Evolution of the art of casting nylon

by Mike Worthington

What do the following items have in common?

- Railroad locomotives.
- Amusement park rides.
- Cranes.
- Food processing equipment.
- Skateboards.
- Pens.
- Toothbrushes.
- Yogurt.

Thought you were onto something until we threw in pens, toothbrushes and yogurt, right? Well, you probably were. The fact is they all use "plastic" in some form or other – but distinctly different types of plastic. Even the first five of the above use several different types of plastic, engineered for a specific purpose.

The competitive world of plastics

Plastic is a huge word in terms of what it covers; it runs all the way from peanuts-per-pound material for yogurt containers and other household items – which anyone can produce by buying an extruder or molding machine – to hundreds of dollars-per-pound for high performance engineering materials, which take specialized equipment to run. Which product fits which application? Will it work as-is or does it need reformulating? Is it readily available? Is it cost justifiable?

As the art of casting nylon continues to evolve, 4 feet x 10 feet plate and 30 percent glass-filled shapes and parts are the latest product offerings from Cast Nylons Ltd.

You have all been there; you have all asked these questions. But who answers them? Normally, the manufacturer does because he or she is the one who has to turn your need into reality.

As products evolve, they often take the well-worn path from "innovative and new" to "commodity." Some, like UHMW-PE and nylon, move quickly because of their ease of processing, low investment cost to produce and wide market potential. Others, like polyimides, move a little slower because they are much higher cost, harder to process and have relatively small markets.

After everyone has jumped on the band wagon, and the market is being saturated by a wide range of products all claiming to do the same thing but better, and whoever has the best price and fastest delivery gets the order, where do manufacturers turn to develop and maintain an edge in a very competitive market? While there is not much one can do with a basic commodity product, except produce it faster, which needs capital investment, the real growth solution lies in innovation and new products. Companies don't grow very quickly, if at all, by cornering the market for low margin commodity items.

So where do plastics manufacturers turn to know what to do next? We listen to our customers as they tell us what they would like to see our products do. We keep track of all the off-the-wall requests until we have enough ammunition to warrant developing something new. We look at the failures of existing products and try to figure out how to make them successful without having the customer completely redesign equipment. To develop a new formulation or a new shape requires, not only a market, but also the ability to produce the product.

Since the casting of nylon is such a small industry, very little exists in the form of off-the-shelf equipment; most manufacturers design and build their own casting equipment to suit each specific process. So as a new product is being developed, so too is the necessary casting equipment, tooling and procedures for processing.

Early product development years

When first developed, cast nylon was natural in color. So, to differentiate it from extruded nylon, a blue dye was added. The material performed extremely well in most applications where it was determined to be suitable but had a tendency to melt under certain bearing conditions. In an attempt to reduce its coefficient of friction and thus improve its performance as a bearing material, molybdenum disulfide was added. This was not a huge success as is evidenced by the fact that no manufacturer today claims any significant bearing advantage for what has become known as "MDS nylon."

To produce a product with a truly lower coefficient of friction, methods were developed to allow the addition of lubricants directly into the raw material mix, some liquid in the form of oil and some solid in the form of wax. These additives provided a significant improvement by increasing the material's PV capability, increasing it from 3,500 for a standard nylon to 16,000 for a lubrication filled nylon. This new product had significant impact in applications where external lubrication is undesirable or difficult to maintain.

Internally lubricated products now fill approximately 30 percent of today's cast nylon market, most of which represents market growth since standard nylons would not be appropriate in these areas. Again, after the first internally lubricated products were introduced, other manufacturers figured out how to copy and the race for an edge was on again.

Additives and new formulations

Nylons have always been a problem operating in high impact areas, particularly

in cold environment applications. To overcome this, plasticizing agents and other impact modifiers are added which significantly increase the materials impact strength. Agents can be in the form of plasticizers or simply a blend of different base materials like type 6 and type 12 nylons; these blended materials are often referred to as copolymers.

There are often needs for higher operating temperature capabilities for cast nylons, and adding a heat stabilizer is as far as we have come to this point. The heat stabilizer increases the material's continuous service temperature limit from 230°F to 260°F, not a lot but enough to help in some applications. (Care should be exercised when designing in this area. Since elevated temperatures cause loss of physical properties, an ambient temperature correction factor should be applied to ensure the material has sufficient strength at these higher operating temperatures.)

All these new formulations take time to develop since any additives to the basic caprolactam/activator/catalyst mix that produces natural cast nylon will have a significant impact on how the material polymerizes. Dyes that look blue in their natural state don't look the same blue after a part has polymerized. So a lot of lab work goes into developing each new formulation and color. It may be easy to produce a 3-inch diameter x 4-foot long cast rod, but trying to increase the length to 8 feet requires weeks of trial and error casting, not to mention a complete new oven to hold the newly designed mold.

Today's growing industry

Where are we going today, what's new and what's "on the drawing board"? Well, I can't tell you much about the drawing board which is constantly busy, but I can tell you about new developments that have recently been introduced to the market.

Extruded products have long been available with a variety of fillers, fiberglass for strength and stiffness and carbon fibers for conductivity among others. This is a relatively simple process of blending the additive fibers into pellets used for extrusion. Customers have asked for a long time to be supplied with glass filled cast nylon to make structurally stronger parts. Manufacturers on the other hand have claimed that additives could not be put into cast nylons because of the problems keeping them in suspension during polymerization. Adding glass fiber to caprolactam is the same as adding sand to water; everything sinks quickly to the bottom.

Recent innovations in processing techniques and additives, however, are now enabling the production of up to 30 percent glass filled cast nylon shapes, with some very interesting glass filled custom cast parts business also developing. Low cost tooling, rapid tool delivery and fast production cycle times are offering significant advantages for lower volume parts where injection-molding tool costs, or even machining parts from blanks, are prohibitive.

Part sizes for cast nylons are limited only by how large an oven is available or how large a tool and part can be safely handled. Originally, cast nylon rods were produced in two-foot lengths. As casting technology improved, rod lengths increased to four feet to enable better part yield, and today are as long as 10 feet. Similarly, tubular bar lengths were originally 13 inches to mimic the lengths of bronze tubes, which was the original replacement target for nylon tube. Again, with improvements in casting technology and capabilities, lengths increased to 26 inches and today they are as long as 78 inches.

Cast nylon plate was originally produced in 24 inches x 48 inches sheets; various other sizes crept in along the way, including larger metric size sheets from European manufacturers. Today, 4 feet x 10 feet sheets are readily available from North American manufacturers. This new sheet size is of significant importance to machine shops using CNC controlled router equipment where sheet size and yield are critical to finished part cost.

So, what 30 years ago was a fledgling, mundane product line, containing three or four formulations, is today a well-rounded product line with some 15 to 16 formulations available. And the product range continues to grow. As I said, I can't tell you what's on the drawing board since that would be like an auto company showing you its concept cars before they become concept cars. I can tell you that new products, and new sizes and shapes for existing products, are under review on an ongoing basis. What we work on first and hardest is that which the market tells us is truly needed. So talk to me and tell me what you want. As TV's Fraser Crane would say, "I'm listening." ■

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