Metallocene polyethylene solutions for structural parts
Overview – TOTAL Gr.

Various Catalysts to make polymers

Metallocene Catalyst – Features & Advantages

Rigidity/Stiffness of various polymer

2 layers and 3 layers foam structures

TOTAL’s Metallocene PE Foam vs Conventional foam

Characteristics and compression test of TOTAL’s Foam

Processing of foam & Applications
TOTAL IN BRIEF

Total is the world’s 4th-ranked oil and gas company¹ and the 2nd largest solar energy operator with SunPower.

WITH OPERATIONS IN MORE THAN 130 COUNTRIES, we have over 100,000 employees who are fully committed to better energy.
MOST COMMONLY USED CATALYSTS TO MAKE POLYETHYLENE AND POLYPROPYLENE

Chromium

Ziegler-Natta

Metalloocene
MOST COMMON CATALYSTS USED TO MAKE POLYETHYLENE AND POLYPROPYLENE

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Metallocene</th>
<th>Ziegler-Natta</th>
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<tr>
<td>Active site</td>
<td>Single</td>
<td>Multiple</td>
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<tr>
<td>Molecular weight distribution (MWD)</td>
<td>Narrow</td>
<td>Broad</td>
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<tr>
<td>Comonomer distribution</td>
<td>Uniform</td>
<td>Heterogeneous</td>
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<tr>
<td>Comonomer repartition</td>
<td>Random</td>
<td>Blocky</td>
</tr>
<tr>
<td>Comonomer incorporation ability</td>
<td>Excellent</td>
<td>Poor</td>
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**Metallocene Catalyst**

**Ziegler-Natta Catalyst**

![Metallocone Catalyst](image)

![Ziegler-Natta Catalyst](image)
RIGIDITY/STIFFNESS OF VARIOUS POLYMERS

- Very flexible (EVA) to stiff (PP) materials
- How to extend further the range? → FOAM structured materials!
The flexural rigidity (Stiffness) of a part is proportional to:

1. Flexural modulus of elasticity of the material, E
2. The 2\textsuperscript{nd} moment of inertia, I

For a solid wall rotationally moulded part, the Second Moment of Inertia, I

\[ I = B \text{ (width)} \times D^3 \text{ (thickness)}^3/12 \]

- Thickness has crucial influence on stiffness: Doubling the thickness will give 8 times (i.e. \(2^3\)) greater stiffness
- However, the weight of the part, and hence its cost, is doubled and the cycle time will be significantly increased

Need to use efficient alternative
STRUCTURAL PARTS WITH FOAM

Single skin rotomolded part, 6 mm wall thickness

3 mm of plain material will be replaced by a foam layer, same overall weight.

150 to 200 kgs/m³

18 mm
2 LAYER FOAM STRUCTURE - SKIN/FOAM (T BAR)
3 LAYER FOAM STRUCTURE - SKIN/FOAM/SKIN (IBAR)

PE / foamed PE / PE
COMPARISION – SKIN/FOAM AND SKIN/FOAM/SKIN

Skin/Foam

Skin/Foam/Skin
TOTAL’s Unique Metallocene Foamed PE (TP-SEAL® and BIO-TPSEAL®)
TOTAL’s Metallocene PE Foam Compound can overcome this problem.
TP-SEAL® & BIO-TPSEAL® SKIN/FOAM/SKIN STRUCTURES: TOMOGRAPHY OF THE FOAM LAYER
Compression Test:

Skin/Foam/Skin samples have been compared to monolayer parts in compression test.

- Single skin part = 7.0 mm thickness (mPE and Alloy of mPE and PLA)
- Skin/Foam/Skin part = 8 mm foam, 3 mm outer skin, 3 mm inner skin
- Skin/Foam/Skin part = 11 mm foam, 3 mm outer skin, 2 mm inner skin
- Skin/Foam/Skin part = 17 mm foam, 3 mm outer skin, 3 mm inner skin
FOAMED STRUCTURED MATERIAL : VIDEO ILLUSTRATION

Compression test = constant displacement and force (N) recording
LOAD VS DEFORMATION

log scale!

10000

1000

100

10

0

2

4

6

8

10

12

DEFORMATION IN % (COMPRESSION TEST)

12 times more load bearing capacity than monolayer with same weight

30 times more load bearing capacity than monolayer with +30% weight

COMPRESSION LOAD (N)

Monolayer

Skin/foam/skin (BTPS) ==> same weight as monolayer

Skin/foam/skin (BTPS) ==> + 30% weight

Skin/foam/skin (TPS) ==> + 30% weight
FOAM – PROCESSING

melt – melt – melt – foam process

- TPSeal® PE FOAM to be dropped at ~135°C
- 3-layer structure formation prior to foaming
- PIAT not exceeding ~160°C in order to prevent cell collapsing

- => importance of monitoring the temperature at each step!
- => electrical heating and robotization are the key of success!

http://www.ams-innovation.com/
FOAM STRUCTURE – KEY ASPECTS

Light

Safe

Clean

Combining the best of different materials in multilayer

Having a perfect understanding of polymer LT & ST behaviour

Functionalizing to change polymer properties
APPLICATIONS OF TOTALS’ FOAM COMPOUND (TP-SEAL® AND BIOTPSEAL®)

• Skin/Foam/Skin ➔ mPE / mPE / mPE

• Boats
• Structural parts
• Buoys

BioTPSeal®

• mPE-PLA alloys
  • Monolayers
  • Multilayers
    • Skin/Foam/Skin,
    • Skin/Skin

• Structural parts.
• Low warpage parts.
• Very high stiffness parts
• Paintable parts
• Design parts
CONCLUSIONS

• TOTAL has been continuously striving to push the boundary of rotomoulding process by introducing various tailor-made products

• With these various new development, industry stake holders can now enter into the applications which have generally been restricted to Engineering Polymers

• With its dedicated team to rotomoulding segment, TOTAL will continue to serve rotomoulding industry in terms of introduction of new material, material characterization, process optimization etc.
Thank You !!

TOTAL REFINING & CHEMICALS

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