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SySTEM Alert!

Tomorrow is almost here.

Let the swarf fly

There's an old saying among sculptors: "Every block of stone has a statue inside it, and it is the task of the sculptor to discover it." This is attributed to Michelangelo in the 1500s, but with a few tweaks it could be made new again: "In every block of metal, there is a perfectly cut part, and it's up to the machinist to find it."

A machinist is a worker who specializes in cutting away at a piece of material to leave only the desired part. The process is called machining and is done in a machine shop. When it comes to metal, the machinist has a serious job. Metal is valued for its hardness, but that also makes it hard to cut. Some serious tools are needed to do the job.

A milling machine is a classic technology for cutting a piece of metal into a desired form.

Metal on metal is what a milling machine does best. A spinning metal tool called an end mill cuts away at another piece of metal. The phrase "hot knife through butter" might not quite describe the apparent ease with which the cutting tool cuts through hard metal, but it isn't far off. The cutter presses against the surface of the metal, spinning its cutting teeth against it to wear it away. In the process, tiny metal chips called swarf go flying.

A standard milling machine relies on the machinist to manually guide the cutting. Another type of milling machine is called a CNC mill. Basically, it does the same thing except that the movements are controlled by computer. The commands are programmed by the operator.

At its manufacturing facility in Pittsburg, Kansas, Pitsco Education uses CNC mills to machine parts such as those for the Pitsco Structures Testing Instrument and the Pitsco Injection Molding Machine. (The Injection Molding Machine is small enough for classroom use, but for info about an industrial-scale injection molder, see the center spread in this issue.) Pitsco's primary CNC mill, which was once used in the aeronautics industry, is in essence the same as other smaller (and larger) CNC mills.

The machinist places a piece of metal that will be made into a part on a table inside of an enclosed workspace. The piece is held to the table with special vises. A vise is a device that secures an object in place between two jaws, which can be tightened together.

Parts are made from careful designs. Tolerances must be followed. Tolerances are the allowable margin of error. Cuts can't be infinitely precise; we don't have the technology to cut a piece of metal to the proper dimensions down to the atom. There is always a small amount of error. But machine shops get pretty precise. Using measuring devices such as calipers, machine shops often make cuts that are precise down to thousandths of an inch.

The machinist uses a keyboard on the CNC machine to program in the cuts the machine will make. The program tells the machine how to move its cutting tool and how to move the piece that is being cut. Every location can be described using three axes: x, y, and z. The machinist tells the machine where to cut by using these x-, y-, and z-coordinates.

On most machines, the x- and y-coordinates – side to side and back and forth – tell the table how to move, which naturally moves the piece vised to it. The cutting tool moves up and down along the z-axis.

The turret holds multiple cutters that can be fitted to the spindle (the part that holds the cutter), depending on which one suits the desired cut. Cutters are made of high-durability metals such as cemented carbide and high-speed steel. The tool spins around like a bit in a drill. But unlike a drill, which always bores straight into material, the CNC mill can make cuts by dragging the spinning tool across the surface of the metal piece, cutting away swarf as it goes. Some cuts might go all the way through a piece while others might merely cut into the piece, making grooves or indentations.

The machinist removes and examines the piece. The excess metal has been cut away. It might not be a piece of art, but the part that was hidden inside the block of metal is now revealed. ⚠

Mills of all sizes

The CNC mill used at Pitsco is, in the words of Machinist Tim Heincker, "a serious piece of equipment." With a workspace of 20" x 50", it can easily fit and cut parts such as the Maglev II Track. However, there are even more serious machines out there. CNC mills can be as large as buildings. One mill used to machine wind turbines, for example, has workspace dimensions of more than 60 feet! ⚠

Online quiz and electronic version now available. Visit www.pitsco.com/SySTEMalert.

Fitting the mold

Right this moment you are probably within easy reach of at least one plastic product. And you can be almost certain that at one point in its life, it was a scalding mass of molten liquid. Melting and reforming plastic is a very common manufacturing technique. One method for doing this is injection molding.

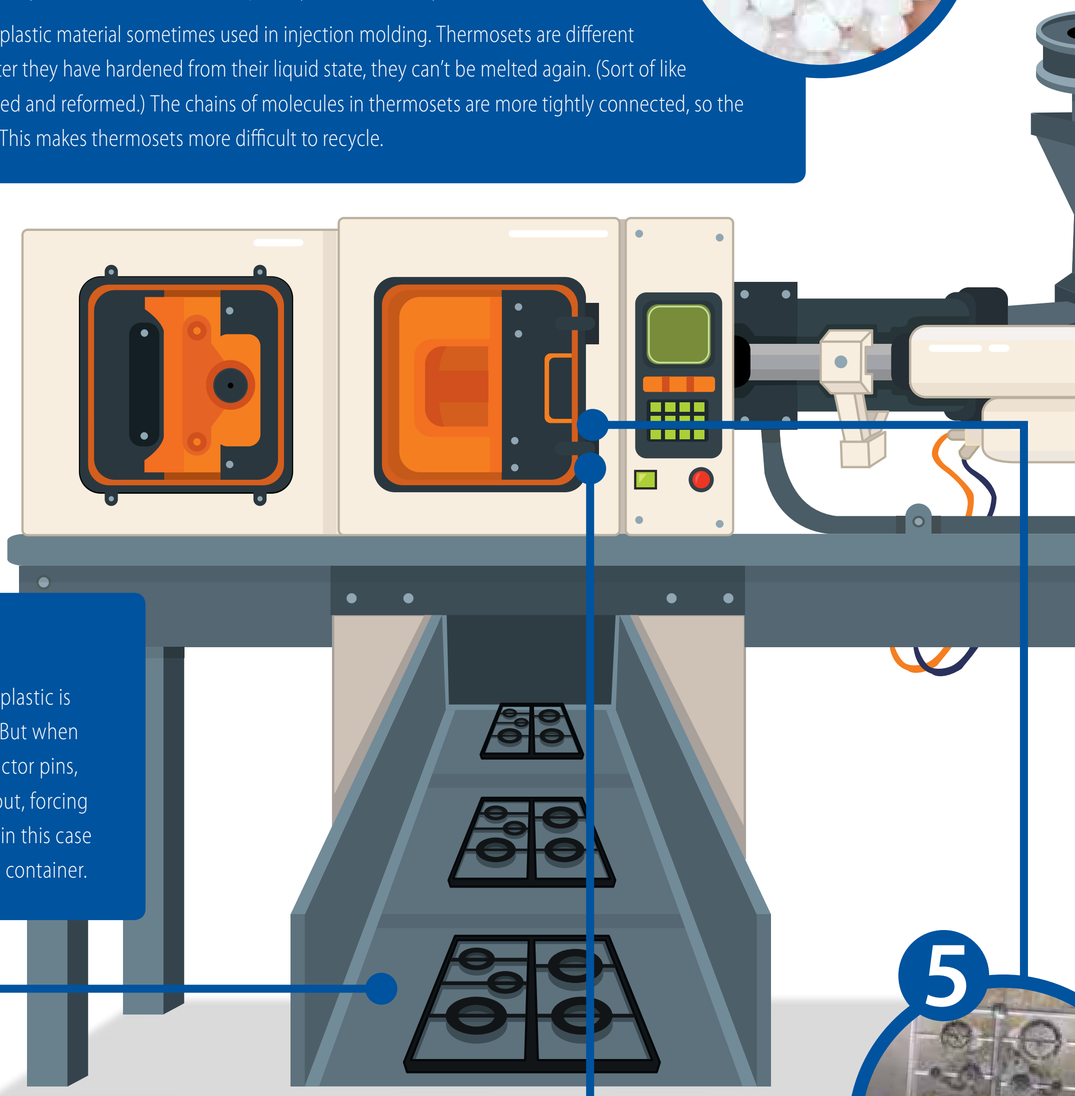
Injection molding can be used to make small products such as fishing lures and large products such as bed frames. At Pitsco, injection molding is used to make many products such as gears for robots and wheels for dragsters. *SySTEM Alert!*'s intrepid reporter recently tagged along during the production of a Pitsco dragster wheel. Though different products will use different processes, the gist is basically the same for anything that is injection molded.

1

The raw material

Usually a manufacturing facility will begin with thermoplastic pellets. This is how Pitsco dragster wheels begin. The advantage of thermoplastics is that they can be melted and formed into different shapes. Thermoplastics are formed of long chains of molecules that slide over one another when heated. This is what gives them their molten fluidity. When they cool, they harden into whatever shape they took when they were melted.

Thermosets are another type of plastic material sometimes used in injection molding. Thermosets are different from thermoplastics because after they have hardened from their liquid state, they can't be melted again. (Sort of like how a cooked egg can't be melted and reformed.) The chains of molecules in thermosets are more tightly connected, so the chains don't slide around easily. This makes thermosets more difficult to recycle.



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Eject

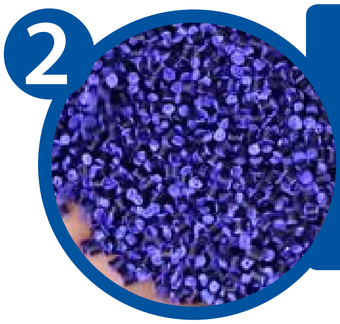
Most molds are constructed in two halves. When the plastic is injected, the two halves are pressed tightly together. But when the plastic has cooled, the halves are pulled apart. Ejector pins, cylindrical pins housed within the mold, are pushed out, forcing the hardened plastic part out of the mold. The piece, in this case several linked dragster wheels, falls out and lands in a container.

6

Cool down

The mold holds the molten plastic until it cools. Water (or sometimes another coolant) is pumped into chambers in the mold to speed the cooling process. The excess heat from the plastic is absorbed by the water and pumped away. The thermoplastic hardens into shape inside the mold as it cools. This cooling might only take a few seconds, or it might take longer.

5

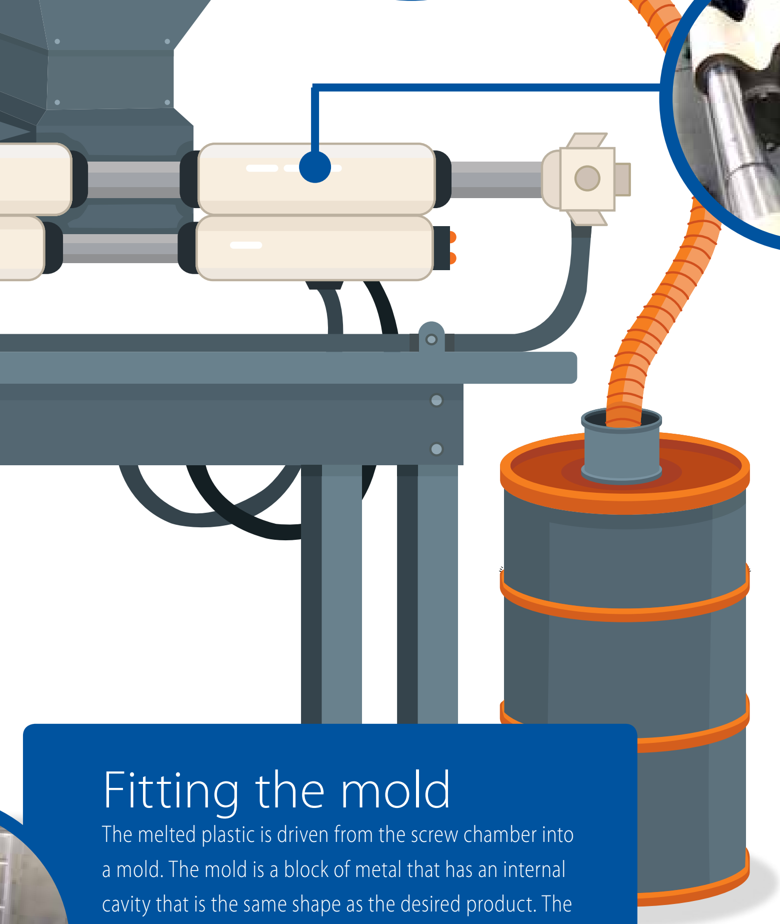


A splash of color

White plastic could do the trick to make a functional dragster tire, but function isn't everything. To add color, a dye is mixed in. In this case, the dye is just colored plastic pellets. This colored plastic is mixed in with the base plastic and both are ground up. When they are melted together, they tint the product. Dyes can be black or even much bolder colors. Fusion Wheels are an example of a product manufactured with bold colors.

Hopper

Now, it's time to get the party started. The ground-up plastic is fed into a hopper. A hopper is a container that feeds material down to a lower level. The plastic for the dragster wheel is first poured into a barrel and is then pumped to the hopper.



Around and around

The plastic is fed into a large interior chamber that holds a reciprocating screw. Have you ever held a standard carpentry screw in your hand and turned it around so that the threads appear to move down the screw? The plastic fills in the gaps between the threads of the screw, and the turning motion of the screw pushes the plastic forward. At the same time, heating elements heat the chamber to a temperature that causes the plastic to melt. Friction and a tightening chamber also play their parts in heating up the plastic. As the plastic is forced toward the front of the chamber, it melts.

Fitting the mold

The melted plastic is driven from the screw chamber into a mold. The mold is a block of metal that has an internal cavity that is the same shape as the desired product. The molds for dragster wheels have holes in them that are the shape of the wheels. The molds for robotics gears have gear-shaped holes (as shown in the picture). The melted plastic is forced into this cavity. Making a mold is an expensive, time-consuming, technical process.

Vacuum forming

Another common technology for shaping plastic is called vacuum forming. This technology also involves hot plastic and molds. Instead of pellets, however, vacuum-formed products start their lives as thin sheets of plastic. The sheets are heated and then stretched over the mold. The air separating the mold and the plastic is sucked away, forming the plastic around the mold.

This process can be experienced in the classroom with the Vacuum Former sold by Pitsco. The unit uses 6" x 6" x 0.20" plastic sheets and is very safe. ⚠

CHECK OUT:
www.pitsco.com/Vacuum_Former

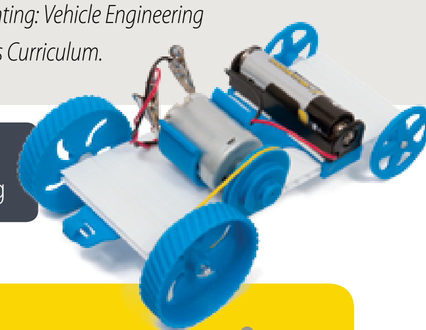
Getting started: One layer at a time

All products begin their life as an idea in somebody's head. Before it can be put into production, a product has to be designed and, usually, tested. Testing ensures the product will work and be safe. One of the most effective ways to test a product is to create a prototype. As 3-D printers have become more common, these machines have been used more and more to make inexpensive prototypes. Pitsco's Research & Development team uses a 3-D printer in the design phase all the time. In the image on the right, a prototype of a clip is being printed by Pitsco R&D Manager Paul Uttley.

1. First, the desired object is created as a 3-D model within a CAD software program and sent to the 3-D printer. After the printer is warmed up, the printing begins.
2. The nozzle moves back and forth, side to side, and up and down over the tray. It lays down the plastic in ultrathin layers, about 20 microns thick for each pass. It starts at the bottom layer and piles layer upon layer. Special plastic is used that cures (hardens) under UV light.
3. The printing process can take several hours. A support material is laid down together with the plastic. The support material holds the plastic in place until the whole object has been printed.
4. The soft support material crumbles away after a power washing in the sink. Protective gloves should be worn during the washing process.
5. The piece is finished. The material might not be suitable if it were a piece meant for the market, but for a prototype, it will work perfectly.

You can get in on the 3-D printing prototyping action in your classroom. The Afinia 3-D Printer offered by Pitsco is perfect for prototyping robotics gears, rocket nose cones, connector pieces, and many other parts. Or you can design hitherto unknown creations entirely from your imagination. The printer is economical and simple and comes with all the needed software. For a deeper experience, couple it with Pitsco's *3-D Printing: Vehicle Engineering Curriculum* or *3-D Printing: Design Solutions Curriculum*.

CHECK OUT:
www.pitsco.com/3Dprinting



Expanding on ExpandOS

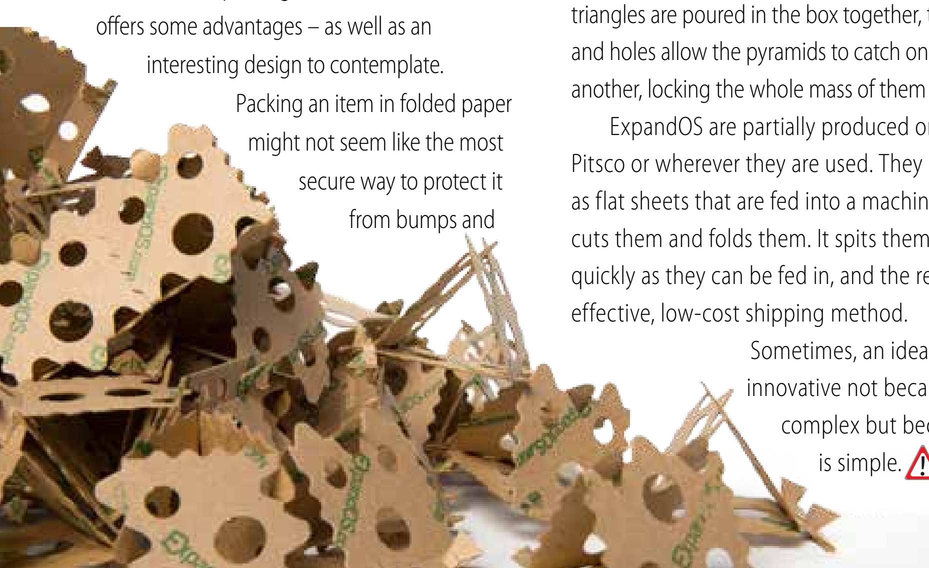
No doubt you've had the "Now, why didn't I think of that?" experience. We all have. Prepare to have it again. Or, if you or your teacher has recently received a shipment from Pitsco and opened the box to find hundreds of little paperboard triangles, you might already be saying that! Compared to bubble wrap and packing peanuts, ExpandOS are a new kid on the packing block. But this alternative offers some advantages – as well as an interesting design to contemplate.

Packing an item in folded paper might not seem like the most secure way to protect it from bumps and bruises. But ExpandOS are designed to suspend the product being shipped without letting it settle toward the bottom of the box or drift toward the sides where it is more likely to be damaged.

The secret is in the teeth along the edges of the triangles and the holes in the sides. First, the teeth along the edges allow the triangles to lock into shape, holding its form. And when the triangles are poured in the box together, the teeth and holes allow the pyramids to catch on one another, locking the whole mass of them into place.

ExpandOS are partially produced on-site at Pitsco or wherever they are used. They begin as flat sheets that are fed into a machine that cuts them and folds them. It spits them out as quickly as they can be fed in, and the result is an effective, low-cost shipping method.

Sometimes, an idea is innovative not because it is complex but because it is simple.



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Student name: ______________________ **Class/Hour**: __________

SySTEM Alert! Quiz (Volume 4, Number 3)

1. In a manufacturing setting, what is a hopper?
   A. a container that feeds material down to a lower level
   B. an electrical device that agitates molecules to make them rise, or “hop”
   C. a screw that turns within a sealed container to push material forward
   D. another name for an ejector pin

2. Small metal chips are a byproduct of machining metal. What are these chips called?
   A. swarf
   B. kerf
   C. chiplets
   D. dross

3. A _______ is a device that secures an object in place between two jaws, which can be tightened together.
   A. drill press
   B. CNC mill
   C. vise
   D. clamp

4. What is the name for a person who makes their living cutting away at a piece of material to leave only the desired part?
   A. former
   B. material cutter
   C. machinist
   D. remnant engineer

5. Any location can be described using three axes. What are these axes traditionally called?
   A. a, b, c
   B. Alfa, Bravo, Charlie
   C. x, y, z
   D. 1, 2, 3

6. What is the purpose of the support material when 3-D printing plastic objects?
   A. The support material chemically hardens the melted plastic.
   B. The support material holds the plastic in place until the whole object has been printed.
   C. The support material helps the printer keep track of its progress on the print job.
   D. The support material acts as a glue to hold the plastic molecules together.

7. What is the name for the spinning metal tool on a milling machine?
   A. end effector
   B. bit
   C. metal cutter
   D. end mill

8. How do the teeth at the edge of ExpandOS packing triangles help support an object that is being shipped?
   A. The teeth grip the object and hold it tight.
   B. The teeth are softer than the rest of the triangle, providing padding.
   C. The teeth catch on one another, locking the ExpandOS into place around the object.
   D. The teeth are harder than the rest of the triangle, providing support.

9. A _______ is a block of metal that has an internal cavity that forms melted material injected into it.
   A. mold
   B. hopper
   C. nozzle
   D. prototype

10. What is the major advantage of thermoplastics over thermosets in manufacturing?
   A. Thermoplastics resist deterioration from UV light.
   B. Thermoplastics melt more quickly.
   C. Thermoplastics can come in any color.
   D. Thermoplastics can be remelted and formed into different shapes.

Bonus question:
Pick a simple object you are familiar with and describe how you think it might be manufactured. Think of the different parts of the object and the steps that might be involved in creating it.