KEIRYO PACKAGING SA
Maximizing materials efficiency for a better environment

The KP Technology Platform
Injection Stretch Blow Molding
Direct Injection

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About this document

This document has been created by Keiryo Packaging SA for the purpose of providing the reader with further detailed perspectives on the selected topic.

Although carefully established, the document does not seek to be complete or exhaustive on the selected topic.

The representatives of Keiryo Packaging are always available to provide further context and to enter into continued dialogue should this be desired. Please refer to the ‘About Us’ page on the website to find the appropriate contact details.

Meanwhile, enjoy the read and we are looking forward to be hearing from you.
The KP Technology leverages the macromolecular dynamics of the semi-crystalline polymer material

**CONVENTIONAL PARADIGM**

Considering the material bulk dynamics only: accepting associated limitations

**Belief:** Exposure to deformational flow is inherently bad for the material

Molecular dynamics are not leveraged beyond the limitations imposed by the bulk polymer material

**Conventional processing technologies have fully exploited material capabilities**

**KEIRYO PACKAGING PARADIGM**

Leveraging the material macromolecular dynamics: creating opportunities

**Fact:** Controlled deformational flow does not harm the material

Activate flow enhanced nucleation & induced crystallization to leverage the molecular dynamics

**KP Technology can further exploit material capabilities**
The deformational flows provide the activation energy required to introduce changes to the molecular morphology of the polymer melt.

**Activation Energy**

**Molecular Stretch**

- **Amorphous material**
  - On/Off threshold
  - Amount of activation energy exercised onto the polymer melt is insufficient to alter the most natural polymer conformation – being random coiled amorphous

- **Oriented Amorphous material**
  - On/Off threshold

- **Internal orientation of spherulites**

- **Fibrillar precursors + shish formation**

**Molecular Disentanglement**

- **Amorphous random coil** is being disentangled - orientation is introduced in direction of flow

- Creation of flow precursors with various molecular conformations based on the degree of molecular stretch being introduced
KP Technology is introduced through 3D metal printed KP Products inserted into the hot runner nozzle housing of a conventional injection set-up.

KP PRODUCTS DELIVER THE REQUIRED ACTIVATION ENERGY ONTO THE POLYMER MELT WHEN PASSING THROUGH THE ENGINEERED FLOW CHANNELS.
The KP Products introduce the required activation energy into the polymer melt

- Pressure
- Δ Temperature
- High Stress
  - Molecular Order
    - Shear / Extension / Confinement
- Activation Energy

- The **activation energy** results from the degree of **molecular ordering** which is being introduced into the polymer melt under an increased **local pressure** and pressure-corrected local polymer **melt temperature**

- **Molecular Ordering** is realized through a **designed** combination of **shear-based**, **extensional-based** and **confinement-based** molecular deformation

- Only the shear-based deformation is scaling with the injection volume rate Q
The KP Products deliver an engineered activation energy which is calculated based on internally developed flow modeling & computational analysis.

**Scientific basis**

**Flow enhanced nucleation & induced crystallization**

**KP FLOW MODELING & COMPUTATIONAL ANALYSIS**

**CHARACTERIZATION OF KP PRODUCTS**

- **Polymer Material Properties**
  - Diverse polymer material characteristics are considered

- **Processing Conditions**
  - Diverse polymer processing conditions are considered

**Flow field strength**

- \( Wi : \text{Weissenberg} \)

**Exposure duration**

- \( De : \text{Deborah} \)

**Thermodynamics**

- \( \Delta T \)
Polymer crystallization level governs material properties. PET has both amorphous and crystalline regions. Balance between amorphous and crystalline regions determines the performance.

**CONVENTIONAL TECHNOLOGY**

1. PET material remains essentially amorphous after preform injection.
   - Conventional technology avoids any thermally induced crystallization in the preform.

2. Bottle functionality obtained through stretch blowing.
   - Crystal formation through material biaxial stretching.

**KP TECHNOLOGY**

1. PET material is self-re-enforcing under the applied flow conditions.

2. Bottle functionality obtained through injection & stretch blowing.
   - Increased orientation.
   - Polymer reinforcement.

**Summary**

- **Underutilizes Material Performances**
- **Optimizes Material Performances**
Maximizing materials efficiency for a better environment

488, Route de Longwy, L-1940 Luxemburg (Luxemburg)
RCSL B 190 814
National Number 2014 2219 604