Lead Screws, High temperatures, High Loads…and Plastic Nuts?

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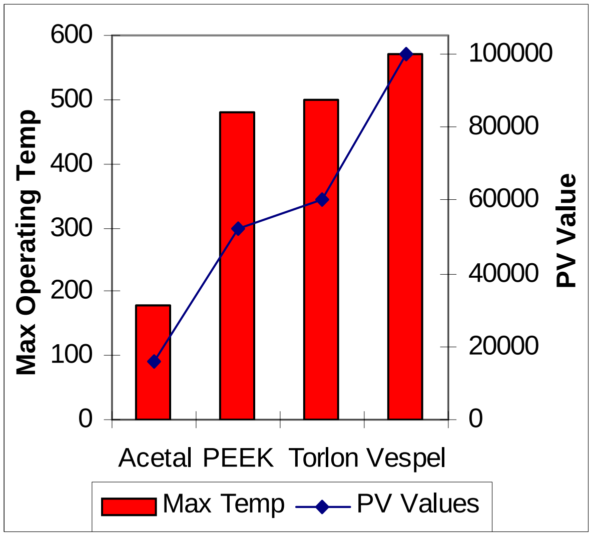
Lead screws are an effective and cost efficient way of converting rotary motion into linear motion. The key to ensuring the utmost efficiency in these screws is to provide proper lubrication at all times. To accomplish this, many companies use internally lubricated plastics in the manufacture of their nuts. This helps ensure that there is always proper lubrication to keep the system running smooth, quiet, and stiction free, without the nuisance of having an elaborate preventative maintenance schedule. However, what happens when the duty cycle is so high that friction generated heat causes the maximum temperature of the plastic to be exceeded? Alternatively, what if the screw assembly is being used in a high temperature application, or there is a high load? Most would say that a lead screw is no longer the correct solution for the application and that one must look into a higher priced ball screw, right? Wrong.

Thomson BSA has found solutions to the frustrating problems of high temperature, high load, high duty cycle applications by offering custom engineered polymers designed to work in these harsh environments. By using these engineered polymers, Thomson is able to apply lead screw technology into applications that previously would not have been possible. The end result is a reliable, compact, highly customizable product with just the right performance for your application.



The above graph shows the maximum operating temperatures and the PV limit for each of the four materials Thomson uses.

Thomson's standard polymer nuts are made from an acetal-based plastic blended with 15% PTFE (more commonly known as Teflon®) lubricant. This is a very cost effective solution but is only suitable for light to medium loads due to its low PV value. PV, or pressure velocity, is a measure of a material's ability to be dynamically loaded. The more load that is applied to a material, the lower the sliding velocity it can handle and vice versa. The PV limit of a material is the point at which friction generated heat can no longer be expelled at a rate to prevent the material from over heating, causing permanent deformation. Thomson has identified and used in practice three alternatives for their standard plastic: PEEK®, Torlon®, and Vespel®.

Torlon®, a plyamide-imide, and Vespel®, a polyimide, arrived on the scene in the 1970's. They offered PV limits 5-10 times greater then that of an acetal plastic and can still be compounded with internal lubricants, making them very attractive to lead screw designers. The down side to these two plastics is that they are more expensive then acetal and, due to their high melting temperatures, are not readily moldable.

In the late 1980's, PEEK® became available. PEEK® (Poly Ether Ether Ketone) has many benefits: it has similar properties to that of a polyamide-imide, it can be blended with all of the standard lubricants to create a bearing grade material and, unlike the other polyamides, it is moldable at high temperatures. And while it is still more expensive than acetal, it is much more reasonable than its polyimide counter parts.

Because these 3 materials have much higher PV limits than that of the standard acetal plastic and can be blended with the same PTFE to create a bearing grade material, they are perfect candidates for lead screw applications with high operating temperatures and loads. Below are a few applications where Thomson has introduced the use of an engineered plastic to help a customer with a design challenge.

Rapid Prototyping

Rapid prototyping machines are used in the product development world to help designers and engineers get products to market faster. This technology allows one to create solid, plastic, three-dimensional (3-D) objects from CAD drawings in a matter of hours. The first step of this process is to create a 3-D model using a CAD system. Then, software chops up the CAD model into a number of layers. Finally, a spray nozzle is moved in the required geometry and deposits a thin bead of plastic to form each layer. The plastic hardens immediately after being squirted from the nozzle and bonds to the layer below, creating a 3-D model. The spray nozzle is mounted on a 3-axis, gantry type system. Since the plastic being sprayed is in liquid form, the operating and ambient temperatures are very high.

Because this is a high accuracy positioning type application with large build quantities, Thosmon engineers decided to use the PEEK® material to mold a standard XC type nut. The XC nut is a patented design from Thomson that provides high axial stiffness, zero backlash, and absolute minimum drag torque. The Active-CAM automatically adjusts for wear, insuring zero backlash for the life of the nut. The PEEK® XC's ability to withstand high temperature, maintain zero backlash, and run nearly maintenance free, made it the perfect solution for this application.

Factory Automation

Many companies have looked at alternatives to pneumatic cylinders and have found that electro-mechanical actuators are an excellent replacement. This removes the need for an external air source and provides a much more accurate and repeatable solution for a positioning or pick and place application.

On one such changeover, one of Thomson's customers decided to go with a high RPM motor, turning at 4500 RPM, with a small 3/8" x .100" lead screw. The load requirement of the unit was 40-50 lbs. This combination of screw speed and load brought the temperature inside the nut up to 400° F, far above the 180° F maximum operating temperature of acetal. Another thing to consider is that this is a positioning application so accuracy is of utmost importance. To overcome these obstacles, Thomson engineers decided to use a Torlon® XC nut, providing a zero backlash assembly that could withstand the high internal temperatures produced by the friction between the screw and nut.

Positioning

In the music and entertainment industry, lighting and presentation are everything. In many situations, lights are moved or rotated frequently during a production to meet a performers needs.

As a case in point, one of Thomson's customers was looking for a gantry style system that would move a lighting system from one position to another. Because of the design of the system, the lead screw nut was located very close to the light itself, creating an extremely high ambient temperature (around 250° F). Another consideration was that this was a positioning application, however the accuracy of the system was not crucial to operation. With these criterion in mind, Thomson engineers concluded that Torlon® should be used to machine a standard nut that would have minimal backlash and could withstand the temperatures of the high intensity light. This allowed the customer to incorporate a low cost lead screw into their system without any design changes.

Plastics have allowed lead screws to go from the depths of the ocean to the reaches of outer space. Improvements in material have fueled advancements in almost every technology that we use today. If material development keeps its current pace in the next century, we will continue to see more and more lead screws replacing their ball screw counterparts in the design of new technologies.