# The *Spherizone* Process: A New PP Manufacturing Platform

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**Summary:** The development of the new Spherizone technology, based on the innovative reactor MultiZone Circulating Reactor (MZCR), exploits its capability to generate innovative polypropylene based materials. The MZCR is made by two legs, through which solid is kept circulating: the riser, operating as a fast fluidized bed, and the downer, where the polymer particles descend in plug flow. With a simple arrangement (a monomer stream, called ''barrier'', fed at the top of the downer), the reactor's legs can operate under different reacting conditions, allowing the production of different polymers in the two zones: the consequent mixing of the two polymer phases is not achievable with any other technologies beforehand. This, in turn, leads to improved properties, such as: stiffness and processability for pipe; broader processing window, good optics and high stiffness/impact in thermoforming; processability at very high speed in BOPP; superior clarity in blow molding, blown and cast film; softness with good tenacity in fiber; improved impact/stiffness in injection molding; high melt strength for foam and compounding.

**Keywords:** fluidization; MZCR; polymerization; polyolefins; polypropylene

## Introduction

Since the early stage of the polyolefins development, the evolution of the catalyst chemistry and morphology as well as the process technologies allowed a wide expansion of polymer properties. This article wants to summarize the development of the new polypropylene technology Spherizone, based on the innovative reactor MultiZone Circulating Reactor (MZCR). The pioneering work on the MZCR began in 1995; then the development was made on two pilot-scale plants at Basell's R&D Center in Ferrara, Italy, and was finally scaled up into an industrial unit started up in Brindisi, Italy, in August, 2002. The Spherizone PP technology has been available for licensing since 2003.

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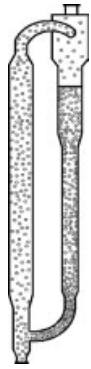
### The Technology

The *Spherizone* process, using Basell's high yield/high selectivity catalysts, produces spherical polymer particles with an outstanding morphology control directly in the reactor. The catalyst is fed continuously to the MZCR, core of this new technology. This loop reactor consists of two distinct reaction zones, each operating under its own peculiar fluid-dynamic regime. In the so-called ''riser'' the polymer particles are entrained upwards by the monomer flow in a fast fluidization regime. Gas superficial velocities are maintained at much higher values than the average particles terminal velocities, so that a highly turbulent flow regime ensues. This generates an optimal heat exchange coefficient between the single particles and the surrounding gas, and ensures that the reaction temperature is kept constant along the reaction bed. Head losses in this area are comparable to those along a fluidized bed of the same solids hold-up, while maintaining a high bed voidage, as typical of fast-fluidized bed.

In the top of the reactor, the riser gas is then separated from the solids, which enter the so-called ''downer''. The latter operates as a moving packed bed, with the polymer flowing downward by gravity. Since it operates close to an adiabatic regime, the reaction heat will increase the temperature of the solid bed as the polymer descends. Therefore, care is taken to recirculate enough polymer to prevent the formation of hot spots and generally excessively high temperatures along the bed. The continuous, massive recirculation of the polymer particles between the two zones makes the residence time per pass in each zone one order of magnitude smaller that the overall residence time.

The two sections of the reactor, riser and downer, can be operated at different compositions in hydrogen (used as chain transfer agent) and co-monomer, allowing for the development of a bimodal polymer structure (in terms of MW and/or comonomer concentration/type) at a macromolecular level. That can be accomplished by the introduction of a fluid hydrocarbon stream, called ''barrier'', on the top of the downer just below the polymer level, so that the gas descending along the downer is replaced by one with a different composition.



This simple arrangement allows the production of different polymers in the two legs and contemporaneously allows an intimate mixing of the different polymers being produced, giving a very good homogeneity of the final product. That, in turn, leads to improved mechanical, physical and optical properties as well as a better processability of the final product.

As an option, the polymer can then be fed to a fluidized bed gas-phase reactor, operated in series with the MZCR, where additional copolymerization can take place to yield high-impact copolymer PP.

The above mentioned features are the major advantages over competing technologies as it greatly expands the product portfolio while keeping operating and investment costs low.

## The Products

While the *Spherizone* technology can make all the conventional PP grades, several new products have been developed by exploiting its unique features. Here below a few examples are reported.

### *Moplen RP1669*

This is a new grade designed for soft textile applications, particularly medical and hygiene. It exploits the capability of the Spherizone technology to control comonomer distribution, combining a low crystallinity component, contributing to the softness, with a high crystallinity component, which gives tenacity. The perfect homogeneity between the two phases makes this product suitable for high spinning speed application, mainly spunbond, but also POY. It significantly improves nonwoven softness and allows very high spinning speed, even at full machine output.

### *Adstif HA1686*

It is specifically designed for high-barrier sheet applications, like crystal clear cups and trays for the packaging of fruit and vegetables. It exhibits a very high stiffness, providing good dimensional stability in thinner gauges after hot-filling or microwave

reheating. New designs and decorations are possible with Adstif HA1686, allowing brand differentiation and substitution of traditional glass and metal small packs.

*Higran RS1684*

This high melt strength resin aims to replace the existing foamed trays made of expanded polystyrene (EPS) and conventional PP. Due to its unique polymer' structure, it has significantly increased melt strength and extensibility in the molten state over conventional PP polymers. The foamed trays show superior overall productivity on automatic packaging lines versus EPS-trays. The excellent processing stability during foam extrusion results mostly in a light, very consistent foamed sheet with a fine micro-structure at densities lower than 500 g/dm.

*Clyrell EC1664*

It offers an innovative combination of clarity, stiffness and low temperature impact to the thermoforming sheet and blow moulding market. Main applications are impact-demanding packaging stored at freezer conditions like chilled packaging of poultry, meat, ready meals and fish.

*Clyrell RC 1314*

It is designed for clear blown film applications in mono or multilayer (side layer) structures.

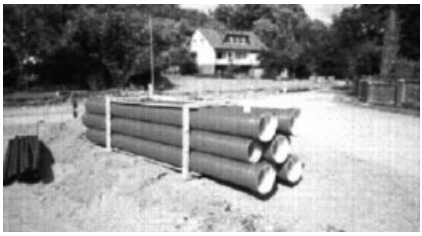
Its unique combination of optical properties, high stiffness, low gel and odour levels, plus good sealing performance make this resin an excellent choice for laminated film and transparent food packaging film applications, like baked goods, biscuits and vegetables as well as textile products. Potential applications include reportable food pouches, hygienic packaging and large pet food bags.

*Hostalen PP H2483*

This pipe grade has outstanding stiffness (flexural modulus above 1900 MPa), while maintaining good impact performance. It has been developed for use in smooth bore pipes where the intrinsically high modulus

is a critical factor. The high rigidity of the material, combined with excellent processability allows a significant reduction of wall thickness (while keeping resistance to deformation under pressure).



*Moplen XH 1760*
It is specifically designed for very high speed production of BOPP films. It can be used in plain and co-extruded film structures, providing easy film stretchability, an improved thickness profile and very good compatibility with the skin layer resin. In addition to the excellent processability also film stiffness and optics are very good.

## Conclusion

Basell's proprietary *Spherizone* polypropylene process was successfully developed and scaled up from pilot plant to industrial size. With a unique way to generate polymers, it allows the production of polymeric materials with superior physical properties and processability.

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