Material Transformation

A Big Wave for the Plastics Industry

Materials transformation is all about having multiple ingredients come together for it to have applications and features that are better than what it could be done earlier. If any organisation is successful in achieving this, it implies a longer successful business proposition. For, only innovation in materials transformation can ensure a sustained growth in business.

Materials have always been responsible for changing the way new products get designed and developed so that enhanced features and functionality can appeal consumers. Whether in household, industrial, defence-related products or components of highly engineered aerospace modules, newer materials with better physicochemical properties and performance are responsible for the impressive progress and breath-taking achievements. The new age materials not only display the potential to weather acute deterioration due to physical, chemical and environmental stress, but also are highly sustainable and eco-friendly in the way they are manufactured.

The demand for constant innovation to improve user comfort and convenience is one major force, but another important one is the quest for improved energy efficiency in the age of climate change and global warming. For instance, car manufacturers are looking at light-weighting of automobiles and they need materials that can meet their stringent requirements and multiple objectives. Likewise, new generation materials are making their way into the aircraft industry, as manufacturers plan to build bigger and better fuel-efficient airplanes to revolutionise the transportation sector.

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Metals, ceramics, stones and such fall into one category of materials that were present well before any life evolved on the planet. Most other materials are carbon forms that contain large molecules of repeating units built by mankind. Whether we call them paper, textiles or wood, these are made from macro-molecules that are synthesised by an organism in a cell. Plastics are made from molecules that are synthesised in a reactor vessel. Such materials can now incorporate other important ingredients for various functional and performance characteristics and such an effective modification leads to the transformation of materials. There is no doubt that effective materials transformation will herald a big wave for the plastics industry in the coming years with amazing new materials. But, how do we achieve it? Do we have the technology to sustain effective materials transformation in the long run?

Transforming Materials: The Question is How?

Technology platform to transform materials effectively are today widely available, but only those that take care of three critical factors, can claim to be successful, as below.

- Control over temperature
- Time taken for processing materials
- Pressure applied

The above three factors result in better control over transformation of materials. These are relevant because the plastics industry faces a unique challenge of ensuring uniformity of the molecular structure of materials when they are processed with complex additives and reinforcements. Achieving an optimal dispersion of these complex additives and reinforcements, while protecting materials from degradation, is made possible through advanced transformation technologies.

A platform technology aimed at continuously processing materials with self-cleaning ability resulting in a chemical reaction to increase the molecular weight or viscosity without gelling, is spurring the development of newer extrusion technology using co-rotating twin-screw extruder.

Such a revolutionary platform technology, available today, is positioned to successfully transform materials such as natural fibre, jute, chicken feather and other sensitive materials for a wide range of applications in plastics. These processing platforms are a combination of high-performance technology, heavily design-oriented and demonstrate advanced engineering at work. It is important that every section is designed with a thorough understanding of mixing and materials for better outcomes.

Comprehending Technology and Processes

Applications in advanced materials technology are significantly influenced by the process capability of a self-cleaning intelligent compounding processor. The fractional-lobed twin screw technology addresses these issues. This is resulting in a greater than ten-fold improvement in process capability accompanied by precise spatial, temporal and functional control, triggering rapid growth of applications in process technology bringing in 21st century outlook to advanced materials development, not just limited to construction materials such as plastics and paints, but also others.

The fractional lobed invention, has transformed the co-rotating twin-screw extruder into a 21st century fully self-cleaning Intelligent compounding processor offering an opportunity to work on wide range of materials using precise application of forces that smear, elongate, re-orient, compress or fold the material – kneading, stirring or shearing at specific zones of the processor. This has resulted in a quantum jump in process capability (> 10x) that allows process to be achieved in a 'fraction of a second' residence time.

> Material transformation is all about doing it right with least energy, inputs and specific mechanical energy input. A good compound is the result of a thorough understanding of what goes on inside the 'extruder processing zone (EPZ)' for materials transformation. The key to success lies with the exact design of the 'element and barrel' configuration and the shaft design.

This fractional lobed processor creates the necessary impetus for product development in a new generation of plastics and sustainable programmes in bio-materials, advancement in polymer compounds and paints, unique processing conditions for food and beverage products; thereby ushering in a new age of advanced materials transformation.

Material Transformation: A Typical Case

Material transformation is all about doing it right with least energy, inputs and specific mechanical energy input (SMEI). Factors to be considered for effective material transformation are:

- Chemical and physical energy needed to transform the material
- Energy input
- Efficient use of energy.

For instance, a good compound is the result of a thorough understanding of what goes on inside the 'extruder processing zone (EPZ)' for materials transformation. The key to success lies with the exact design of the 'element and barrel' configuration and the shaft design.

A recent example included developing an enhanced process for a compound comprising of polylactic acid (PLA) with aluminium trihydroxide (ATH) flame retardant, chopped glass fibre, silicon oil and plasticiser (oil). Achieving an optimal dispersion of these complex additives and reinforcements while protecting the PLA from degradation was an industry challenge.

It is well documented that PLA and ATH are very sensitive to heat and shear. PLA will have excessive loss of molecular weight and properties, and aluminium trihydrate (ATH, Al(OH)3) will degrade and lose its capacity as a flame retardant. ATH loses its water molecules when heated or sheared. PLA is also very sensitive to hydrolysis (MW loss) in the presence of water. If ATH loses its water during processing, the water will hydrolyse the PLA. It is also desirable to remove water immediately after melting the PLA through vacuum venting.

It is advantageous to retain the fibre length of chopped glass to enhance reinforcement properties. Typically, 6 mm chopped glass will experience significant attrition during compounding so that the average fibre length in the final product is less than 1 mm. The silicone oil and plasticiser are immiscible in PLA. For optimal performance, it is necessary to create a very fine droplet formation. This requires dispersive mixing which can increase glass fibre attrition still further, reducing fibre length in the final product, and creating an environment where PLA and ATH are damaged from the excessive shear and heat. Intelligent energy management is required to create a processing environment in which excellent mixing of all components are achieved with minimal damage to the components.

Success has been achieved in producing a product that retained the properties of the PLA, provided optimal dispersion of the ATH and oil, and all while preserving the length of the reinforcing glass fibre.

Business Growth Through Technology

An accurate materials processing platform technology, which can deliver the desired results, is crucial for the plastics industry. Some currently available platform technologies processes materials which are sensitive to shear. Even the most sensitive of materials can now be transformed into value-added functional products.

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