a family of joint ventures with local partners around the globe.

This lecture focuses on the exceptional growth potential of polypropylene. The global demand for polypropylene has already reached 32 million of tonnes produced, with Basell technology representing about 50% of the total world-wide production capacity.

Basell's leading role in the polypropylene industry is fuelled by the company's premiere technology position and a pipeline filled with new technological platforms.

Polypropylene, a business without frontieres.
The geographical expansion and Basell's role in its growth

For more than four decades, the polypropylene industry has been an exiting and rapidly growing business and Basell, through its predecessor companies has been a key player in this success story. I will always remember my first visit here to Ferrara in 1993, when as a part of my site tour, I was shown the famous "Reactor monument" where polypropylene was first commercially manufactured in the 1950's.

From the beginning, Basell has been committed to technological innovation to create value for its customers and we have been committed to development on a global basis. This combination of innovation and globalisation have been very synergistic: by embracing both dimensions Basell has helped to shape both its own destiny as well as our industry. Today, wherever one is in the world, we encounter polypropylene as a common material in our everyday lives.

During my remarks, I will highlight the role Basell has played in this international development. Historically, through deliberate choices to make our technology available to outside companies, and to participate directly in global opportunities through a family of joint ventures, own investments and dedicated marketing teams, Basell has played a vital supporting role in building polypropylene to a 32 million ton worldwide industry today. As for the future, with its intrinsic balance of excellent price/performance characteristics, active innovation pipeline and continuing global development - polypropylene opportunities remain exciting. And we in Basell, intend to play our part.

Looking forward, my slogan would be: "it's the same story, only more so".
It is amazing when one looks at the spectacular speed by which the world has embraced polypropylene as a material of choice for convenience and value.

In particular, since the introduction of Spheripol in 1982, the time for 10 million ton increments of market development and demand growth has shrunk to only five years.
In the early years of Spheripol commercialisation, our strong pro-active licensing strategy greatly contributed to this dramatic growth - by making better polypropylene properties widely available to the global market at a much improved cost of production.

Future growth will come from a clear shift in global demand towards Asia, growing to 44 % of total demand in 2010 from 33 % in 1990. Basell's well established presence in this region, through a network of family joint ventures and an extensive representation network will ensure that tomorrow's innovations are brought into the market in a timely fashion.

It is also useful to study the per capita use of polypropylene world wide to confirm the remaining untapped potential for PP growth.
When compared to the developed countries, where PP per capita use exceeds 20 kg, there is no doubt that polypropylene will continue to expand internationally.
Developing economies like China or India, at less than 4 kg per capita, represent particularly important opportunities.

We know how important it is to be a part of this development. Being present in those developing countries via a strong manufacturing platform, an expert marketing and supply network, and strong customer relationships is absolutely critical to our future success.

Let's also reflect for a moment on the penetration of our technology in the polypropylene market.
Spheripol process technology and Basell's dedication to catalyst developments and innovations have played a key role in the international expansion of PP.
Basell technology today represents about 50 % of the total world wide PP capacity of 35 million tonnes; about half of our share is operated by Basell and our Joint Ventures and the remainder by our licensees.

Another important cornerstone of our international success has been the deliberate strategy to participate in the commercial growth of polypropylene via joint ventures. We believe joint ventures are the structure of choice in these markets, by combining local partner strengths with our own. By pooling resources, we have been able to leverage our market presence far beyond what Basell could have achieved on its own.

Our concept is a partnership approach on a long term basis, with the goal to be a leader internationally - in our target countries and market segments.

This global presence enables us to provide product/service and innovative solutions for our customers wherever they are based and whenever they choose to expand. Future growth will come from international development, so it is essential that Basell has a global network skilled at rapid commercialisation of new products and applications, with the genuine ability to deliver value to our customers.

Our ventures are our main face to this expanding market place, and through full and open exchange of knowledge and experience plus pro-active teamwork we are able to bring Basell effectively to customers worldwide through our Joint Venture Family.

Looking at our global position in 1995, Basell participated in 1,250 kton of PP with 5 joint ventures and one wholly owned company in Australia.

Based on our strategy to expand internationally primarily through joint ventures,

We have reached a capacity o f almost three million tons in our international Basell Family. And we will add an eighth PP joint venture early next year when SPC, a 450 kton PP complex in Saudi Arabia begins operations. This combined capacity places Basell in a clear leadership position in the growing markets of Latin America, the Middle East and Asia Pacific.

But production facilities in selected key countries are not enough. For Basell to drive our International strategy forward also requires us to be a viable supplier in many more country markets. So, our International Family also includes a network of dedicated commercial representatives who sell in more than 120 countries, supplying products from our Joint Ventures and from our European or North American assets.

This year marks the 30th anniversary of our first joint venture, TPP in Taiwan, and the 25th anniversary of our Brasilian venture, Polibrasil; milestones which clearly back up our philosophy of partnership on a long term basis.

And we have been active in global Spheripol licensing for almost 20 years, since we sold our first license in India.

Basell has genuinely lived its philosophy of long term partnerships, and commitment to the international commercialisation of technology innovation.

But the polypropylene story is far from finished. Happily, Basell's project pipeline is full of technological ideas and venture projects to support tomorrow's demands for enhanced Polypropylene performance and expanded, reliable supplies.

In summary, one can visualise Basell's continued commitment to PP development as a kind of wheel. It starts with ideas and significant research and development sponsorship. This leads to innovation that is brought to our Basell customers, through our family network. Third parties also get access to the technology and in turn help extend PP innovation for the benefit and convenience of more customers around the world. This results in an expanded market reach for the products and enhanced earnings to Basell so that we can re-invest the money in new innovations as well as in new joint ventures -- resulting in expanded supply capabilities. The learnings on this PP "circle of life" pathway result in new ideas for which we invest new R&D efforts and so the process continues to regenerate.

If we can keep this circle unbroken, we look forward with great anticipation to the next four decades of the Polypropylene story.

More of the same -- only more so !!

Thank you very much for your attention.

basell
Polyolefins

Polypropylene, a Business Without Frontiers : The Geographical Expansion and Basell's Role in its Growth

Randy Woelfel
Ferrara, 12-13 June 2003

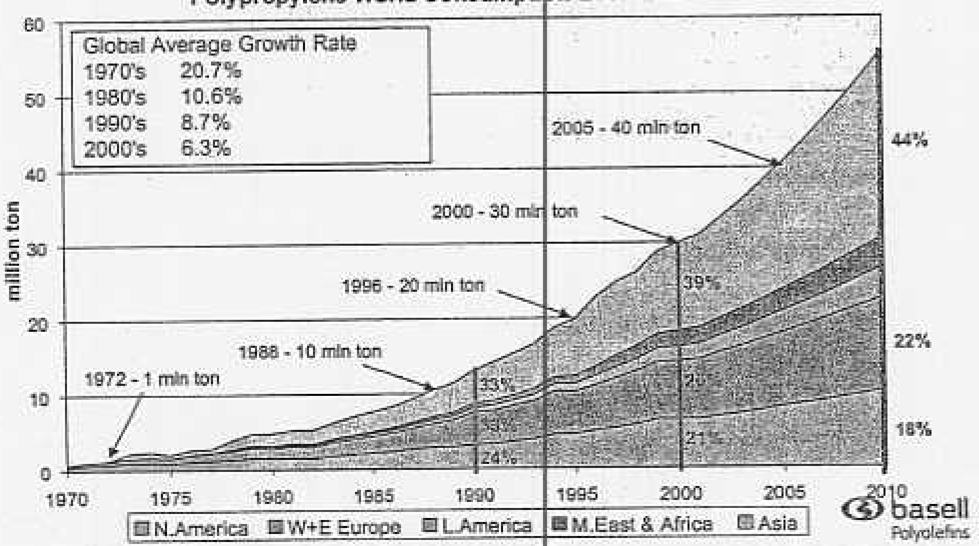
Story Line

- The Polypropylene "story" combines impressive, continuous innovation and global impact
- The Basell "story" echoes the same themes
- Global forces will increasingly shape Polypropylene's future
- Basell will be "on the field" as this plays out

basell
Polyolefins

PP demand keeps steady growth rate

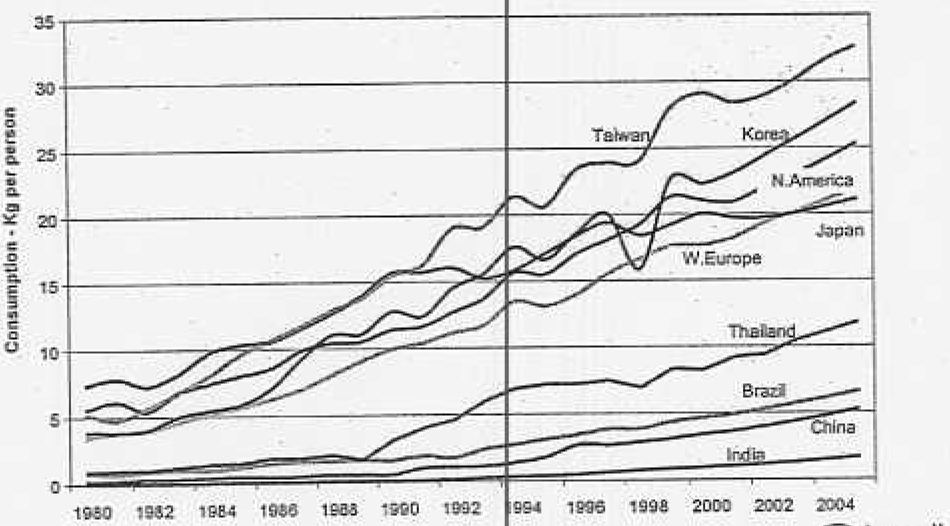
With Global Demand share shifting toward Asia



basell Polyolefins

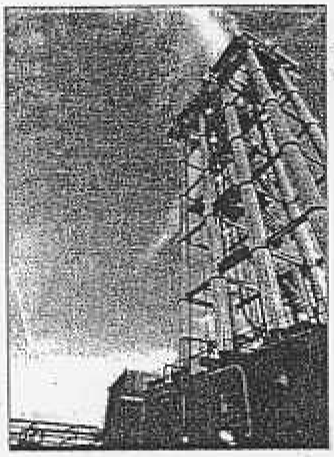
PP Per Capita Usage

Potential in Developing Countries



basell Polyolefins

The Role of the *Spheripol* process in PP Growth



- 15.7 million tonnes licensed capacity
- 50% of PP capacity
- 92 licensed lines
- 78 lines in operation

- Basell plays a key role in Innovation and its development Internationally

basell Polyolefins

Basell's Global Reach Through Joint Ventures

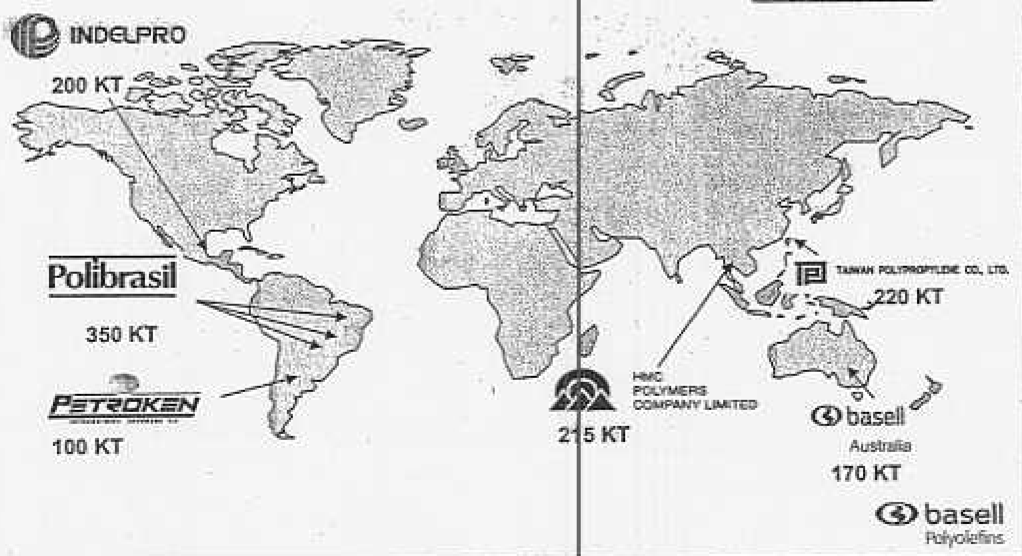
- Deliberate Strategy to participate internationally via JV's
- Partnership on long-term basis
  - Value brought to JV from all owners
- "Independence" and "mutual dependence"
- Strong mutual influence & collaboration
  - Marketing networking
  - Technology Innovation and knowledge exchange
  - Benchmarking and best practices
  - Personnel exchange

basell Polyolefins

Basell's Family

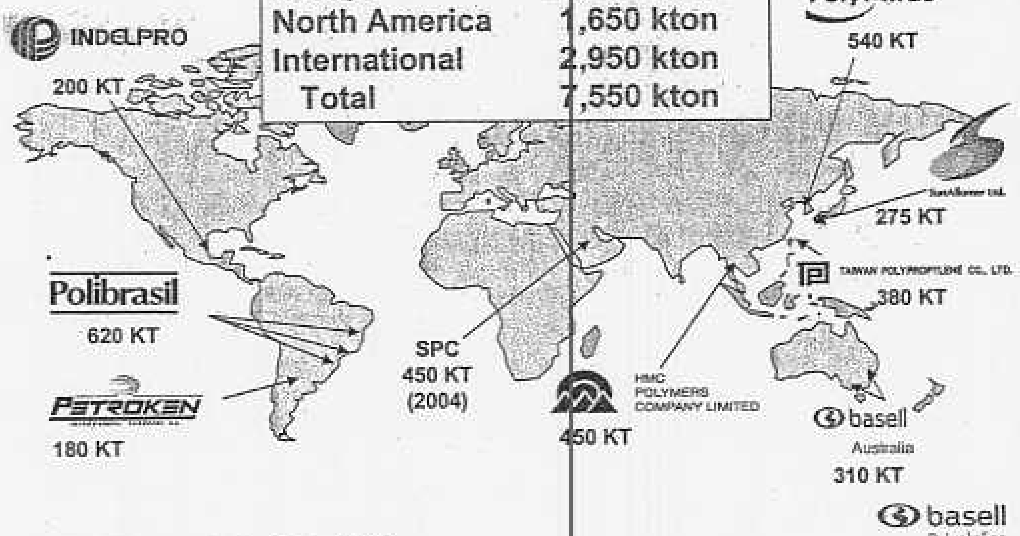
1995 Picture

1,250 kton



Basell PP Capacity in International and the World 2003

Europe	2,950 kton
North America	1,650 kton
International	2,950 kton
Total	7,550 kton



JV capacity at 100% nameplate. Excluding Catalloy and PCMA

Basell's Strong Geographic Diversification

Selling in over 120 countries
Producing in 18 countries

- → Global Polyolefins leader, both in terms of manufacturing & marketing
- → Network of partnership plus worldwide representation
- → Leading commercial presence in all major markets
- → Key OEM relationship plus position in selected market segments

● Production Sites

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Basell Internationalisation Milestones

1973	Creation of JV, TPP, Taiwan
1977	Creation of JV, Polibrasil, Brasil
1982	First *Spheripol* plant Montedison (Brindisi, Italy)
1984	First *Spheripol* licence to a third party IPCL (India)
1987	Creation of JV, HMC, Thailand
1988	Creation of JV, Indelpro, Mexico
1990	Creation of JV, Petroken, Argentina
1995	50th licensed line, reached 1 m tonnes licensed in Korea
1999	Creation of JV, Sun Allomer, Japan
2000	13 million tonnes licensed capacity reached 500 reactor-years with no major accident
2000	Creation of JV, PMC, Korea
2001	Creation of JV, SPC, Saudi Arabia
2003	New 300 kta *Spheripol* license operational at JV, Polibrasil
May 2003	15.7 million tonnes licensed capacity

basell Polyolefins

The Engineering Company, a key player in the industrialization step

Where does Spheripol come from

Allow me to open this short presentation with a very obvious statement:

Technological innovation usually develops within large corporations, which have the financial strength and strategic vision to sustain the difficult path that leads from the original idea to its industrial application, through the necessary research and development.

Montecatini had precisely this kind of creative corporate environment when, in the early 50s', its management understood the unique potential of the research made by Professor Natta on the stereo specific catalysis (the starting point of what later on became the Spheripol process) and supported its development.

Tecnimont was at that time the engineering division of Montecatini and had a key role in supporting the industrialization and the internationalisation of the available technological assets. **[- slide N.1-]**

Today such integration between R&D, production and engineering development phases is not easily achieved.

The cooperation between Basell and Tecnimont, therefore, remains one of the few cases where the common industrial roots have maintained and strengthened these synergies, contributing to the unique success of the Spheripol technology in the world.

Technology as a shared asset

It has soon been proven that a highly innovative Technology like Spheripol could have not been protected simply with Patent registrations.

Instead, the real defence of the leadership has been achieved through the sharing of the technology with the market: Montecatini and its successors (ultimately Basell) have been successful in converting a technological leadership into a worldwide business leadership.

Ironically, the more the Technology widens its range of licensees and applications, the more its value and leadership are strengthened.

A dedicated organization for the industrialization.....

Thanks to its close integration with the R&D steps, Tecnimont has been very successful in supporting the industrialization of the former Montecatini, and presently Basell, technologies.

In the process, our company has achieved a recognized world leading position as engineer in the field of Polyolefins and more specifically in Polypropylene. **[- Slide N. 2 -]**

This has been made possible through a dedicated organization, which integrates high technological and process expertise with specific engineering and procurement capabilities. **[- Slide N. 3 -]**

Through such an organization Tecnimont has been able to services which range from the Process Design up to the Plant commissioning and operation.

Feedbacks from Polypropylene operating Plants come not only from those Projects that we are managing worldwide but also through our Engineering Unit in Brindisi, which has been operated for many years within the Basell organization.

......and for the internationalisation of a winning technology.

Localization or, in other words, the need to match the specific requirements and standards in any Country where a new Project is developed, is a key factor in the business of Engineering Contractors.

The consistency with such specific needs does not represent a pure and simple working tool but shall become a natural tool and a cultural asset.

This "Cultural Sensitivity" has been the foundation for Tecnimont' s success in promoting Spheripol in new Countries like India, Russia, China, Iran and Latin America.

Such an attitude has then been integrated with a stable presence and monitoring of the market through a network of offices and subsidiaries.
[- Slide N. 4 -]
Spheripol represents a unique case in the industry and has become by far the world leading and most utilized technology.

We are proud of having provided our modest contribution to its success **[- Slide N. 5 -]**

Flexibility: a task for the future

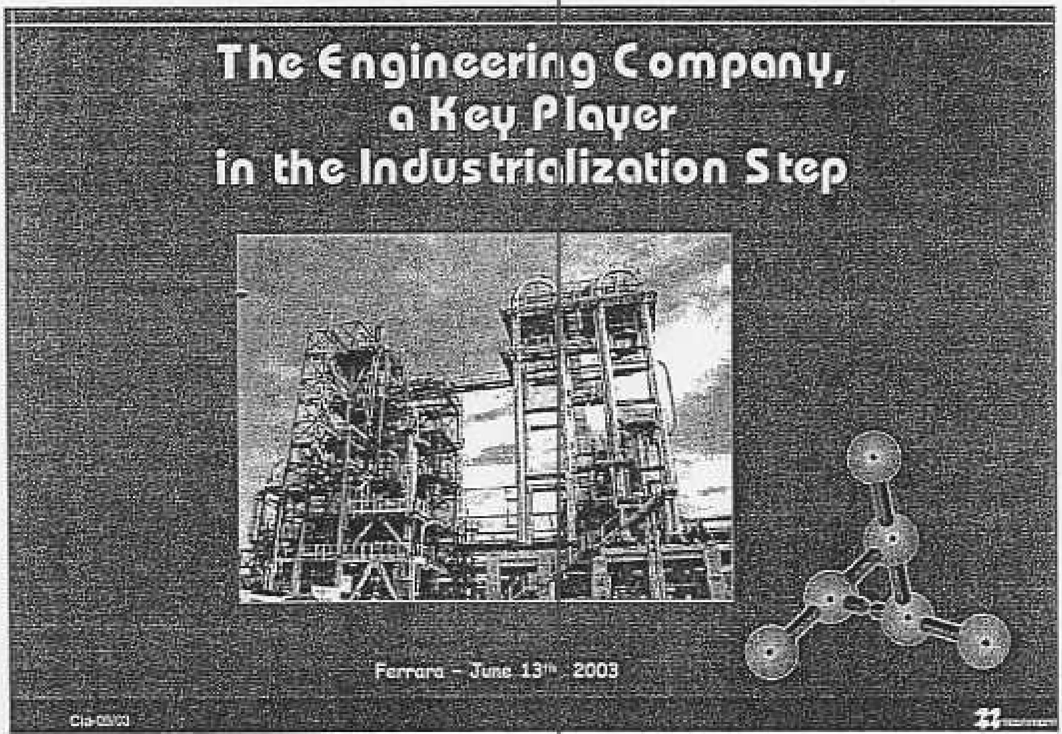
An investment decision today needs to be supported by exhaustive assessments involving product ranges and applications, value improvement practices (Capex optimisation), financing options and off-take prospects.

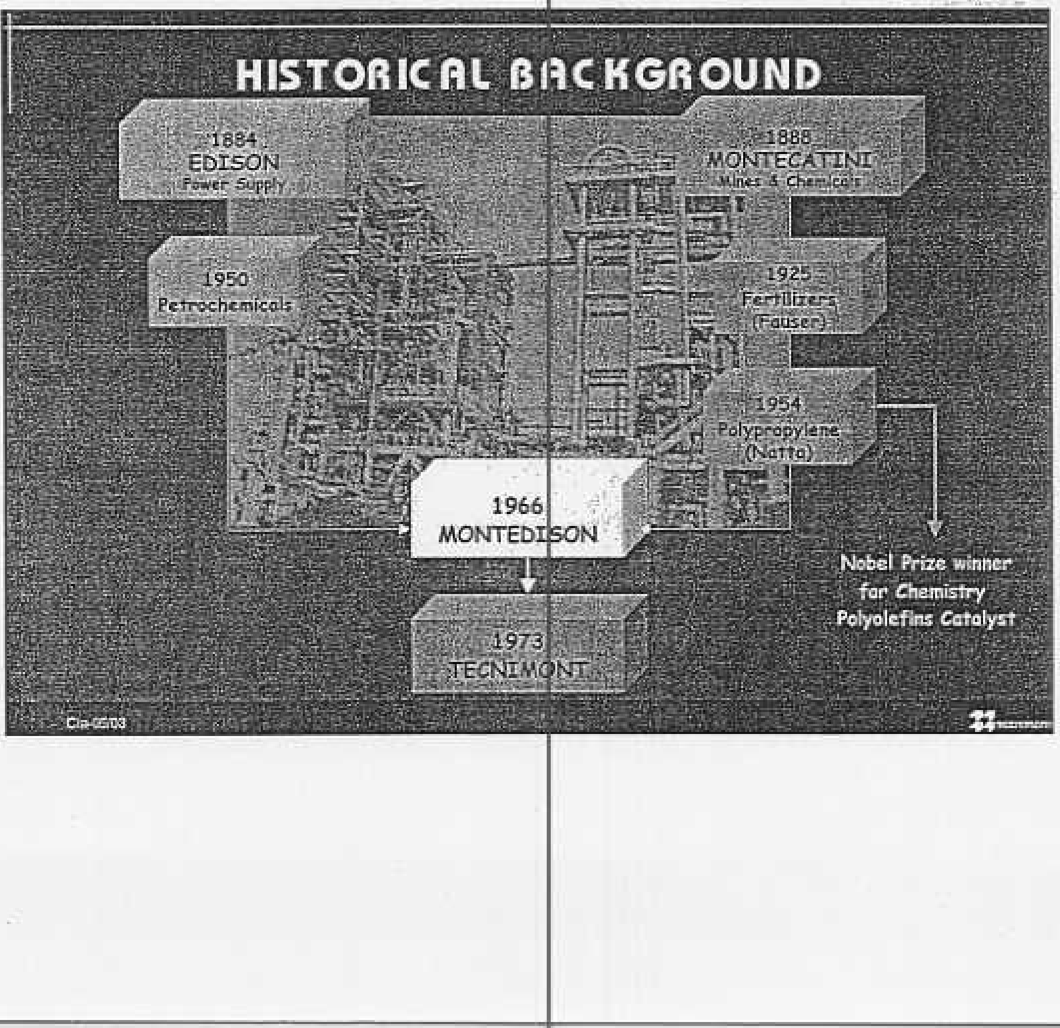
An Engineering Contractor, therefore, has to provide full interface to these requirements in order to support not only the technology selection but also the investment decision itself.

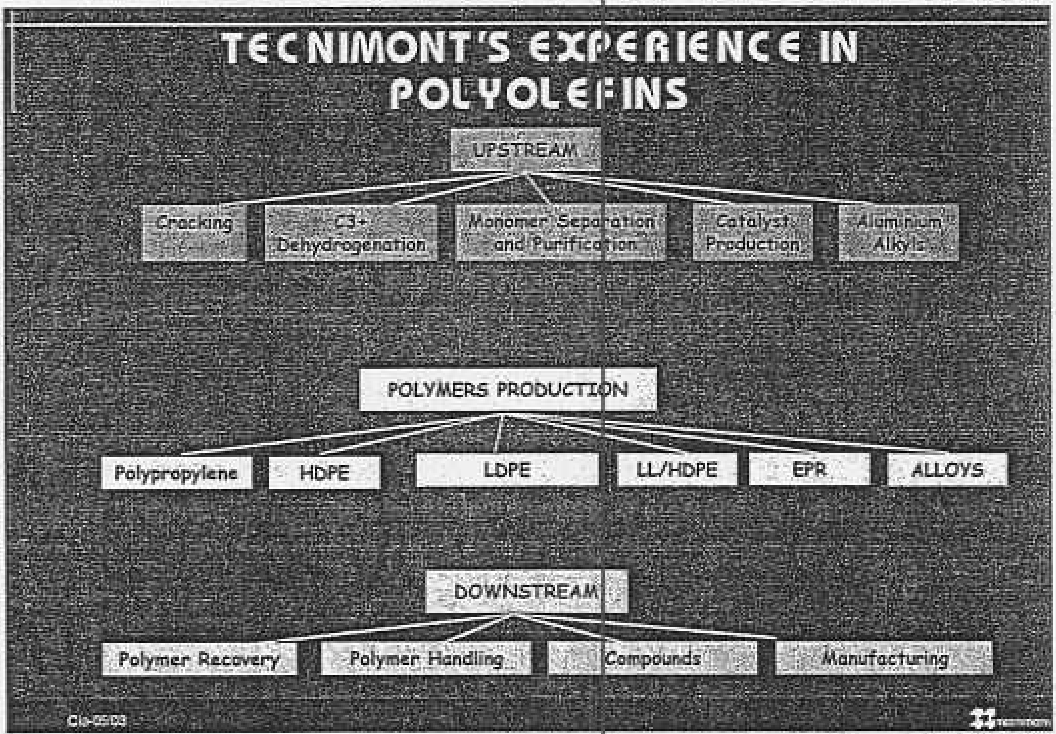
In this connection, Tecnimont' s rich experience and its long term relationship with Basell and its predecessors is the best guarantee for any potential Investor.

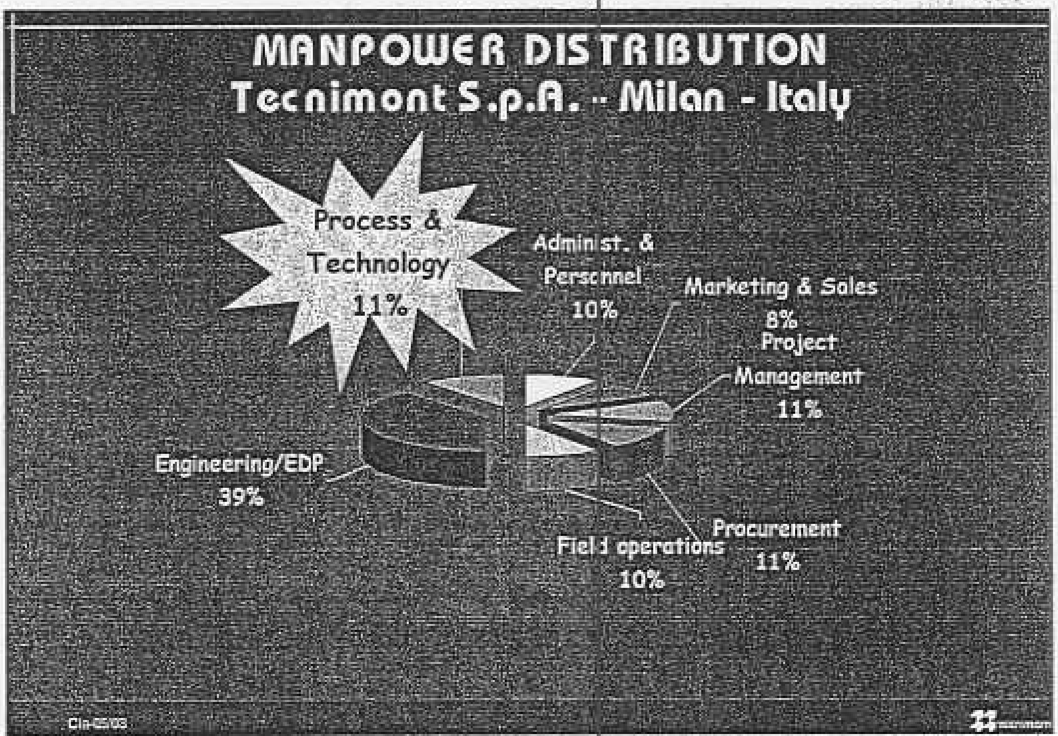
A long lasting relationship that grows and creates value

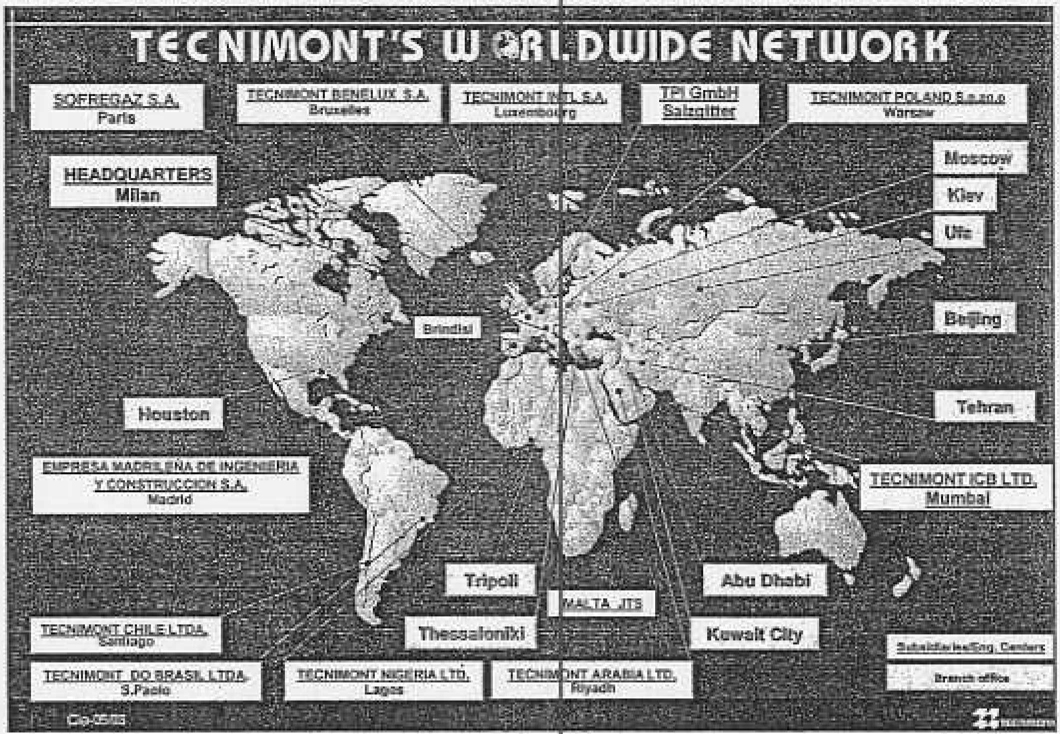
The cooperation between Tecnimont and Basell has become in itself an important and valuable common asset and we wish that it will continue to develop and strengthen in the years to come.

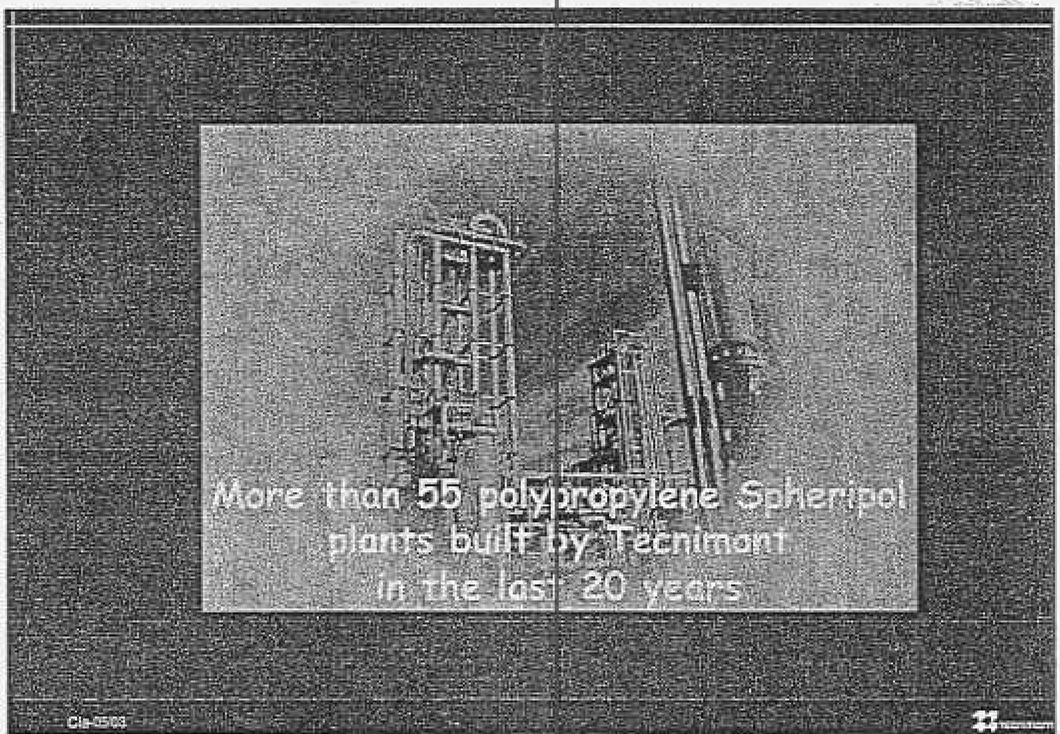

The Engineering Company,
a Key Player
in the Industrialization Step
Ferrara – June 13th 2003


HISTORICAL BACKGROUND
1884
EDISON
Power Supply
1888
MONTECATINI
Mines & Chemicals
1950
Petrochemicals
1925
Fertilizers
(Fauser)
1954
Polypropylene
(Natta)
1966
MONTEDISON
1973
TECNIMONT
Nobel Prize winner
for Chemistry
Polyolefins Catalyst


TECNIMONT'S EXPERIENCE IN POLYOLEFINS
UPSTREAM
Cracking
C3+ Dehydrogenation
Monomer Separation and Purification
Catalyst Production
Aluminium Alkyls
POLYMERS PRODUCTION
Polypropylene
HDPE
LDPE
LL/HDPE
EPR
ALLOYS
DOWNSTREAM
Polymer Recovery
Polymer Handling
Compounds
Manufacturing
Cla-05/03


MANPOWER DISTRIBUTION
Tecnimont S.p.A. - Milan - Italy
Process & Technology 11%
Administ. & Personnel 10%
Marketing & Sales 8%
Project Management 11%
Engineering/EDP 39%
Procurement 11%
Field operations 10%
Cla-05/03


TECNIMONT'S WORLDWIDE NETWORK
SOFREGAZ S.A.
Paris
TECNIMONT BENELUX S.A.
Bruxelles
TECNIMONT INTL S.A.
Luxembourg
TPI GmbH
Salzgitter
TECNIMONT POLAND S.p.zo.o
Warsaw
HEADQUARTERS
Milan
Moscow
Kiev
Ufa
Brindisi
Beijing
Houston
Tehran
EMPRESA MADRILEÑA DE INGENIERIA
Y CONSTRUCCION S.A.
Madrid
TECNIMONT ICB LTD.
Mumbai
Tripoli
Abu Dhabi
MALTA JTS
TECNIMONT CHILE LTDA.
Santiago
Thessaloniki
Kuwait City
Subsidiaries/Eng. Centers
TECNIMONT DO BRASIL LTDA.
S.Paolo
TECNIMONT NIGERIA LTD.
Lagos
TECNIMONT ARABIA LTD.
Riyadh
Branch office
Cio-05/03


More than 55 polypropylene Spheripol
plants built by Tecnimont
in the last 20 years
Cio-05/03

Marco Bergaglio

Piber Group
Sales Managers

Education:
Graduation in Economics.
Bocconi University, Milano

Additional information:
After a one year experience in a financial company, he jointed Piber Group in 1992, as a sales assistant for the plastic packaging sector.

In 1995 he jointed the Board of Graziano Macchine Utensili, with the responsibility to built up the Sales department, the International Distribution Network and the marketing strategy.
The challenge was very hard as the machine tool market is one of the most competitive. The goods results achieved by the company in the following three years were noted by a big player of the market, quoted at the Stock Exchange, that bought the company in 1998.

In 1999 he took the responsibility of Sales Department in Piber Group, developing the export sales in the EC and Canada.

He is a Member of the Board of Entrepreneur Associations of Pavia

Marco Bergaglio
Sales Manager, Piberplast

The inroad of polypropylene into the rigid packaging industry

Giulio Natta Celebration
Ferrara, Italy - 13 June 2003

Abstract

This lecture focuses on the excellent progress polypropylene has made in the packaging sector, as experienced by Piberplast, a leading company in the European packaging market. It compares the utilisation of polystyrene and polypropylene, which was introduced in Piberplast in 1973.

Thanks to its intrinsic properties, polypropylene has emerged as the strategic raw material for Piberlplast's rigid packaging business. After initial processability and purity issues were overcome with costly conversion techniques and expedients, the potential of polypropylene as a material for packaging was quickly realised.

The advent of the *Spheripol* process in the early 1980's significantly contributed to solving the issues linked with polypropylene's first generation technology and Piberplast was able to take full advantage of the new and improved polypropylene products.

Polypropylene has now replaced polystyrene in a wide range of sophisticated packaging solutions provided by Piberplast, whose customers include such highly regarded food companies as Unilever, Nestlé and Galbani.

The inroad of polypropylene into the rigid packaging industry

Established in 1959 by P.A.B., Piberplast began its history with the production of packaging using plastic materials initially in the pharmaceutical market, and then quickly developed into the food market during the first few years.

The raw materials used in those years were essentially CRYSTAL POLYSTYRENE, SHOCKPROOF POLYSTYRENE and POLYETHYLENE, which were used for the caps and lids shown above.

CONTENITORI PER PRODOTTI ALIMENTARI

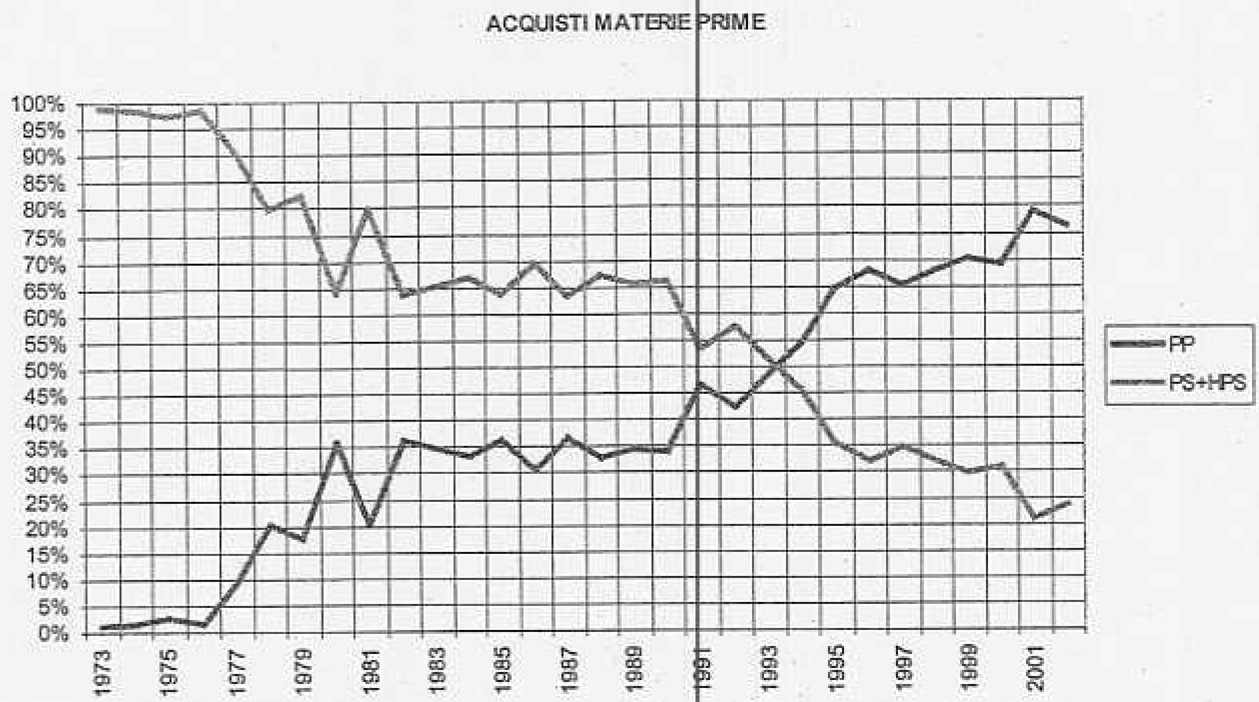
La Ditta Piberplast di Pontecurone - Alessandria, da molti anni stampa materie plastiche e si è specializzata in modo particolare nella produzione di contenitori di ogni forma, tipo e dimensioni per l'imballaggio di prodotti alimentari e affini. Nella figura alcuni campioni della produzione Piberplast.

Estratto da "Tecnical News" del 9-10-1967

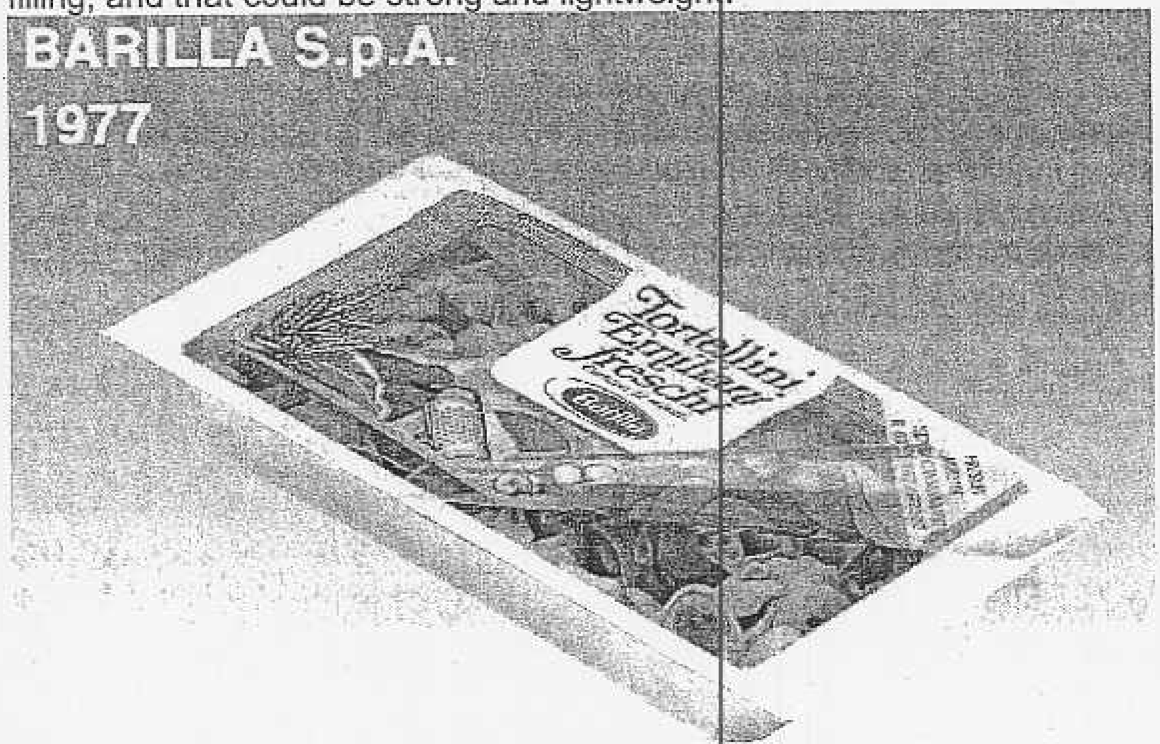
Between the end of the 1960's and the beginning of the1970's, the demand for plastic packaging increased considerably, thanks both to the increase in consumption (economic boom), and to the peculiar characteristics of the plastic packaging such as lightweight packaging, resistance to aggressive ingredients, shape flexibility, ability to personalise the packaging).

With the tensions in the oil market that were taking place in 1973, Piberplast started to do the first tests on polypropylene, with an annual consumption that went up to 250 tons.
Some aspects were immediately clear:

- On one side it was necessary to reconsider many of the production methods used up until that point (mould engineering and materials, type and power of the injection moulding machines, packaging decorating methods, etc.)
- But, at the same time, the promises of the new material were very encouraging in terms of food contact and physical characteristics of the products.

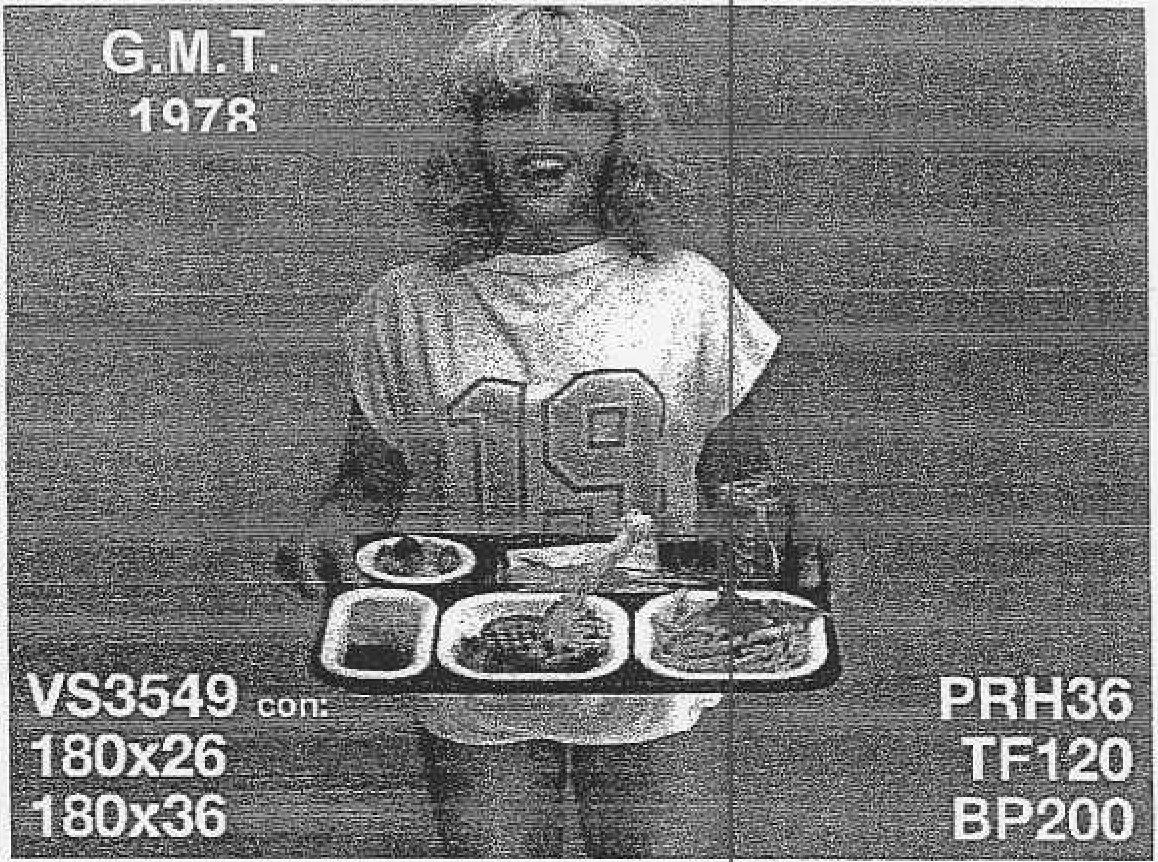


The first large scale production was in 1977, when, a tray for Barilla was manufactured with a range of characteristics that made it particularly innovative. As a matter of fact, thanks to polypropylene it was possible to manufacture a tray with an optimal steam barrier that could be thermo-sealed with an easy-open peelable film, that could bear a sanification process in warm conditions after the filling, and that could be strong and lightweight.



240 H 33

During those years, the public catering business discovered the potential of polypropylene, above all its lightness, the durability, its easy opening and sealing and the possibility of refrigerating and heating up to 120°C.

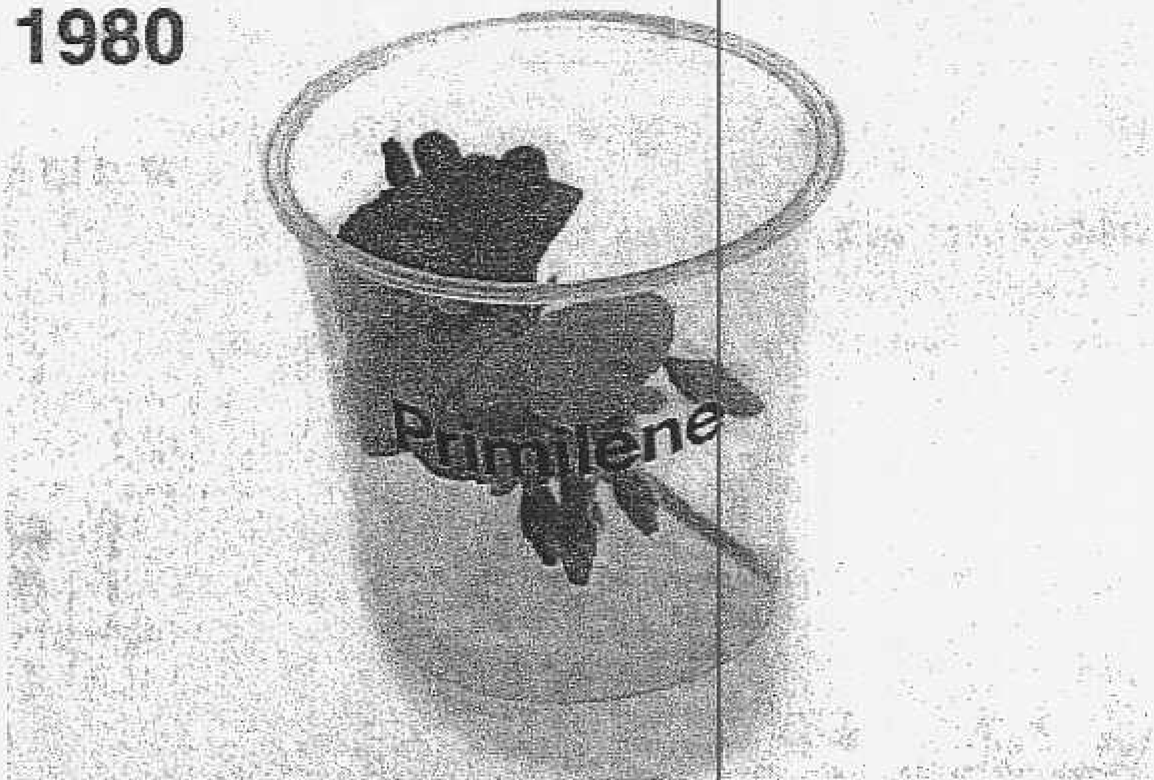


In only 3 years (78's – 80's) there followed a range of new applications for some very prestigious customers (MOTTA, SANSON), who took the percentage incidence of the polypropylene consumption in Piberplast from zero up to 35%.
It was a very fast and steep evolution if we think that in those years polypropylene could offer innovative and interesting features, but very disappointing colour, smell, purity, firmness and workability processability characteristics.
Piberplast found itself in the position to need to develop production techniques and expedients that, somehow had to provide an improvement in these new packs.
In particular, PP had to undergo a "DEGAS" phase before the injection.
Further, in order to obtain products with thin walls and good characteristics of dimensional stability, it was necessary to proceed with a compression of the mould which had to follow on immediately from the injection phase, thus complicating and slowing down the cycle time.
The machines generally used in the production of polypropylene components were not really suited for this material, above all for their power characteristics in the injection phase.

Despite these technical difficulties, excellent results could be achieved by introducing packaging with innovative characteristics: see, for example, this packaging in transparent PP produced in 1980, initially manufactured in crystal polystyrene, which is well-known for its fragility and brittleness.

CAMPAGNA PUBBLICITARIA SUL PP TRASPARENTE

1980



Other prestigious customers benefited in the following years from the potential of polypropylene, such as in the case of Galbani, who have since 1981 been using PP for ricotta and mascarpone cheese packaging with hot filling.
Or indeed like Unilever Italy (Van Den Bergh) who prefer PP for its excellent behaviour when in contact with fats.

MU 250 con **104 ASS**

The consumption of PP in Piberplast during the 80's increases at absolute value, but not yet in percentage value in comparison with the other raw materials which grow in line with that of general market expansion.

The first generation of PP had opened the way, had enabled a significant range of applications where some particular characteristics gave some reward, but we can say also despite some still obvious limits.

Only at the end of the 1980's did the market data outline the importance of the technological jump of the *Spheripol* technology.

The possibility to control the polymerizing processes and the use of the high yield catalyst removed the limits of the first generation PP, by opening the way to a distribution of consumption with an unstoppable growing cycle, that during the19 90's enabled the consumption incidence of PP to 80% of the total polymer requirements.
Practically speaking, within 20 years, polypropylene material has replaced polystyrene.

The years of delay between the scientific evolution (*Spheripol*) of 1982/83 and the upturn of the substitution rate PP/PS (1991) are physiological, above all when, to this replacement are tied many elements such as: necessity of new investments in moulds, injection and offset printing machines, needs to modify the food packaging lines, sealing films improvements, etc.

So, starting from the 1990's, almost all the packaging has been projected and realized in polypropylene, thanks, above all, to a wide range of PP now available (in terms of fluidity, form, transparency, resistance to low temperatures, etc.)

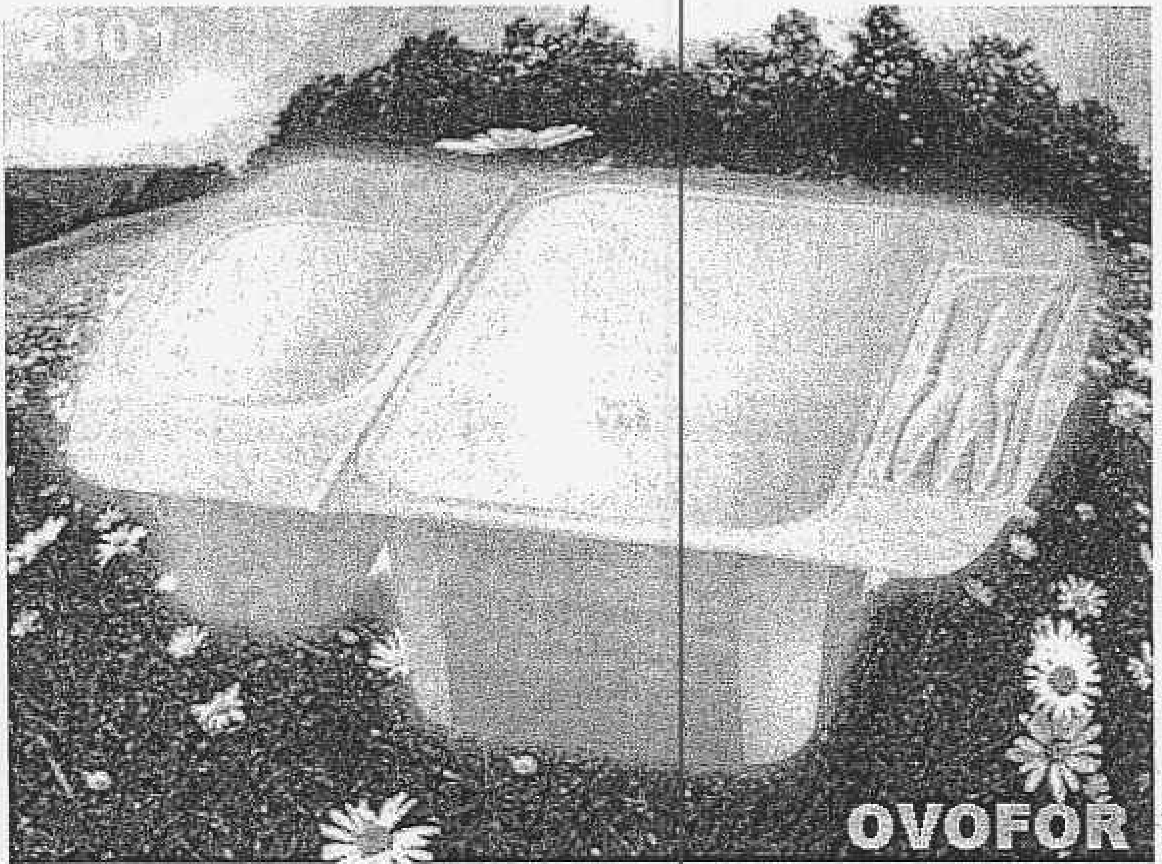
The examples would be never-ending and I just quote the most representative ones: in '99 for UNILEVER in the ice cream market, with the transparent tub CARTE D'OR, one of the European previews of Piberplast.

In 2000 for NESTLE, the realization of a two-colour re-usable container.

ITBIC 1 con **CITBIC**

In 2001 for GALBANI, the realization of a container in PP, oval-shaped and completely covered by a polypropylene label.

Today, materials and converting technology enable the proposal of solutions that differentiate the product and offer a service to the consumer.
Like in the case of this packaging, that incorporates in only one unit and single production process, cutlery that is removable and hygienically protected during the distribution phases.



Or like this packaging that presents a handle that is integrated in only one unit and production process, but removable when needed for use.

Dated 2003 the tub for Nestle with an integrated tamper evident system

As well as an application for the margarine sector that has enabled the integration in only one packaging of extreme characteristics of lightness (a winning result compared to the thermoforming process), freezing resistance, IML decoration on the lid, production in sterile conditions.
Once more PP has enabled the formulation of a suitable answer to the precise demands of the customer, that are really unachievable with other alternative materials.


VEDIAL S.A.
2003
FRANCIA
St Hubert
41
DEMI-SEL
au sel de mer
St Hubert
41
VED500 + COVED

G. Natta
Celebration Event

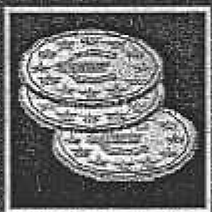
The inroad of Polypropylene into the rigid packaging industry

Marco Bergaglio - Sales Manager

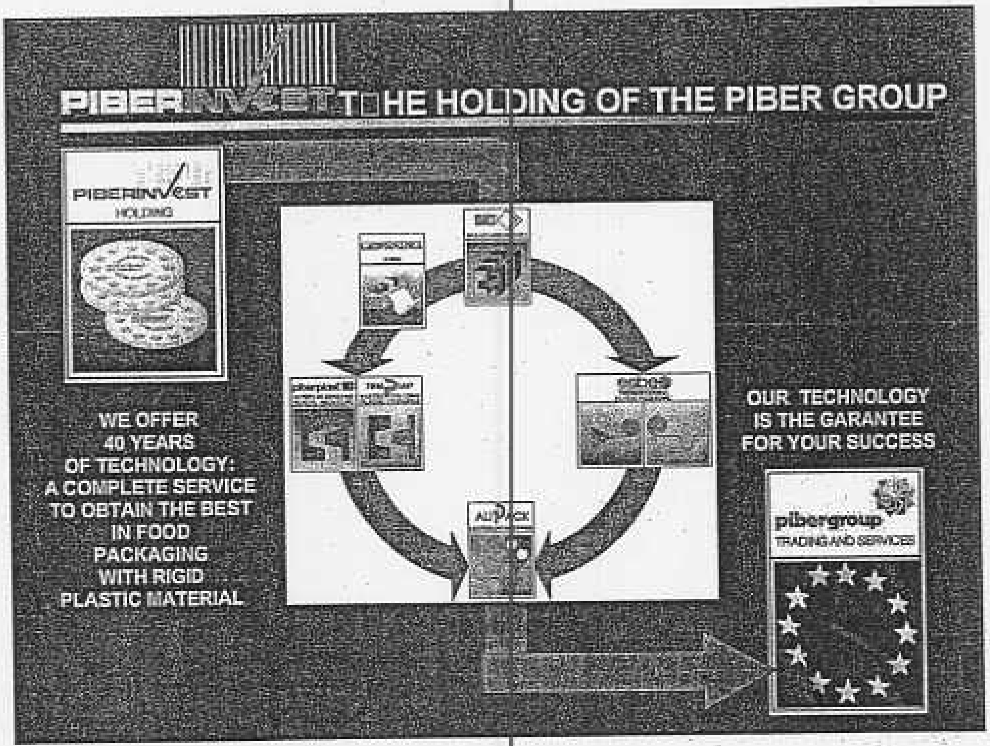
Ferrara, 13 June 2003

PIBERINVEST THE HOLDING OF THE PIBER GROUP

- PIBERINVEST S.p.A., having its legal seat in Voghera (Pv), is the holding company that controls the societies of the Piber Group. The Group is made up of 10 companies, with about 600 employees.
- The plants cover an area of 250.000 sq.m, of which about 50.000 sq.m are covered.



- The consolidated gross turnover of the PIBER GROUP on the year 2002 was about 79,9 million Euro.
- 90,4% of this turnover comes from the activity of rigid and semi-rigid packaging, 3,3% from packaging engineering and 6,3% from services.
- The PIBER GROUP produced in 2002 n° 1,06 milliard of packagings and lids, transforming about 15.000 tons of plastic material.


PIBERINVEST THE HOLDING OF THE PIBER GROUP
PIBERINVEST
HOLDING
WE OFFER
40 YEARS
OF TECHNOLOGY:
A COMPLETE SERVICE
TO OBTAIN THE BEST
IN FOOD
PACKAGING
WITH RIGID
PLASTIC MATERIAL
OUR TECHNOLOGY
IS THE GARANTEE
FOR YOUR SUCCESS
pibergroup
TRADING AND SERVICES

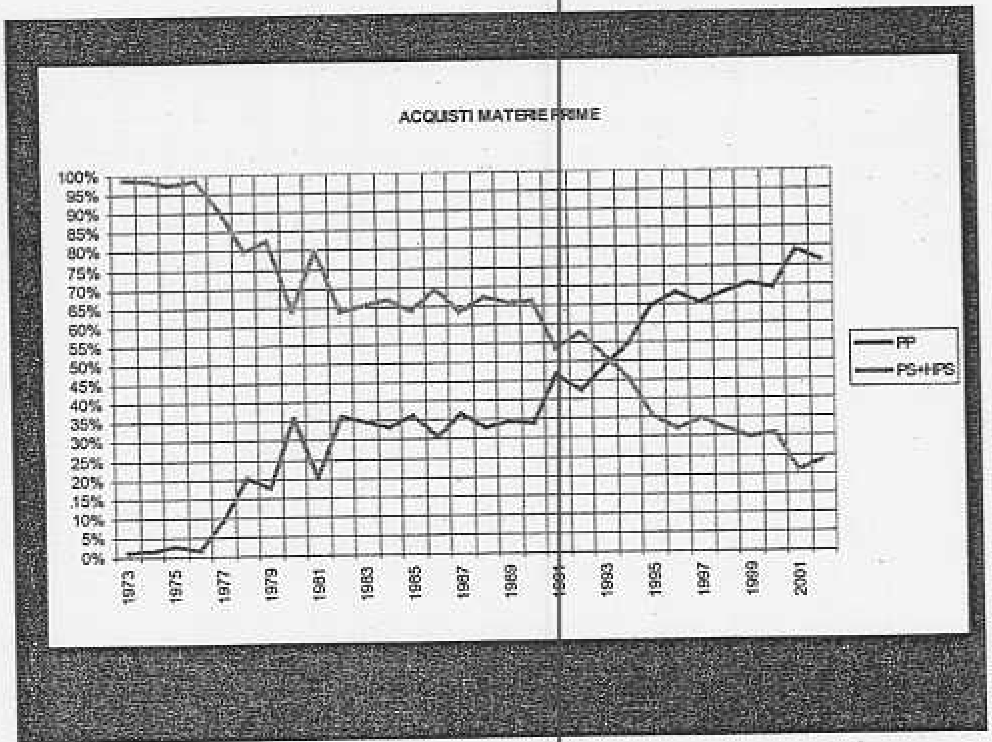

PIBERINVEST OUR TOP 10 CUSTOMERS YEAR 2002
1° NESTLE' Group
2° SAMMONTANA
3° GALBANI
4° UNILEVER Group
5° ESKIGEL
6° PARMALAT Group
7° BESNIER-LOCATELLI
8° A-27
9° KRAFT
10° UNIPLASA

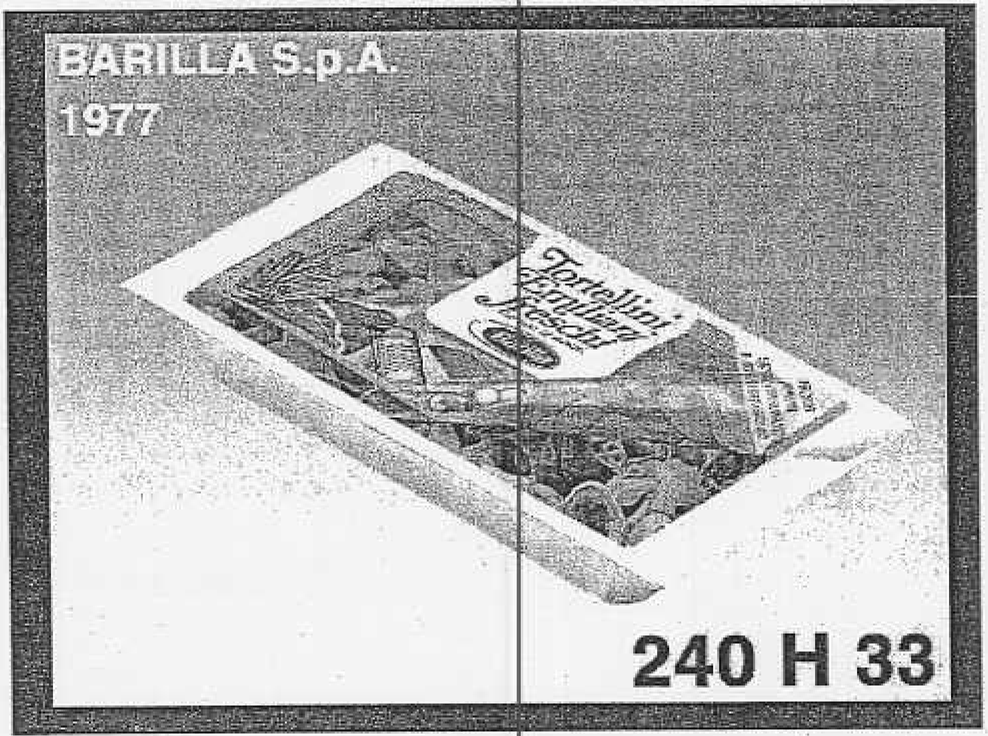
CONTENITORI PER PRODOTTI ALIMENTARI

La Ditta Piberplast di Pontecurone - Alessandria, da molti anni stampa materie plastiche e si è specializzata in modo particolare nella produzione di contenitori di ogni forma, tipo e dimensioni per l'imballaggio di prodotti alimentari e affini. Nella figura alcuni campioni della produzione Piberplast.

Estratto da "Tecnical News" del 9-10-1967

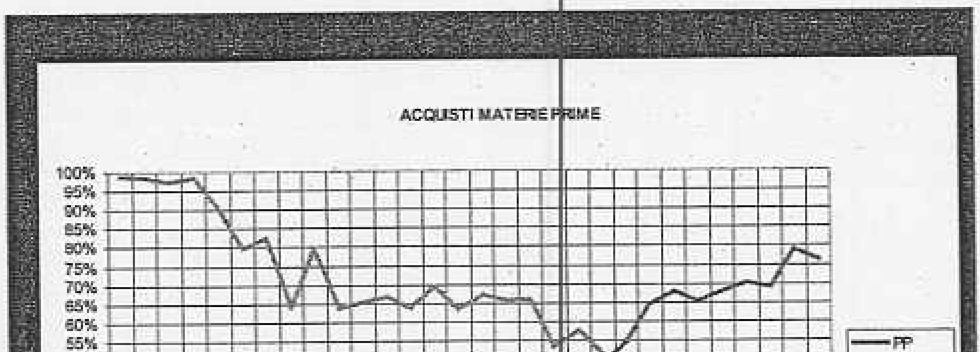

Gli anni che vanno dal 1965 al 1975 è importante rilevare che in Italia si verifica un grande consumo di Yogurt e gelati da passeggio e la piberplast è stata certamente una protagonista in questo settore producendo milioni di vasetti stampati ad iniezione con sovrastampa in offset a 4 colori.


ACQUISTI MATERIE PRIME
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
PP
PS+HPS


BARILLA S.p.A.
1977
Tortellini
Emiliani
Freschi
240 H 33


G.M.T.
1978
180x36
180x26

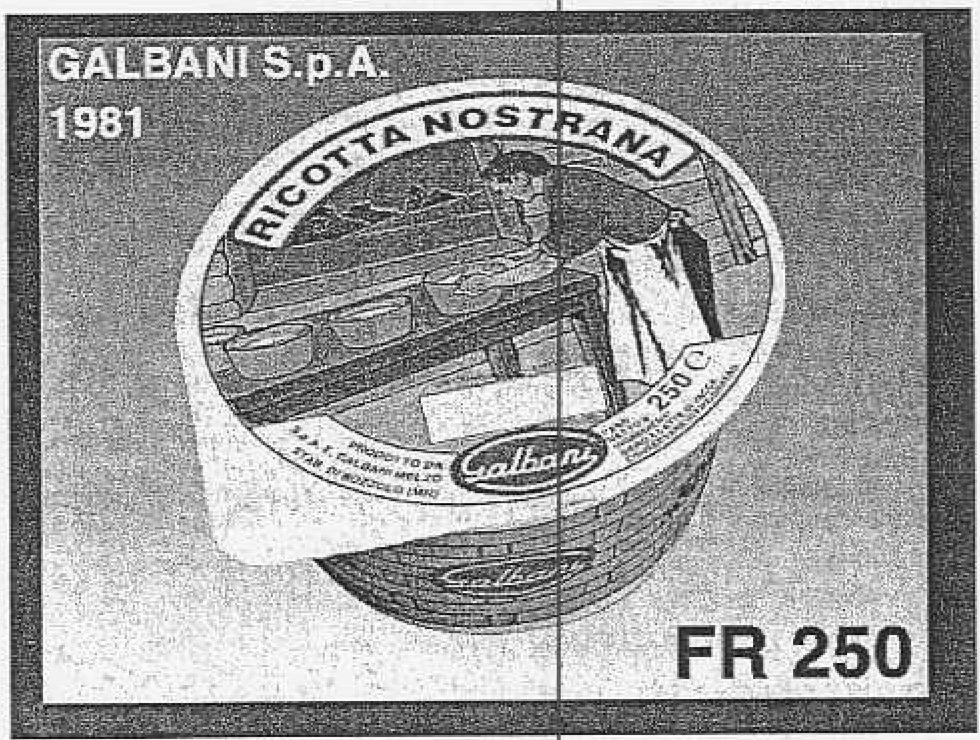

G.M.T.
1978
VS3549 con:
180x26
180x36
PRH36
TF120
BP200


ACQUISTI MATERIE PRIME
PP
PS+HPS

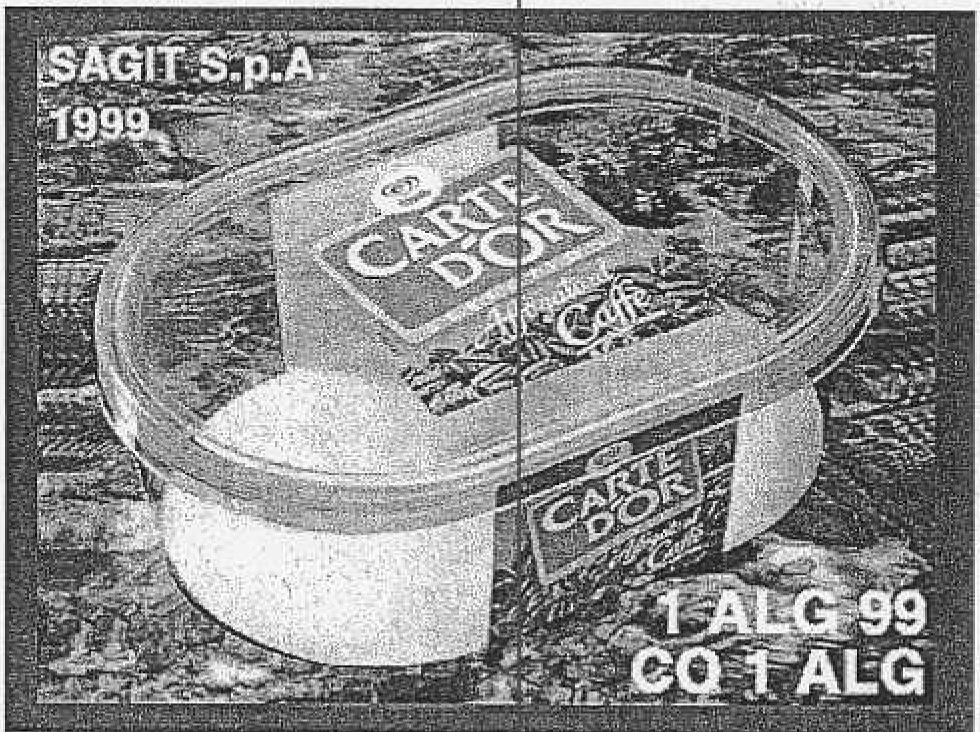

MOTTA - SIDALM S.p.A.
1978
Marrons Glaces
in pezzi
Motta
MO 720


GELATI SANSON S.p.A.
1978
PP 700 (IML)
con LID 111


CAMPAGNA PUBBLICITARIA SUL PP TRASPARENTE
1980

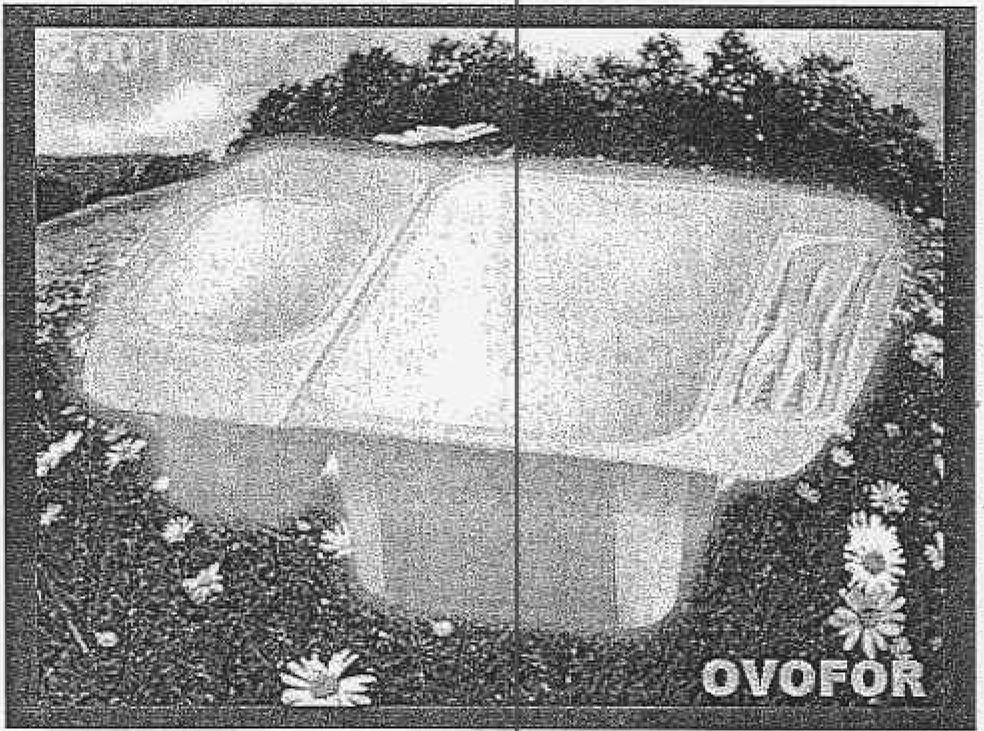

GALBANI S.p.A.
1981
RICOTTA NOSTRANA
Galbani
250 G
FR 250


UNIL-IT DIV.VDB S.p.A.
1981
Rama
ancora più buona
MARGARINA
MU 250
con
104 ASS

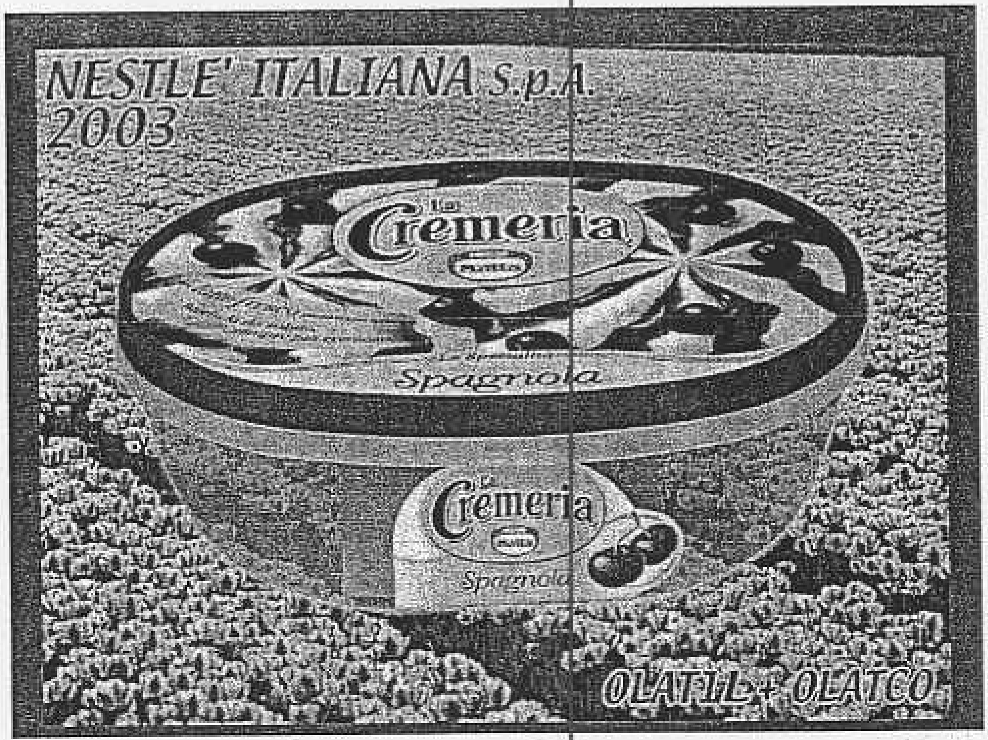

SAGIT S.p.A.
1999
CARTE D'OR
Caffè
1 ALG 99
CO 1 ALG


NESTLE' ITALIANA S.p.A. DIV.ITALGEL
2000
ITBIC 1
con
CITBIC


GALBANI EGIDIO
2001
NOVITA
Galbani
L11H40


OVOFOR


ILC MANDARA S.p.A.
2002
MOZZARELLA
DI BUFALA
CAMPANA
D.O.P.
GE100M con 123PPT


NESTLE' ITALIANA S.p.A.
2003
Cremeria
Spagnola
Cremeria
Spagnola
OLATIL + OLATCO

Dario Beltrandi
General Manager,
Beverage & Packaging
Division, SACMI IMOLA

Education:

Graduation in Mechanical Engineering, Bologna University.
Management Development Program, Bocconi University, Milan.

Additional information:

In parallel with the University studies, he joined TECNO F1 racing team in Borgo Panigale, Italy for three years in designing racing cars.

In the middle 70s he worked as a free-lance mechanical design engineer consultant.

In 1976 he joined SACMI and he was given the responsibility to lead a project of automatic machines for ceramic tiles handling system in the Ceramic Division.
In three years he gave an important contribution to the automation of the ceramic tiles process manufacturing.

In 1979 he was appointed Technical Director of the newly born Packaging Division of SACMI Imola.

In one decade, he has developed new processes and systems to produce metal, aluminium and plastic caps and, in this field, he contributed to file some important patents that still are the heart of the current business.
During this period, he wished to have continuous contacts with the market that he considers the source of the company guidelines.

At the beginning of the 90s he was nomitated Vice-General Manager of Packaging Division in SACMI, taking care of the coordination of engineering department with the marketing and production and his management experience increased too.
In this position he gave a strong thrust to the development of the compression moulding technology.

In 1999 he was appointed General Manager of the Beverage & Packaging Division of SACMI Imola.
In the last four years the business has expanded to new areas such as process control systems, fruit quality control systems, PET containers, etc. and the closure business has increased significantly.

Today thanks to the internal expansion and many aquisition SACMI has become a major Group including many companies in the beverage, food and packaging industry.

He is currently a member of the Board of Directors in NEGRI BOSSI, Cologno Monzese, a company listed in the Stock of Exchange in Milan.

He is Vice President of BM Biraghi, Monza.

He is President of the shareholders board of RAYTEC VISION, Parma and is also a member of the Shareholder board in in SACMI LABELLING and SACMI FILLING.

He is also President of FARO INNOVISION, Haifa Israel.

Dario Beltrandi
General Manager,
Beverage & Packaging Division,
SACMI IMOLA

Polypropylene & Compression Technology
A successful case history

Giulio Natta Celebration
Ferrara, Italy - 13 June 2003

Abstract

We can confirm that the discovery made by Professor Giulio Natta allowed SACMI to achieve significant industrial success.

When the first PET bottle began to appear on the market, SACMI's initial thought was that this could become a threat to its business, which was mainly based on machinery for manufacturing crown caps and metal closures.
Instead of defending the metal caps, SACMI immediately began analyzing this new product, which, of course, needed new closure systems.
SACMI launched research programs on compression molding technology which they derived from the experience in metal cap liner production in order to find out the most suitable process to manufacture closures for the PET bottles.

The close technological partnership between SACMI and HIMONT could guarantee SACMI the essential support and also the guidelines to develop the resin that could be most suitable for the process and for the machine. The combined research efforts led to the construction of an initial compression molding machine prototype and SACMI used the resin MOPLEN EPC 57 MA; the results proved to be extremely good.
The plastic cap molding business expanded to a point to overshadow the metal caps market and plastics became SACMI's main product line.

SACMI's experience with closures allowed them to build up quite a reputation in the industry and so they decided to widen their sphere of action by offering customers alternatives of compression; therefore, they purchased Negri Bossi, the leading Italian producer of injection presses. Subsequently, BM Biraghi and OIMA were also purchased.

Polypropylene has given SACMI the opportunity to turn a threat into an industrial opportunity.

Polypropylene & Compression Technology: a successful case history

Introduction

I wish to thank Basell for the honour granted to Sacmi Imola in allowing us to illustrate the significant industrial success achieved by a machine constructor, all thanks to the discovery made by Professor Giulio Natta: Polypropylene.

Sacmi is a leading company in the field of machines and complete plants for the production of closures for containers of various types, such as bottles, phials, tubes etc.

Our company history dates back to the immediate post-war period when Sacmi started producing machines for the manufacture of crown caps: in just two decades it succeeded in becoming the absolute leader in this particular packaging field.

In the 80s world crown cap output stood at about 300 billion pieces per year: over 70% of them were produced using our machines.
The associated production technology can be broken down into distinct phases: pressing of the metallic cap to give it shape, followed by construction of the liner via a thermoplastic polymer compression moulding process.
Most crown caps are used as closures on glass bottles.

The advent of plastic bottles: a threat becomes an opportunity

At the start of the 80s the first PET (polyethylene terephthalate) bottles began to appear on the market. This was nothing less than a market revolution, as these containers had characteristics that were very different from those of glass bottles.
In Sacmi, we immediately began analysing this new container and straight away became aware that it represented a serious threat to our business.
However, it was not our aim to defend the crown cap at all costs, despite the fact that it had, for many years, been our sole source of development: our strategy, rather, was to defend our share in those specific segments of the beverage industry in which we had already made a name for ourselves.
Thus all efforts were directed at sustaining the new container which, of course, needed new closure systems.

Research programs were thus launched along several different lines: the aim was to identify the type of closure that would be most suitable for the container and the systems and processes that would be most convenient for its manufacture.
Our aim was to differentiate ourselves from the injection moulding process, the system then universally adopted for the production of plastic caps.
Our studies, based on the compression technology and know-how derived from extensive experience in producing the liners on metal caps, showed that, in theory at least, there was a good chance of compression-moulding the cap itself.

Himont and Sacmi form a winning team

However, our research program did not, of course, allow us full autonomy as regards all the resin-linked aspects.
To this end a close technological partnership was formed with Himont of Ferrara. Their Technical Centre, acknowledged as the most advanced in the world, guaranteed us essential support by supplying us with technological guidelines and developing the resin that would be most suitable for our process.
Un meeting that goal, POLYPROPYLENE was eventually identified as being the material which, more than any other plastic, had all the necessary specifications.
Our compression technology research also involved some universities; working together with them, we developed and perfected highly complex calculation systems used to study how plastic materials behave when subject to compression.
Analysis confirmed expectations: the use of compression techniques gave, with respect to injection, the advantage of higher productivity. This advantage was more marked with PP than with HDPE on account of its lower heat conductivity coefficient. This, then, reinforced the decision to use compression together with Polypropylene!

POLYPROPYLENE gives rise to a technological miracle

Combined research efforts led to the construction of an initial compression machine prototype, equipped with 32 moulds capable of producing 300 caps per minute.
The resin used on this model was perfected by Himont and produced and marketed under the product code MOPLEN EPC 57 MA: it was a Polypropylene resin with excellent melt strength and impact resistance characteristics.

Thanks to the excellent characteristics of the employed resin, results proved to be extremely good in terms of both machine performance and cap quality.

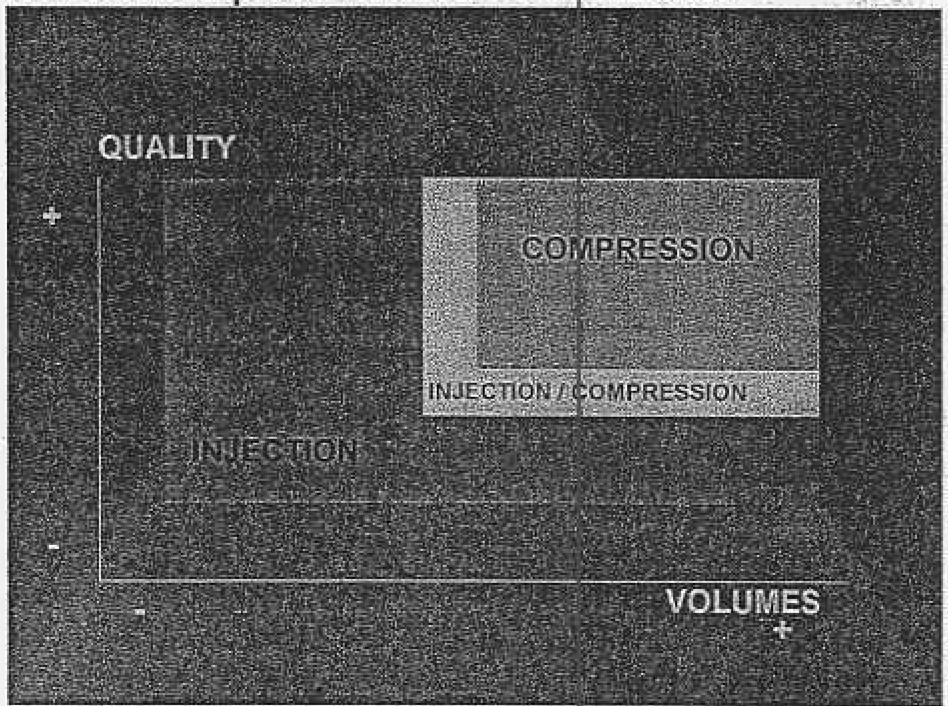
The performance requirements of the bottles - subject to internal pressure and thermal production cycles - were, in fact, met in full. What's more, goals were also achieved economically as the EPC 57 MA responded well to all requirements and also proved to be highly adaptable to the compression process.

The results of the BASELL – SACMI partnership

Marketing of the new product began in 1993: since then the plastic cap moulding business has gone from strength to strength and expanded to a point at which it overshadows the metal caps market. For Sacmi's Packaging Division, plastic caps are now the main product line.

Sacmi and Himont had entered into a binding agreement whereby Sacmi offered its clients the machines while strongly suggesting use of the Himont resin, which, on account of the enormous amount of development work that had been done, was evidently the number one choice for top performance of both machine and moulded product.

How has compression fared on the market?



Compression moulding has proved considerably competitive in those areas where high output rates and very high product quality (in terms of aspect, consistent size and extremely limited de-moulding/cooling deformation) are required.

The future

Sacmi continues to channel considerable resources into compression in order to enhance performance and extend its range of application.
Our advanced research labs are currently testing 32-mould machines that can produce 800 caps per minutes and the technology is being tried out on several different products.

Our experience with caps has allowed us to build up quite a reputation in the industry: in order to capitalise on this acknowledgement we have decided to widen our sphere of action by offering customers alternatives to compression in those areas of the cap market where injection technology still appears to be the best way forwards. Those areas include plastic caps produced in relatively small lots, a scenario in which injection moulding is generally preferable.
To this end, seeing as we also believe that, over the coming years plastics will - in packaging alone - take on ever-greater importance, we purchased Negri and Bossi, a company quoted on the Milan stock exchange and the leading Italian producer of injection presses. Subsequently, BM Biraghi and OIMA were also purchased.
These three companies have a combined production potential of 1500 presses a year and have allowed us to become Italy's leading constructor and one of Europe's biggest.
Summing up, Sacmi is the only constructor able to offer both plastic cap production technologies and is, thanks to extensive experience, able to provide clients with optimum solutions on a case by case basis.

Within the field of injection for PP caps, we expect cooperation between Basell and Sacmi to continue: in fact, we're counting on it.

Thank you Giulio and thank you Basell!

PP has given us the opportunity to turn a threat to our company into an industrial opportunity that is now used in hundreds of plants and a significant share of the market.

For all these things, we shall always be incredibly grateful to Professor G. NATTA and BASELL.

SACMI Beverage & Packaging

G. Natta Celebration Event

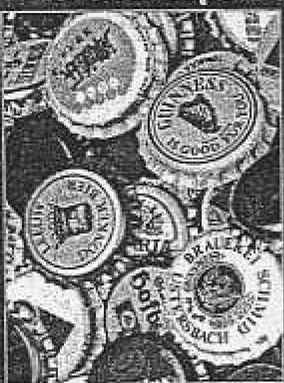
Polypropylene & Compression Technology

a successful case history

Dario Beltrandi, General Manager, Beverage & Packaging Division

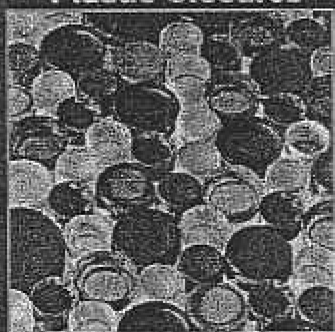
Ferrara, 13 June 2003

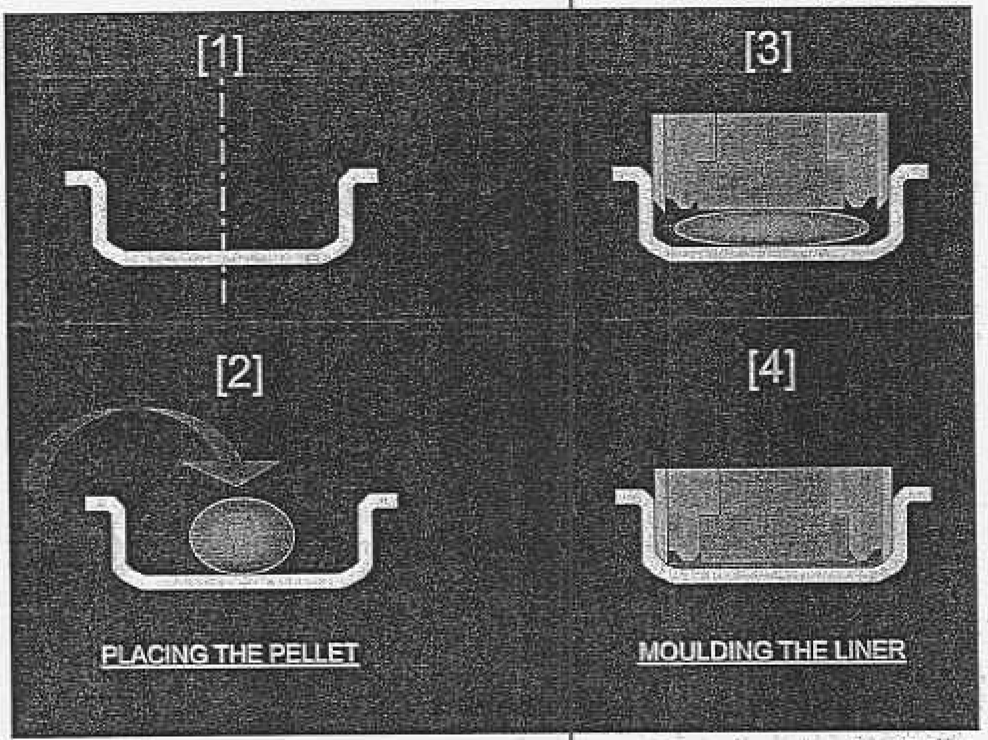
Crown Caps



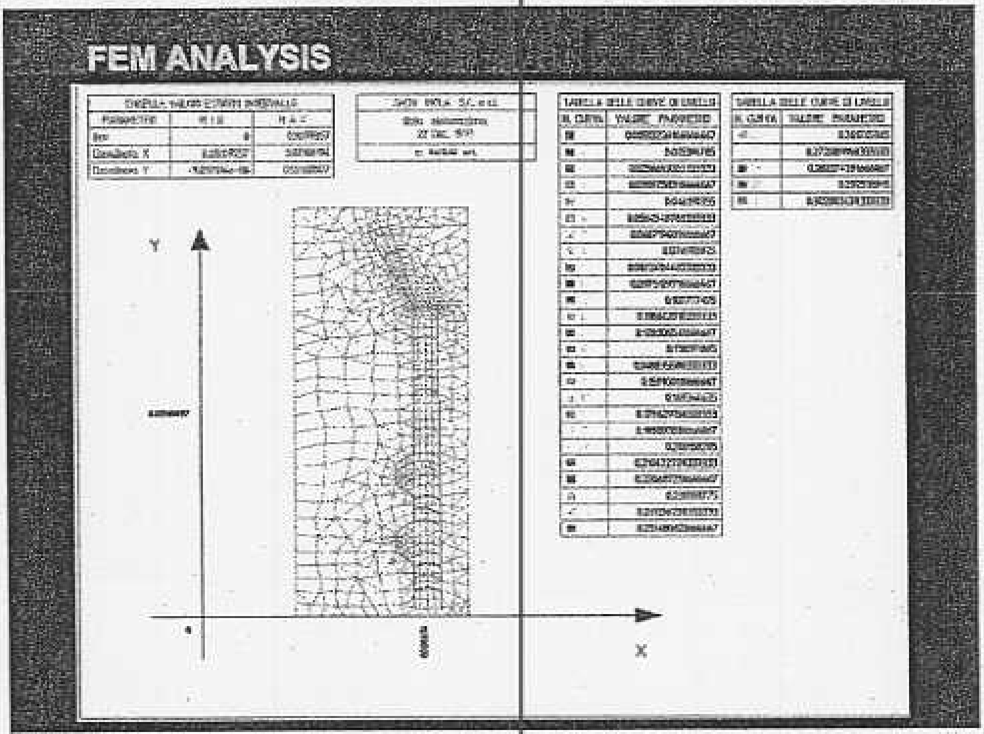
Aluminum Screw Caps

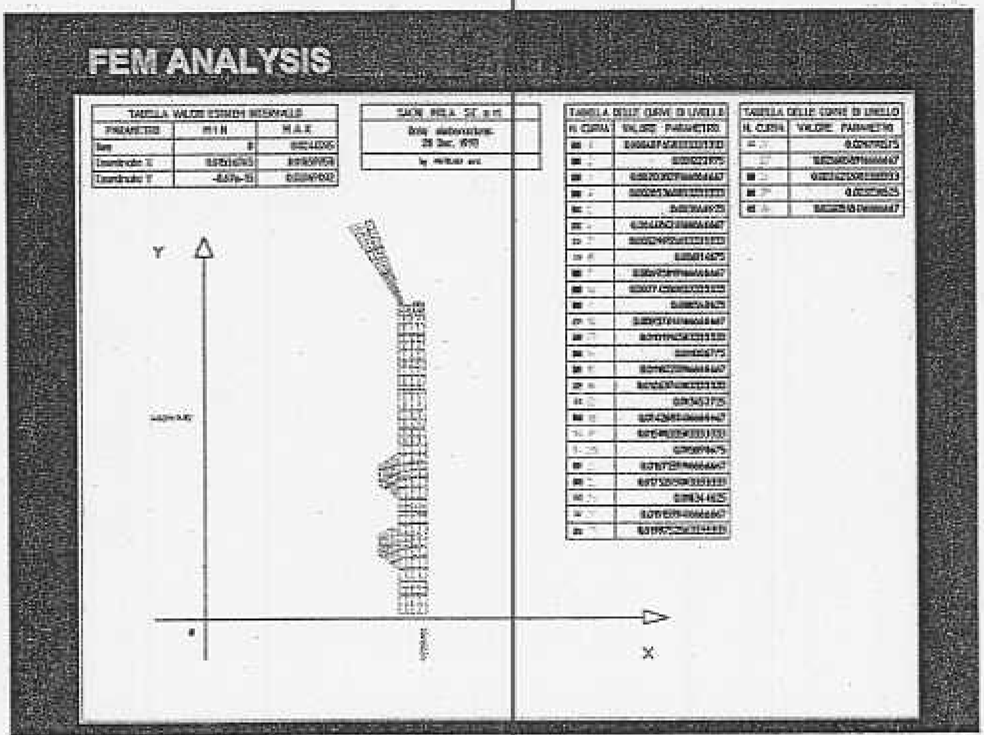
Plastic Closures




[1]
[3]
[2]
[4]
PLACING THE PELLET
MOULDING THE LINER


AN UPCOMING THREAT
THE PET BOTTLES


FEM ANALYSIS
Y
X


FEM ANALYSIS
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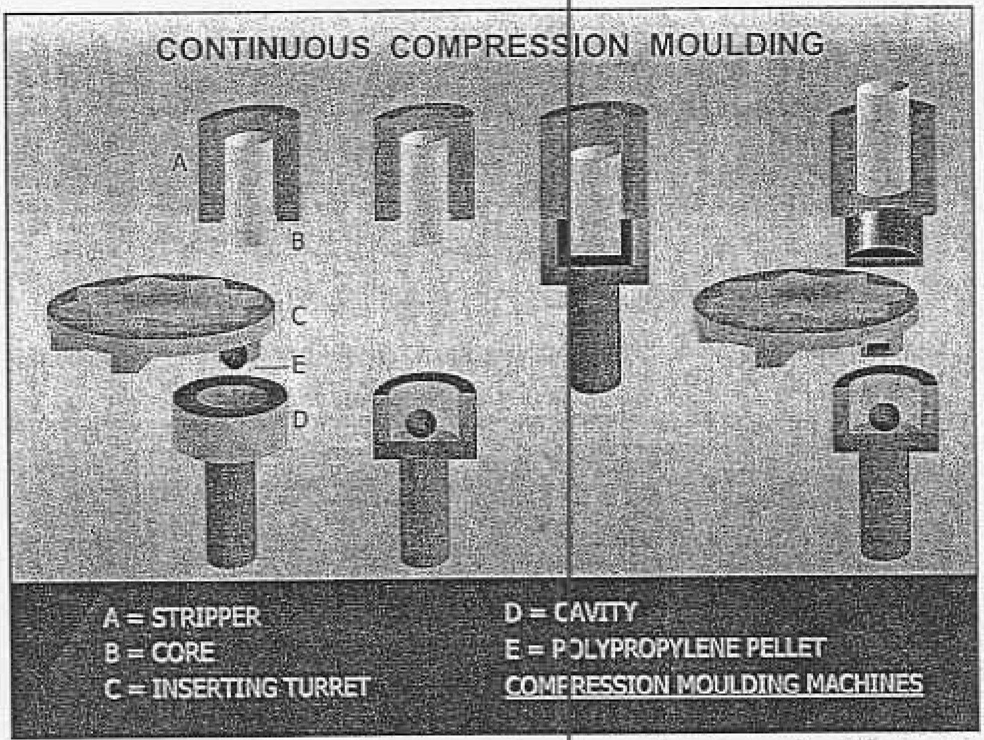
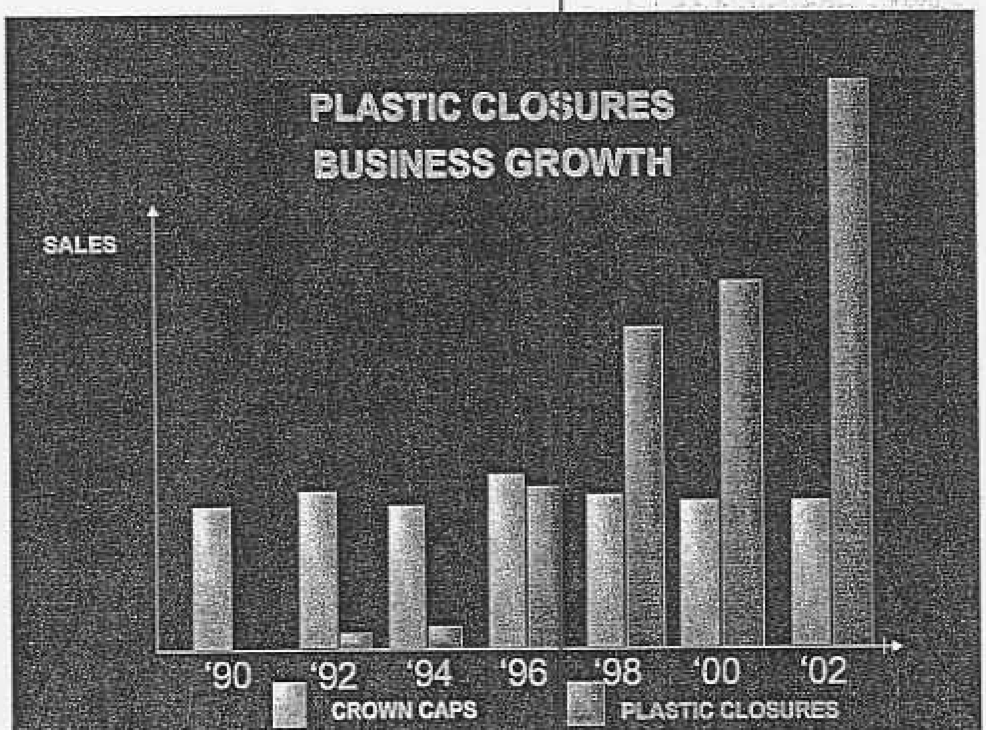
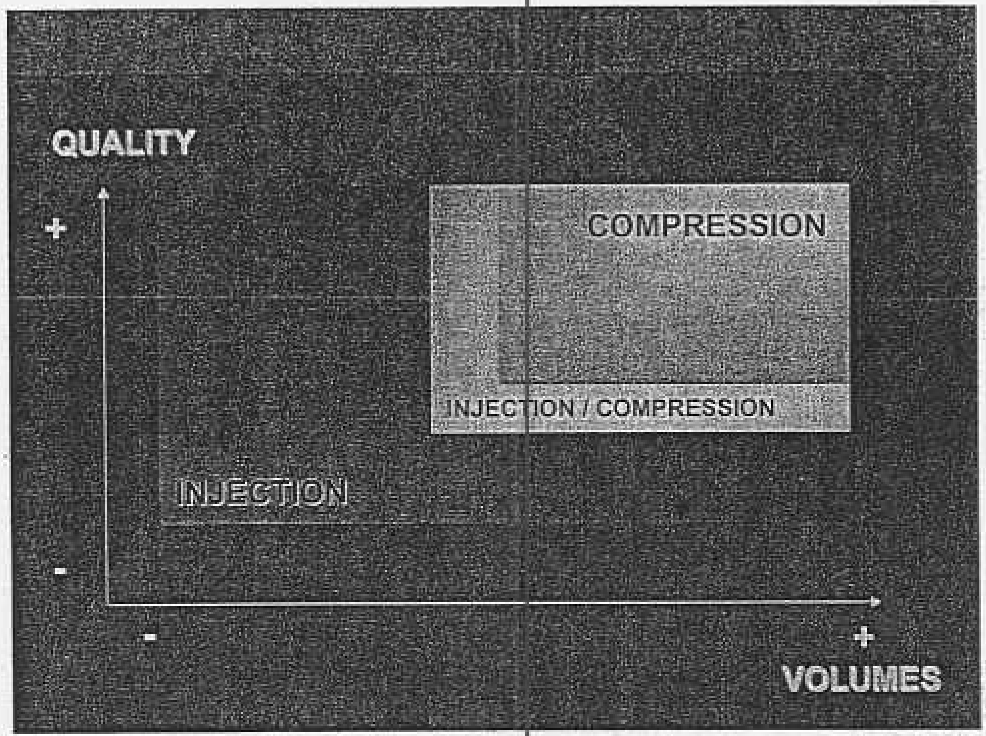
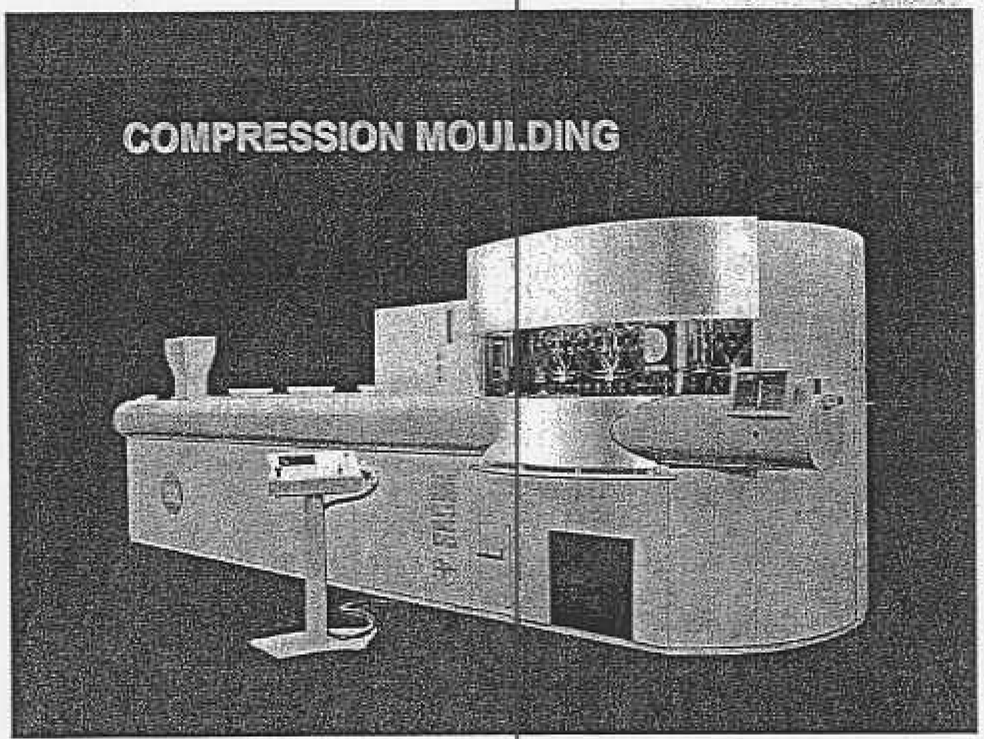
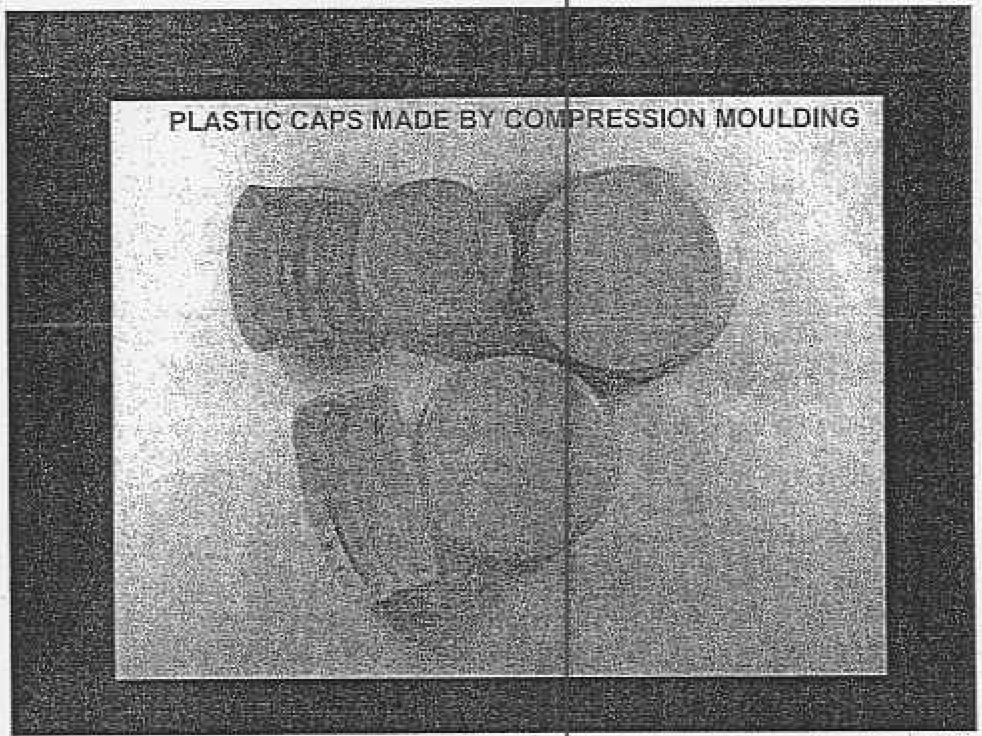

CONTINUOUS COMPRESSION MOULDING
A
B
C
E
D
A = STRIPPER
B = CORE
C = INSERTING TURRET
D = CAVITY
E = POLYPROPYLENE PELLET
COMPRESSION MOULDING MACHINES

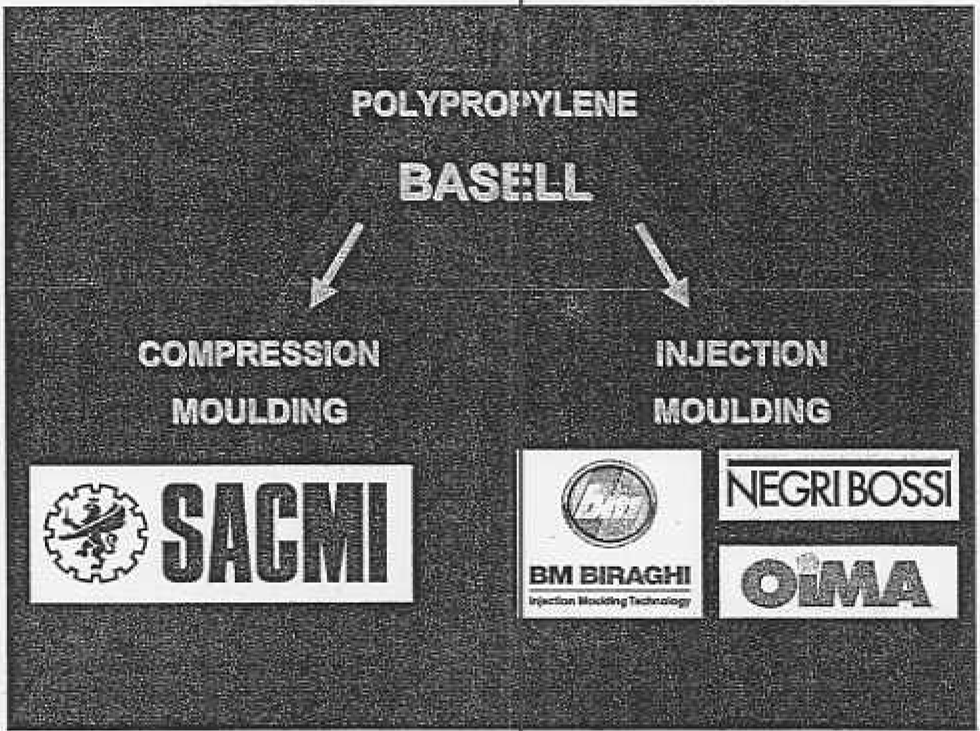

PLASTIC CLOSURES
BUSINESS GROWTH
SALES
'90
'92
'94
'96
'98
'00
'02
CROWN CAPS
PLASTIC CLOSURES


QUALITY
+
COMPRESSION
INJECTION / COMPRESSION
INJECTION
-
-
+
VOLUMES


COMPRESSION MOULDING


PLASTIC CAPS MADE BY COMPRESSION MOULDING


NEGRI BOSSI
OiMA
BM Biraghi


POLYPROPYLENE
BASELL
COMPRESSION MOULDING
INJECTION MOULDING
SACMI
BM BIRAGHI
Injection Moulding Technology
NEGRI BOSSI
OIMA


Thank you Giulio
Thank you BASELL
basell
SACMI

Brian Gersh
Principal

Education
M.B.A. Finance, New York University, Graduate Sch
Business Administration (Stern School)
B.A. Chemistry, Case Western Reserve University

Additional Information
Brian Gersh, Principal, specializes in helping clients i polymer, plastics, elastomers, packaging, and compos industries with urgent management, technology, and issues. Prior to joining CRA, Mr. Gersh was the Poly Principal in the Global Chemicals practice of Arthur where he spent 13 years helping clients focus on grow innovation, and optimized business performance. Wh ADL, Mr. Gersh's work with clients all over the worl the entire range of polymeric materials, fabricated pro industry services. In addition to playing an important consolidation of the global polyolefin industry, he ha played a key role in helping clients with significant ch within the engineering plastics, vinyls, styrenics, uret elastomers, and fabricated products businesses. Prior ADL, Mr. Gersh spent 12 years working in new busin planning and development, product management, and for AlliedSignal Engineered Plastics (today Honeywe Specialty Materials), and in engineering roles for the divisions of the Ford Motor Company and Rockwell International.

Brian P. Gersh
Principal
Charles River Associates, Inc.

Global Polyolefins Industry: Situation and Future Challenges

Giulio Natta Celebration
Ferrara, Italy - 13 June 2003

ABSTRACT

The global polyolefins industry has become a very large business. In 2002, PE demand was 55.8 MM Tonnes and PP demand was 34.1 MM Tonnes—both growing at rates higher than GDP. Both businesses are maturing, as growth rates have slowed over the last 10-15 year period. Over this period, polyolefin businesses have failed to create sustainable value for their shareholders. In response, there has been a dramatic reduction in the number of polyolefin participants and industry concentration has increased significantly (eg. top 10 suppliers as percentage of industry capacity jumped from roughly 35-52% for both PE and PP). The significant challenge facing the consolidated industry is how to improve profitability to sustainably attractive levels on a global basis.

Charles River Associates (CRA) has developed a framework for evaluating and driving value-creation in the polyolefin business. In our model, superior sustainable returns are based on value-creation in three dimensions:

- Olefin Competitiveness
- Polymer Excellence
- Technology Monetization

These value-creation pillars are optimally supported by management, operating, and support processes organized on a regional basis. In "**Olefin Competitiveness**," feedstock economics, asset configuration and optimization drive leadership. In **"Polymer Excellence,"** leadership is defined by breadth of product offering, operations location, scale, effective customer focused processes, & a continuing pipeline of new products. Finally, leadership in **"Technology Monetization"** is determined by sales of process technology and catalysts underpinned by the continuing development of catalyst and process innovations.

The companies that will create sustainable business value and polyolefin leadership will be those that combine strength in all of these value-creation pillars. They include resource-rich companies, some of which have advantaged raw materials; large market-oriented producers that have attained global scale; and technology-oriented companies that fill market needs and are able to leverage technology developments across a global platform.

Global Polyolefins Industry: Situation and Future Challenges

Thank you very much for inviting me to speak today in front of this distinguished audience as we honor the achievements of Professor Giulio Natta. I am Brian Gersh, a Principal in the Chemical and Petroleum Practice of Charles River Associates (CRA). I came to CRA in May of 2002 when the Chemicals and Energy Practice of Arthur D. Little (ADL) was acquired by CRA. At ADL, I spent 13 years as the Principal - Polymers in the Global Chemicals Practice working on business and management issues for global polymers and plastics companies—and at CRA, I am continuing in that role. Today, I am going to talk about the global polyolefins industry – the current situation for stakeholders as well as future challenges that they face.

The global polyolefins industry has become a very large business *(slide #1)*. In 2002, global polyethylene demand was approximately 55.8 million tonnes, anticipated to grow at 5.9 percent per year over the next five years. While good growth is still expected from highly developed regions like North America and Western Europe, outstanding growth is envisioned in Asia/Pacific where the current business base is already the largest of all regions. LLDPE and HDPE are forecasted to grow at above average PE growth rates, with LLDPE (at 8.9 percent per year) setting the pace. Volume growth is significant for both LLDPE and HDPE, with LDPE much less as it grows at a discount to GDP.

Global polypropylene demand in 2002 was roughly 34.1 million tonnes, with expected five-year growth of almost 7 percent per year *(slide #2)*. We see similar patterns among the regions, as in PE, with good growth among the large and developed regions (e.g. North America and Western Europe); and outstanding growth in Asia/Pacific, which is already the largest PP-consuming region. Volume growth in PP over this period is expected to be significant!

When people think about polyolefins, they think about products that were in their growth phase in the 70s and 80s. Today, they associate these products with maturing businesses that no longer are exciting. For perspective, we compare polyolefins to other process industries like steel and paper; both businesses which are mature, and in which participants are fighting for survival! *(slide #3)* Even today, polyolefins have a long way to go before they catch up with either paper or steel; growth rates for polyolefins continue at significantly higher rates than GDP, paper, and steel. So, the excitement has not yet been totally eliminated from polyolefins!

Despite robust growth seen in the past and anticipated looking forward, stand-alone polyolefin businesses have failed to create sustainable value for their shareholders *(slide #4)*. Except for a select number of differentiated PE and PP products which represent market niches, products representing the largest portions of the market do not appear to provide attractive returns. This picture is a big concern for a business that is still growing at attractive levels, for which continuing investment will be necessary to realize this growth.... One response to these financial challenges *(slide #5)* has been a dramatic consolidation of the producer landscape. In PE, a concentration of the global industry has occurred, as the top 10 companies today represent over 50 percent of capacity; whereas 10 years earlier, it was 35 percent. In PP *(slide #6)*, we see a similar pattern as the top 10 companies went from 36 percent to 52 percent of global industry capacity over the same period. Not only have larger "polyolefin" companies been formed, but this trend has resulted in more globally-oriented participants as well. There are fewer single-region companies left among the top tier of participants.

The industry faces a significant challenge *(slide #7)* – how to grow while providing acceptable profitability on a sustainable basis? Participants are searching for ways to drive their business portfolio toward the "value maximization zone."

Charles River Associates (CRA) has developed an analytical framework for evaluating and driving value creation in the polyolefins business *(slide #8)*. In our model, superior sustainable returns are based on value creation in three dimensions:

- Olefin Competitiveness
- Polymer Excellence
- Technology Monetization

These value creation pillars are optimally supported by management, operating, and support processes organized on a regional basis.

In **"Olefins Competitiveness"**, we look at the incremental value of steam cracking over the alternative value of feedstock *(slide #9)*. In **"Polymer Excellence"**, we consider the incremental value created by polymer manufacturing over monomer at merchant market price. And in **"Technology Monetization"**, we look at the incremental value of process licensing and catalyst sales leveraging strength in overall longer-term technology developments. This analytical framework views value creation in a pragmatic manner that is consistent with the way that polyolefin companies take profits in their value chain.

The framework underlying **"Olefins Competitiveness"** concentrates on feedstock economics, asset configuration, and asset optimization. This includes such considerations as: feedstock cost and security, scale, and site configuration-- which considers synergy advantages with other related businesses, such as refining and gas operations, and linkages to downstream polymer operations. **"Polymer Excellence"** evaluates needs in the premium and commodity components of the business, as well as customer-focused support activities. This includes consideration of: product mix, operations location and size, efficiency and effectiveness of customer-focused business support processes, and the incorporation of technology development to maintain a pipeline of short-/medium-term innovations. And finally, in **"Technology Monetization"** we evaluate the development of process technology and catalysts for use in the captive polyolefins business and for sale to Third Party licensees. This includes the "evolutionary" development of "next generation" polyolefin technologies, the commercialization of resulting products in the manufacturing business, and the business of selling process technology licenses and catalysts to Third Parties.

Based on these diverse and complex considerations, several different types of polyolefin leaders have evolved *(slide #10)*:

- "Big oil/resource owners"
- "Market players"
- "Technology-oriented players"

Leading players tend to be strong across several value creation pillars; some are leaders in specific pillars and only average in others. Participants have different "natural" strengths and need to make sure they don't have an "Achilles' Heel." "Big oil/resource owners" earn their way in polyolefins through competitiveness in the largest component of the cost structure – raw materials *(slide #11)*. Examples include ExxonMobil, SABIC, and Shell, which exploit a basic position back to the well-head and/or exploit advantaged feedstocks. While the position of these companies is strong, they still have the challenge of capturing the lion's share of global growth (e.g. Asia/Pacific), replicating their raw material strength in new regions, and securing strong channels to market—this is no trivial task, even for companies of this scale, reach, and heritage. "Market players" earn their way in polyolefins through competitiveness in commodity products to build scale, and a strong participation in specialty/premium products *(slide #12)*. Examples include Dow, Basell, and ExxonMobil, which operate in several regions or globally, offer broadly competitive-grade slates, and have excellent pipelines of short-/medium-term technology developments that are well focused toward specific market channels. These companies are challenged by the "commoditization" of materials businesses by end-users, which makes it difficult for them to continue innovating on a global basis as profitability is compressed. And finally, "Technology-oriented players" *(slide #13)* earn their way in polyolefins through developing next-generation/cutting edge technologies, commercializing them through large scale/captive operations, and selling them to third parties. The most visible examples are Univation Technologies (PE) and Basell (PP), owners of the flagship polyolefin process technologies – Unipol (PE) and Spheripol (PP). These companies and their predecessors have led in the development of the leading process technologies and catalysts for the manufacture of gas-phase PE and bulk PP. These companies are on the cutting edge of next-generation polymer products, through continuing innovations in process technology and new catalysts. While the economics of the business have challenged the "staying power" of these participants and their ability to continue investing in technology, we believe that the leaders in polyolefins will continue to be those that innovate in technology development while keeping their eyes on maintaining and growing strength in the other two value-creation pillars.

Thank you very much for your time.

Global Polyolefins Industry: Situation and Future Challenges

Basell Prof. Giulio Natta Celebration Event
June 13, 2003

Presentation By
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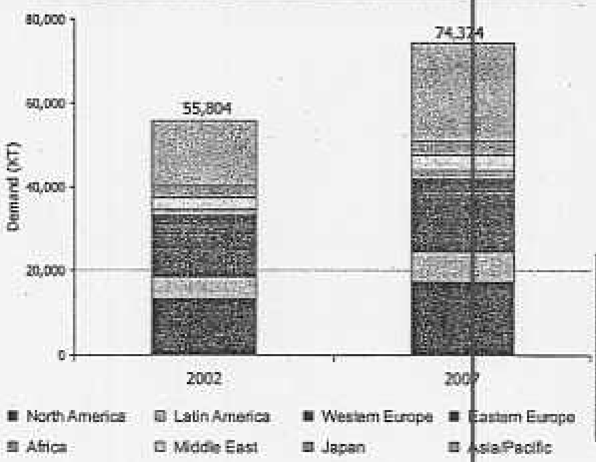
Since the introduction of low-pressure polyolefins in the late 1950s, the business has become a 90 MM Tonne global industry—PE represents over 60% of this industry...

Global PE Demand – By Region



CAGR 2002-2007 %	
North America	5.3%
Latin America	7.0%
Western Europe	3.2%
Eastern Europe	5.0%
Africa	5.8%
Middle East	6.0%
Japan	3.9%
Asia/Pacific	8.5%
Total	5.9%

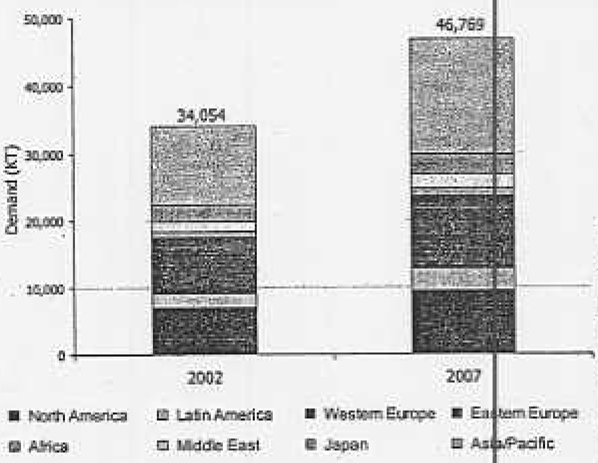
Volumes (KT)			
Region	2002	2007	Δ
North America	13,557	17,537	3,980
Latin America	4,878	6,834	1,956
Western Europe	12,511	14,661	2,150
Eastern Europe	2,173	2,777	604
Africa	1,639	2,174	535
Middle East	2,558	3,423	865
Japan	2,855	3,458	603
Asia/Pacific	15,633	23,510	7,877
Total	55,804	74,374	18,570

Source: CRA ANALYSIS

Global Polyolefins Industry   Situation

... and PP, itself a large business, represents the rest

Global PP Demand : By Region



CAGR 2002-2007 %	
North America	6.4%
Latin America	8.8%
Western Europe	4.7%
Eastern Europe	7.0%
Africa	6.6%
Middle East	6.9%
Japan	3.3%
Asia/Pacific	7.9%
Total	**6.6%**

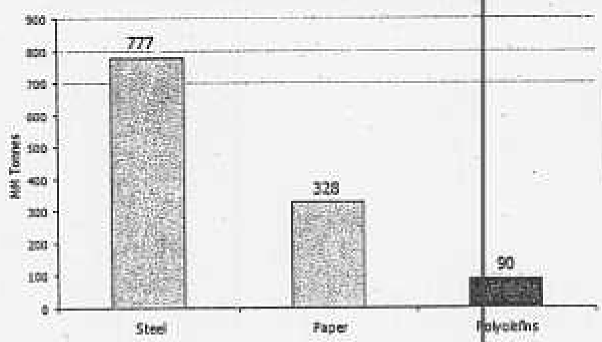
Volumes (KT)			
Region	2002	2007	Δ
North America	7,030	9,569	2,539
Latin America	2,112	3,217	1,105
Western Europe	7,410	9,325	1,915
Eastern Europe	1,063	1,489	426
Africa	828	1,139	311
Middle East	1,460	2,039	579
Japan	2,546	2,989	443
Asia/Pacific	11,605	17,001	5,396
Total	34,054	46,769	12,715

Source: CRA ANALYSIS

Global Polyolefins Industry   Situation

However, the evolution of the steel and paper industries shows that the "maturity" of polyolefins has been much exaggerated

Selected Process Industries — Global Demand (2002)

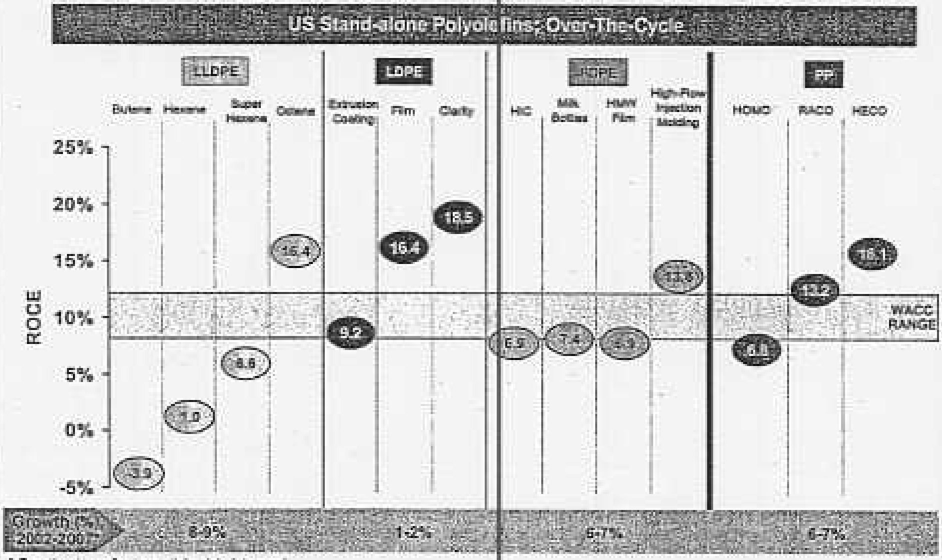


CGR% (2002-2007)	
Steel	2.1%
Paper	2.8%
Polyolefins	6.2%

Source: CRA estimates.

Global Polyolefins Industry Situation

As in all large commodity markets, it is difficult to make attractive returns from simple manufacturing of undifferentiated products

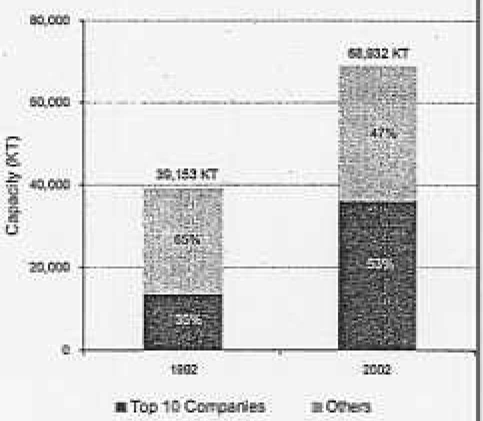


* Growth rates reflect growth in global demand
Source: CRA ANALYSIS

Global Polyolefins Industry Situation

Responding to these financial challenges, the PE participants have consolidated to a more concentrated landscape...

Global PE Industry Structure



1992	
Top 10 Companies	Capacity Share (%)
Dow	7%
Quantum	5%
EniChem	4%
Union Carbide	4%
Exxon	4%
Chevron	3%
Neste	3%
Solvay	3%
Hoechst	2%
BP	2%
Subtotal	35%

2002	
Top 10 Companies	Capacity Share (%)
Dow	11%
ExxonMobil	9%
BP/Solvay	7%
SABIC	5%
Chevron Phillips	4%
Basell	4%
Equistar	4%
Borealis	3%
Formosa	3%
AtoFina	3%
Subtotal	53%

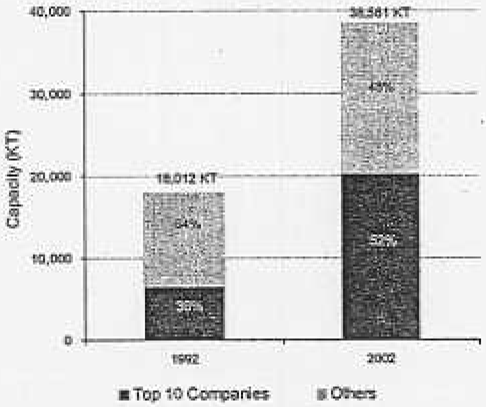
NOTE: Includes Joint Venture Capacity

Source: CRA ANALYSIS

Global Polyolefins Industry   Situation

...and the observed pattern is similar for PP

Global PP Industry Structure



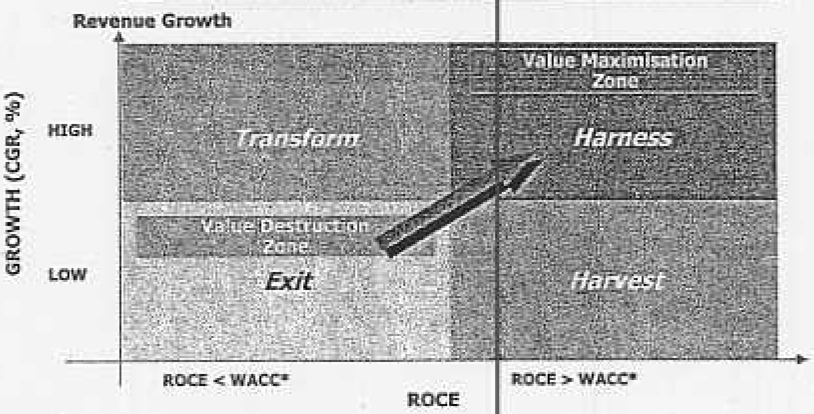
1992	
Top 10 Companies	**Capacity Share (%)**
Himont	8%
Shell Chemical	6%
Amoco	5%
Hoechst	3%
Neste	3%
Fina	2%
Exxon	2%
Solvay	2%
PCD Polym.	2%
Montefina	2%
Subtotal	**36%**
2002	
Top 10 Companies	**Capacity Share (%)**
Basell	15%
BP Chemicals	7%
AtoFina	6%
ExxonMobil	5%
SABIC	4%
Borealis	4%
Japan Polychem/Chiss	3%
Dow	3%
Reliance	3%
Mitsui	3%
Subtotal	**52%**

Source: CRA ANALYSIS

Global Polyolefins Industry   Dilemma

In PE and PP, consolidation has not been sufficient to deliver results and participants are still searching for ways to drive towards both high growth and returns

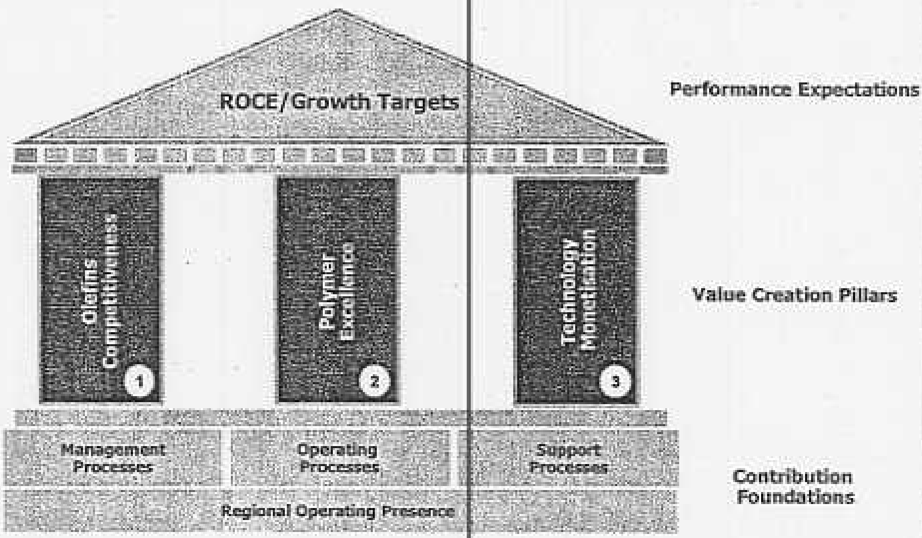
CRA Growth and Performance Matrix



* Weighted average cost of capital

Global Polyolefins Industry Value-Creation Model

In our framework for driving value-creation in the polyolefins business, we believe strength is necessary in three "pillars" to make satisfactory returns



Global Polyolefins Industry Pillars of Competitiveness

Our "Pillar Model" is used as a basis to estimate Financial Performance and Competitiveness in the olefins/polyolefins integrated value-chain

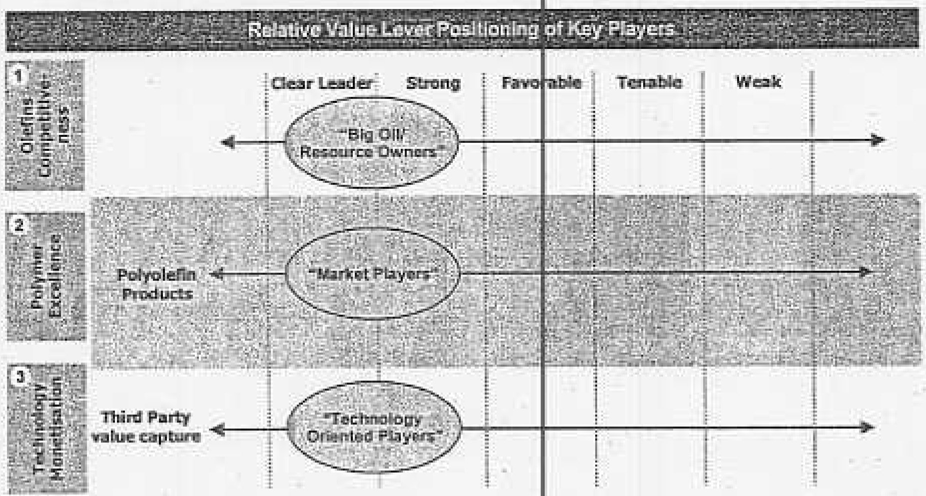
1 Olefin Competitiveness — Incremental value of steam cracking operation over alternative value of feedstock and "general interest" synergy contribution

2 Polymer Excellence — Incremental value of polymer manufacturing with monomer at merchant market price including "richness" of product mix, business size, global reach, and technological strength.

3 Technology Monetization — Incremental value of process licensing and catalyst sales leveraging strength in overall longer-term technology developments (shared with the polymer business)

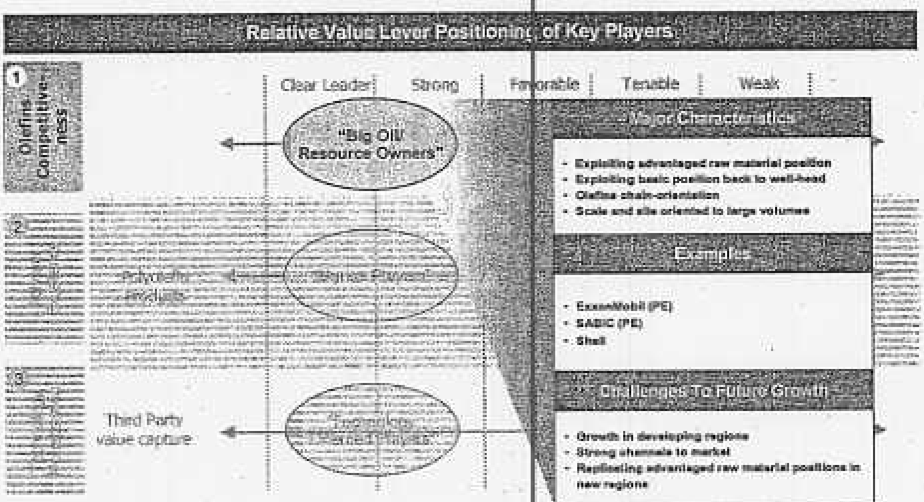
Global Polyolefins Industry "Winners" (Overview)

Leading players are strong across several of these value-creation pillars; participants have different "natural" strengths and need to make sure they don't have an "Achilles Heel"



Global Polyolefins Industry "Winners"

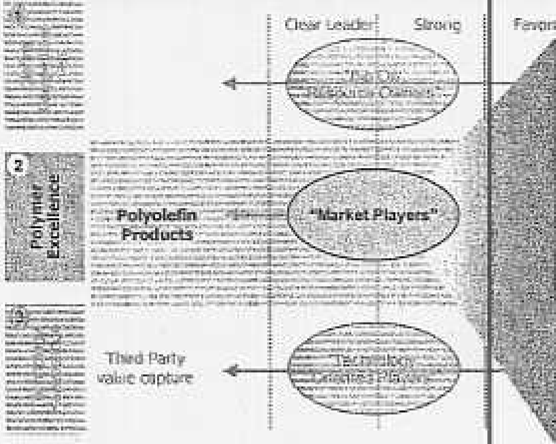
"Big Oil/Resource Owners" succeed in polyolefins through competitiveness in the largest component of the cost structure—raw materials



Global Polyolefins Industry "Winners"

"Market Players" succeed in polyolefins through competitiveness in commodity products to achieve scale, along with a strong participation in specialty/premium products

Relative Value Lever Positioning of Key Players



Major Characteristics

- Highly competitive and broad product offering, usually well aligned with competitive upstream crackers
- Multi-regional/global position
- Broad & well-focused channels to market
- Excellent pipeline of short/medium term technology developments

Examples

- Dow (PE)
- Basell (PP, PE)
- ExxonMobil (PE, PP)

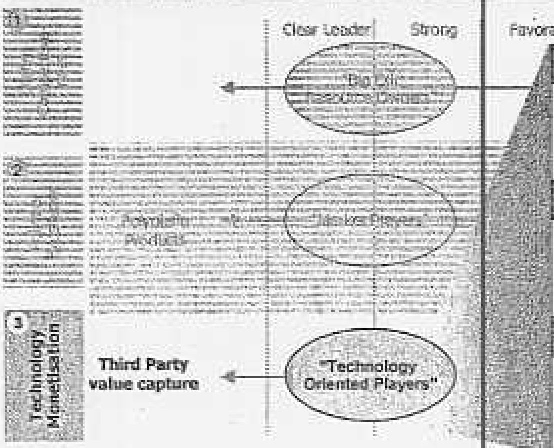
Challenges To Future Growth

- "Commoditization" of materials by end-use customers
- Strong channels to market in developing regions
- Continuing to respond to unmet market needs
- Fueling the continued development of a differentiated technology pipeline

Global Polyolefins Industry "Winners"

"Technology-Oriented players" add value through developing next-generation technologies and leveraging them for their owners and third parties

Relative Value Lever Positioning of Key Players



Major Characteristics

- Leader in process technology and catalyst developments
- "Cutting-edge" development of next-generation polymer products
- Able to demonstrate and commercialize new developments

Examples

- Univation (PE)
- Basell (PP, PE)

Challenges To Future Growth

- The economics of the business and the "staying power" to continue innovating
- Catering to the diverse needs of both the developed and developing regions

A.G. De Vries
President R&D
Basell Polyolefins

Education:

Chemical Engineering graduate from Delft Technical University (Netherlands).

Additional information:

Anton De Vries started his career in 1977 with Shell Chemicals in the Netherlands.

After several assignments in different chemical areas of Shell and working in several european countries in 1991 he became responsible for Shell's new petrochemical complex in Germany and the start up of the polyproylene plant near Cologne.

With the formation of Montell in 1995 he transferred from Shell to Montell and after an assignment in the strategy group in the Netherlands moved to Ferrara, italy and became in 1998 Director of the R&D Center and responsible for Montell's Research & Development activities in Europe.

With the formation of Basell, in 2000 he took on global responsibilty for all product and application development

In 2002 Anton De Vries was appointed President of Basell R&D.
In this function he is also a member of the Basell Management and involved in several corporate projects including some strategic activities at board level.

Anton de Vries
President, Basell Research & Development

The Technological Challenge Continues

Giulio Natta Celebration
Ferrara, Italy - 13 June 2003

Abstract

We can truly confirm that the research work initiated in 1954 by Professor Giulio Natta, with the first synthesis of isotactic polypropylene, has given results unimaginable at his time. We are sure that Prof. Natta would be proud to see how his successors in Ferrara and in other parts of the world are continuing his tradition of creativity and talent in our research centre dedicated to his memory and many others centres around the globe.

The latest result of this development work has been the announcement of a newly developed polymerisation technology, *Spherizone*, which is going to become the new world-wide industry standard for polypropylene production.

Spherizone enlarges the application field of polypropylene resins, creating new product families. This is made possible using a new revolutionary polymerisation system which is the core of the new technology, the Multi-Zone Circulating Reactor (MZCR), together with the recently introduced Ziegler-Natta catalyst of 5th generation, *Avant* ZN Diethers and Succinates, yet another development from our R&D centre.

The *Spherizone* technology and these new *Avant* ZN catalyst systems are only the most recent results of Professor Natta heritage; our continuous challenge remains to push the application of polypropylene beyond where it is today and moving the scientific limits. It is this attitude and the passion with which it is done that has brought Basell where it is today: the world leading company in polyolefins.

The Technological Challenge Continues

Slide 1

Good afternoon. I am honoured to have the privilege of concluding this session of the celebration day for the centenary of Professor Giulio Natta birth.
Today we have learned about how much of Professor Natta scientific heritage is still lively and pulsating in the heart of Basell researchers.

But for all of us, the best and most important gift of Professor Natta is not even the special catalytic system, which is named after him, or the isotactic polypropylene.
For all Basell researchers, the best gift is his attitude to continuously challenge the limits of the scientific knowledge, which has brought us to be always the world leading company in polyolefin technologies, catalysts and products.

Slide 2

When we talk about technical leadership in polypropylene, everybody's mind goes immediately to Ziegler-Natta catalysis and then to *Spheripol* technology, the world leading polypropylene technology.

First introduced in the early 80's, thanks to the work of Ferrara researchers, nowadays *Spheripol* is present all over the world with more than 80 operating plants and about 50 percent of the world licensing business.

Since its introduction, *Spheripol* was considered a milestone in polymerisation technologies; after more than twenty years *Spheripol* is still considered the best technology in the world for manufacturing polypropylene resins of all types.

Slide 3

The technological challenge for Basell researchers was then: how can we go beyond *Spheripol*? How can we create a new benchmark? How can we further exploit the use of the newly introduced *Avant* ZN catalytic systems, Diethers and Succinates?
As a result of intense studies, Basell has introduced last year *Spherizone*, the new polypropylene polymerisation technology for the next decades. The first *Spherizone* plant came on stream last August in Brindisi, the same site where the first *Spheripol* plant was also realised

The official launch of *Spherizone* was in October last year and no place other than Ferrara could be chosen for this announcement.

Slide 4

When you consider the process flow chart, it is hard to think about something simpler than *Spheripol* process, where many process steps present in previous technologies, like catalyst removal, washing, centrifuging, solvent recovery, etc., were totally eliminated. But we succeeded. The new *Spherizone* technology is simpler and more efficient than any other previously existing polypropylene polymerisation technology, including *Spheripol*.

Slide 5

Spherizone technology takes advantage of the controlled morphology catalysts developed by Basell and utilising a unique reaction scheme, virtually eliminates the unhomogeneity of the particles, typical of multi-stage processes.
The result is a process that is energy efficient, cost competitive, safe and environmentally sound. Last, but not least, *Spherizone* provides a unique combination of product properties and a wider spectrum of possible polypropylene resins.

Slide 6

The core of the new *Spherizone* technology is the so-called Multi-Zone Circulating Reactor (MZCR); its principle is illustrated on the left side of the slide.
In the MZCR, the growing polymeric granules are kept continuously circulating between two interconnected zones, the riser and the downcomer (or downer). Each zone has a different fluid dynamics regime. By means of a fluid barrier they can have different gas compositions, generating different materials. The increased frequency of the particle oscillation through the two environments facilitates the production of uniform, intimately homogenised polymers with expanded properties.

The properties expansion versus previously available technologies is well illustrated in the spider diagram on the right side of the slide. Properties like maximum rigidity, impact/stiffness balance, creep resistance and melt strength, just to mention a few, can be greatly enhanced, combining the *Spherizone* technology with the *Avant* ZN catalysis.

Slide 7

The new *Spherizone* technology will allow expansion of the polypropylene resin market into non-traditional market segments, even though this technology can also be used to facilitate the improvement of products for traditional market applications, such as BOPP and CPP film, fibre or consumer goods.

This slide visualises the polypropylene range actual expansion, which can be realised with the *Spherizone* technology; new product families, as well as full exploitation of resin families envisaged on previously available technologies such as *Adstif*'s, will open new market opportunities for polypropylene producers.

Slide 8

For example, durable goods have been so far influenced to a limited extent by polypropylene, being preferred the use of traditional materials as well as other thermoplastics.

The combination of the unique way of polymerising of *Spherizone*, together with the newly introduced family of *Avant* ZN catalysts called Succinates has generated resins with unparalleled performances in terms of processability, creep resistance, temperature resistance and durability.
Spherizone technology makes polypropylene well suited for non-traditional polypropylene markets, such as pipes, profiles and goods for industrial uses.

Slide 9

In a well-established polypropylene market, like food packaging, the synergism of *Spherizone* technology and another recently introduced *Avant* ZN catalytic family, Diethers, has generated new resins having performances beyond those available before. Higher purity and improved inertness, better transparency, higher toughness, higher fluidity at equivalent mechanical performances are just a few of the advantages offered by this new product generation.

Slide 10

In another important industry for plastics, automotive, the advent of *Spherizone* and its combination with the new *Avant* ZN catalytic systems will bring significant advantages both to converters and car manufacturers, allowing them to further reduce the number of resins in use in a single model car.

Thanks to the applicability of *Spherizone* resins in a wider set of car parts, cars will result lighter and easier to recycle, contributing to energy saving programs.

Slide 11

Concluding my speech, I want to thank you all for having accepted so numerous our invitation to Professor Giulio Natta celebration day and for your kind attention during all this day. It was a privilege for me to present the most recent evolution of the pioneering work of Professor Natta to this audience and I would like to conclude saying:

Thank You, Professor Natta, from all of us.

Giulio Natta Celebration

Ferrara, June 13, 2003

The Technological Challenge Continues

Anton de Vries

President,

Basell Research & Development

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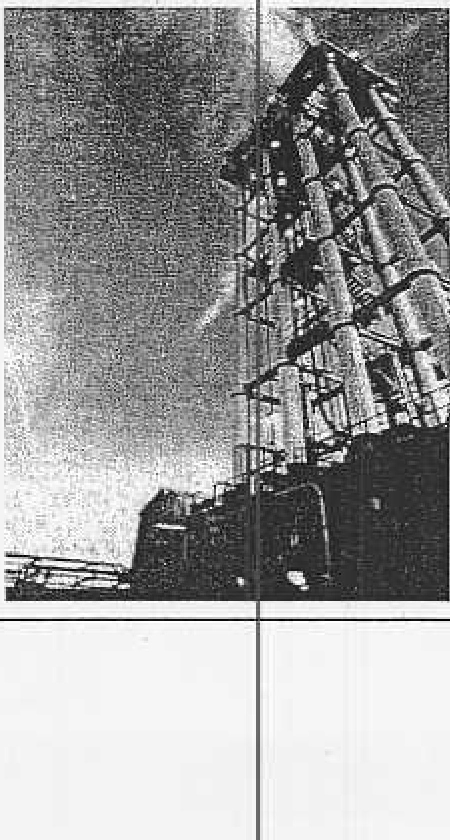
Basell *Spheripol* Technology: the PP process for last two decades



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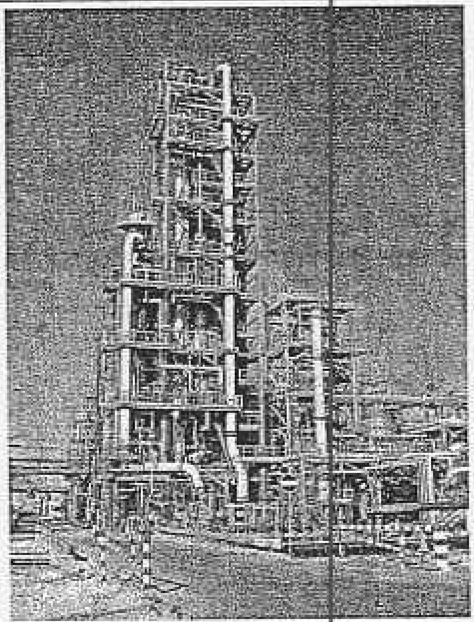
The new Basell PP Technology: *Spherizone*



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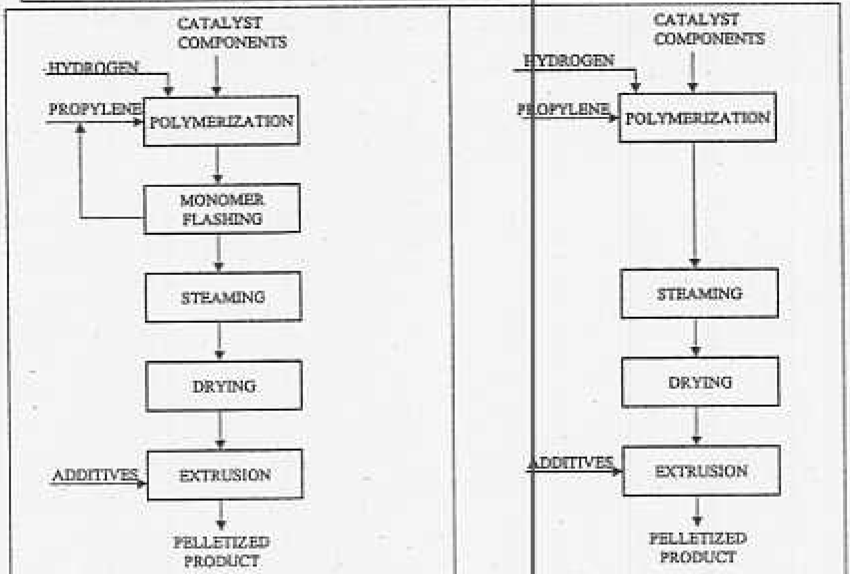
The impossible challenge: further simplify *Spheripol*



Spheripol Process | *Spherizone* Process

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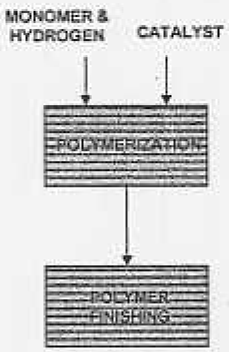
Spherizone Technology: the polypropylene new standard

STATE-OF-THE-ART PROCESS: BASED ON HIGH YIELD, HIGH SELECTIVITY , MORPHOLOGY CONTROLLED CATALYST



Spherizone Process

Process Advantages:

- NO NEED OF ASHES REMOVAL
- NO NEED OF SOLVENT RECOVERY AND AMORPHUS REMOVAL
- LOWER INVESTEMENT COST
- LOWER OPERATING COSTS
- EASIER AND SAFER OPERATION

Product Advantages:

- EXPANDED PRODUCT CAPABILITIES
- IMPROVED PRODUCT PROPERTIES

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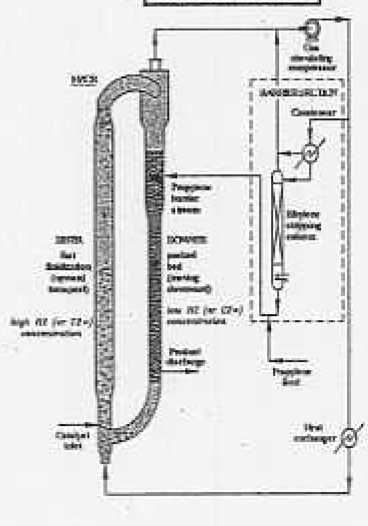
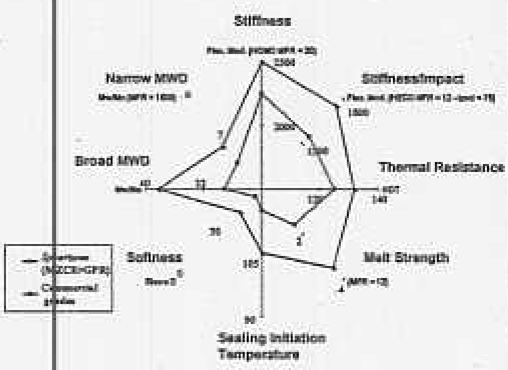
Spherizone Technology: the basic characteristics

MZCR Scheme



Product Property Balance



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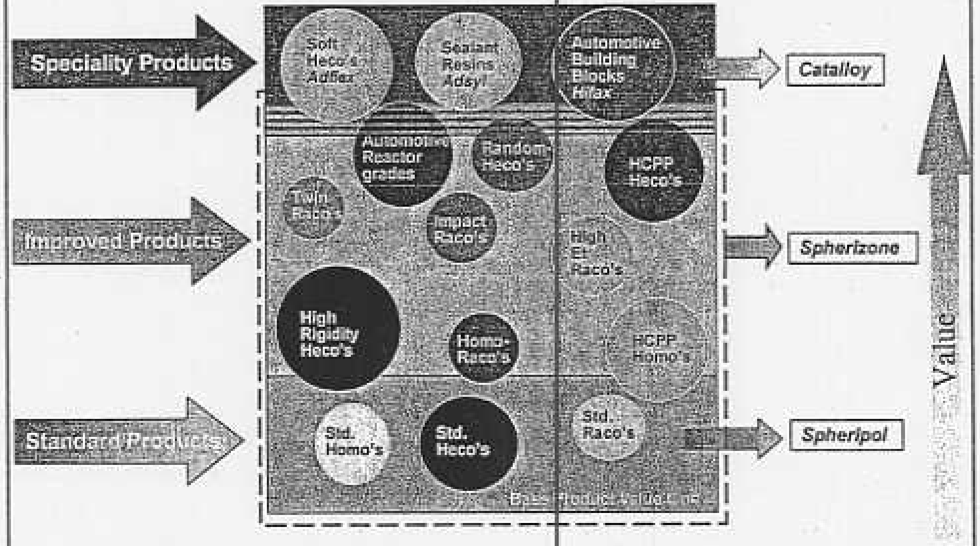
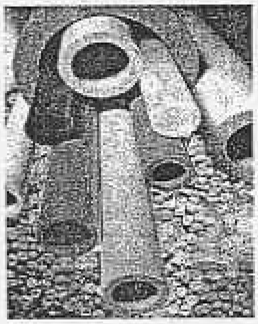
Basell Polypropylene Technology Portfolio

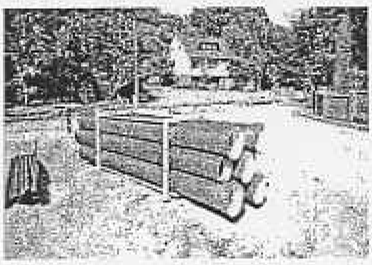


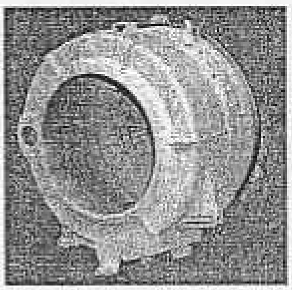
The material properties challenge: durable goods



The combination of *Spherizone* technology and *Avant* ZN Succinate catalysts allows the introduction of new resins having unpreceded characteristics:

- Improved creep resistance
- Higher melt strength
- Enhanced processability

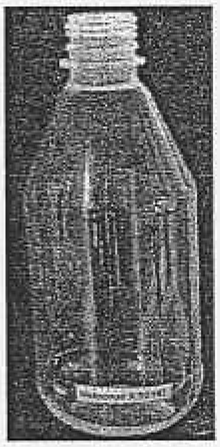




The material properties challenge: novel resins for food packaging

The combination of *Spherizone* technology and *Avant* ZN Diether catalysts generates new polypropylene products, having:

- Better intrinsic purity and inertness
- High clarity and toughness
- lower weight at equivalent mechanical performances ⟶ better packaging effectiveness



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The material properties challenge: wider applicability

In automotive industry, *Spherizone* technology and Avant ZN new catalysts permit to cover wider range of product requirements, allowing:

- Raw material rationalisation
- Further weight reduction
- Easier recyclability

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In conclusion:

Thanks to the *Spherizone* technology and to the newly developed Ziegler-Natta catalysts, Diether and Succinates, the technological challenge for polypropylene properties expansion will continue also in next decades; these are the most recent results of Professor Giulio Natta heritage.

Thank You

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