A Modified Vince Gingery Plastic Injection Molding Machine

By R. G. Sparber

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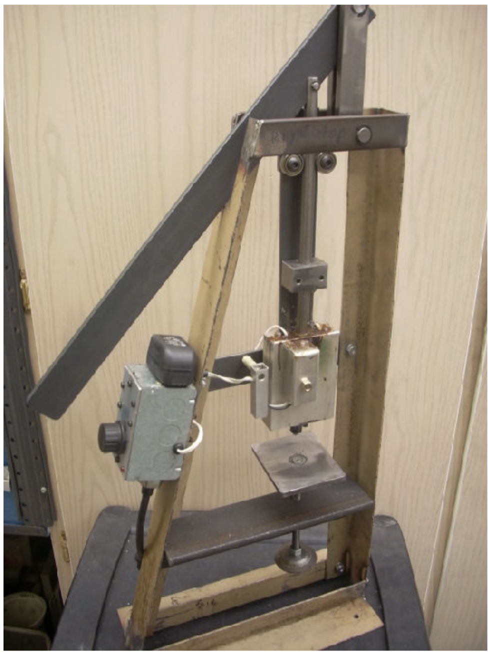
Introduction

Our lives are peppered with a lot of useless little bits of plastic junk. Yet molded plastic also shows up in many useful places like molded cables and the odd fastener. Molds can be machined from blocks of aluminum but can also be formed with molding plaster if a part is to just be duplicated. My initial goal is to mold polypropylene around wire splices.



What's it for?

This machine lets me make plastic parts at a very low cost. Rather than spend many dollars for cold mixed plastics that can then be formed into the desired shape, I can use recycled plastic. Even "virgin" plastic can be bought for around $2 per pound and one pound lasts a very long time. Corey, my "partner in crime", discovered a wonderful source of colored plastic at a big box store: plastic clothing hangers. They come out at around $1.37 per pound.

How does it work?

The plastic is heated in a chamber until soft. The lower end of this chamber has a small hole. The upper end of the chamber has a plunger. When ready, the plunger is forced through the chamber resulting in the molten plastic squirting out the small hole.

The initial Design

My starting point was Vince Gingery's design which can be found in:

http://www.lindsaybks.com/dgjp/djgbk/inject/index.html

Some modifications were selected before construction while the rest evolved as I started to use the machine.

My first set of mods related to my desire to use materials that were on hand. This included using some bed frame rails which can be seen here in tan. It was thinner than specified in the book but I was fairly confident that it would be strong enough.

Note that the handle pivots on one end. The shiny rod hanging down is the plunger. It connects to the handle via a pair of long links. The vertical bar to its right will support the plunger guide and heater block.

The first thing that bothered me about this design was the locating of the holes in the frame. The plans specified all hole locations followed by assembly. The holes are all close fit to the fasteners that will pass through these holes. If I drilled all holes first and then assembled the parts, it is very likely something would not be exactly aligned. These hole positions are really not that important, only the relative position of the frame members matters. So in all cases I drilled the holes at one end of each member, aligned it, and "match drilled" the other set of holes. When two holes are drilled at the same time like this, alignment is guaranteed.

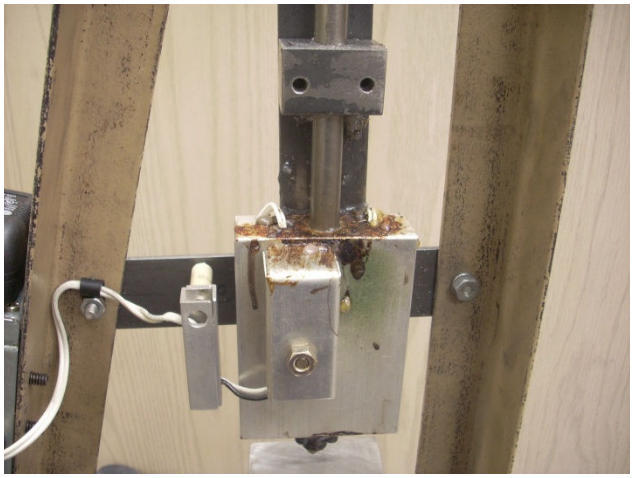
Plunger/Pull Handle Modification

Shortly after finishing the machine, I started to have trouble with the plunger/pull handle mechanism. There was far too much side force on the plunger. One good pull and my plunger bent. Time for a redesign. To my surprise, the design Corey gave me has the same number of parts as the old design yet works much better. It looks a lot like an old style hand water pump.

Side force on the plunger is greatly reduced but not eliminated.

I added a pair of ball bearings to support the top of the plunger and now the machine works well.

Plunger Guide and Heater Block



Below the ball bearing guide is my original plunger guide. It is a block of mild steel drilled and reamed for a close fit to the ½" diameter plunger. The plunger fits into a drilled and reamed ½" hole in the aluminum block. This block gets rather hot yet I don't want to also heat the frame. To minimize this heat loss, I have a piece of "FR-4" epoxy glass circuit board material between block and support frame. Another piece of this material is between the piston support block and the support frame.

Gingery specified a single 250W cartridge heater but I found two 150W heaters on eBay. The heater block design was modified accordingly. I also went with a different scheme for regulating the heat. More on this later.

Injection Nozzle and Support Table

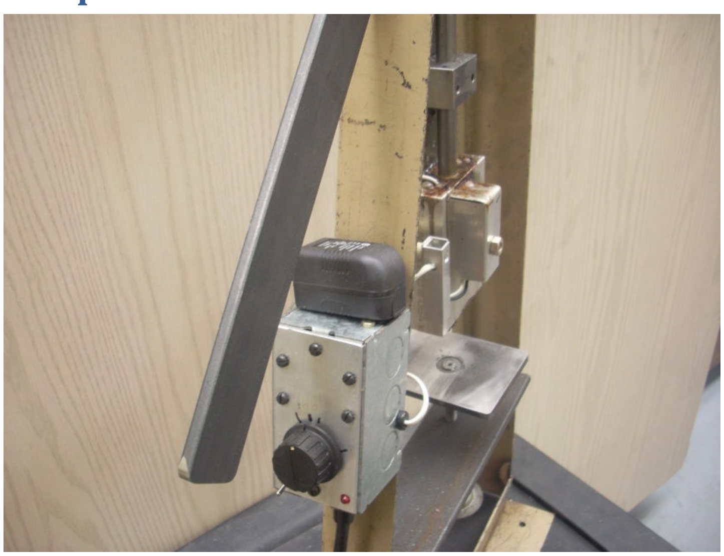
I made the nozzle out of mild steel. It bolts to the bottom of the block.

The plate below the nozzle is free to wobble. This permits the mold that is pushed up against the nozzle to align. The nozzle has a taper cut in the bottom. My mold has a countersink hole in the top. Alignment is quick and accurate.

Gingery suggests brazing the top of the rod to a washer in order to capture the support table. My little MAPP gas torch doesn't put out that much heat. I used a center drill to cut a cone shaped hole in the top of the threaded rod. With the table in place, I peened the end over just enough to hold but not so much that it would bind.

Nothing fancy here. I just took a piece of threaded rod and put two nuts and a fender washer on the lower end.

Temperature Controller



I saw nothing wrong with the temperature controller specified by Gingery but wanted to make my own. Starting at the heater block, I have a thermocouple fitted into a hole and clamped in place such that some expansion is permitted. The tip of the thermocouple is in direct contact with the heater block in a hole between the melting chamber and one of the heaters. Given that the block is aluminum, I get a fairly decent reading of the chamber temperature. One challenge is that the block is at about 400° F so my wire insulation must be protected or it will melt. I do this by using solid wire and bending it so there is air between all metal directly connected to the block. This wire goes to a second little box which contains my splice to stranded wire.

The control box is just below the pull handle. On top is an old "wall wart" that powers the electronics. The knob sets the heater block temperature. In the lower right corner is an LED that shines whenever the heaters are on. When at temperature, this LED flickers. It takes about 10 minutes to come up to full heat and stabilize.

One unique thing about this temperature controller is that my ground point is at the tip of the thermocouple. The power supply floats and my control of the 120V circuitry is optically isolated. The frame of my machine including the heater block is at ground to minimize any shock hazard.

There is not much to the electronics. I take the few mV of signal from the thermocouple, run it through a voltage amplifier. This output voltage is then compared to a set point defined by the position of the knob. When the temperature is too low, the comparator turns on an opto-TRIAC which in turn turns on a power TRIAC. That applies power to the heaters. The LED is in series with the input of the opto-TRIAC.

When the desired temperature has been reached, the comparator removes current from the opto-TRIAC and the heaters turn off.

I calibrated the system by using a separate thermocouple that connects to a digital readout. The probe was stuck directly into the molten plastic. The knob was marked at the point where the plastic was constantly at 160° C (320° F).

Associated Tools

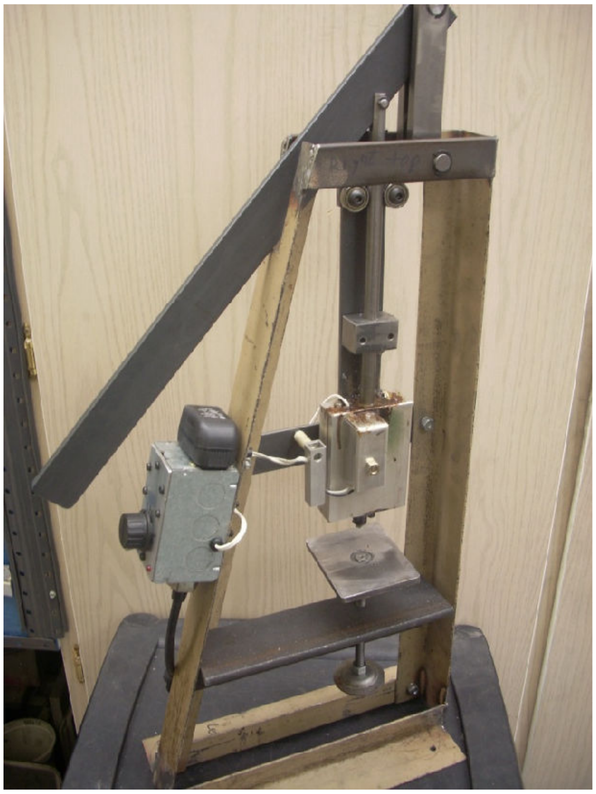
I have a few tools that help in the operation and maintenance of the machine. Starting on the far left is a plate of stainless. When I'm done using the machine, I inject the unused plastic onto this plate to create a long string of plastic. When cooled, this string is easily stored. When I wish to recharge the machine, I feed this string back into the heated chamber and lower the plunger to cut the end off.

To the right of the stainless plate are my plastic pellet "spoon" and my brass plunger scraper. Next to them is my cup of virgin plastic pellets and my nozzle cleaning tool. Plastic is constantly oozing from the nozzle. Just before I place my mold, I use this cleaning tool to cut off the drip. Failure to do this causes a solid plug of plastic to block the mold's sprue (the opening into the molding chamber).

The pliers are just generally useful for handling bits of molten plastic. Over on the right is my dual timer. The top timer is set to 10 minutes for the initial heat up. The lower timer is set to 30 seconds which is plenty of time to insure that a fresh charge of plastic is up to temperature.

The rod along the top of the picture is my cleaning plunger. This is another great idea from Corey. When done molding, I pull out the injection plunger and slide in this cleaning plunger. It has some squishy high temperature plastic on the end (PTFE rod from McMaster Carr). The plastic deforms and forms a tight seal with the walls of the molding chamber. Almost all bits of molten plastic are pushed out the nozzle.

Normal Operation



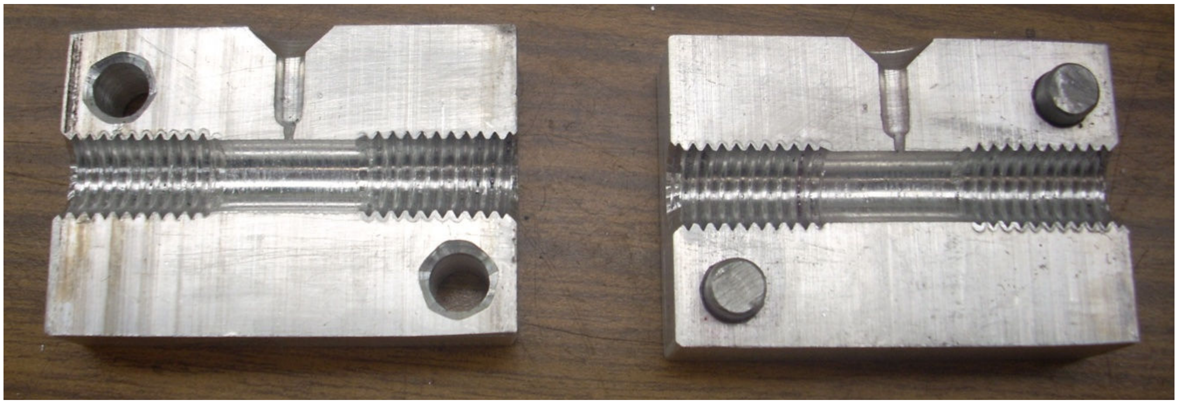
Just before shut down, I lower the plunger into the heater block. Small bits of plastic coat the guide block, plunger and heater block. Once cooled, the plunger is frozen into position.

At start up, the block starts to heat. Some of this heat is conducted into the plunger and onto the guide block. Within 10 minutes the plunger is free to move.

With the plunger in the up position, I feed in my first charge of plastic. When the plastic is ready, I pull the handle, drive the plunger down into the chamber, and plastic squirts out the nozzle into the mold.

I took this picture against a neutral background but normally the machine is clamped to my work bench.

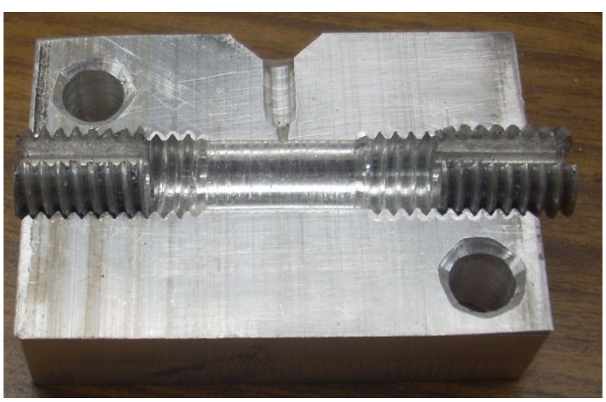
A sample Mold



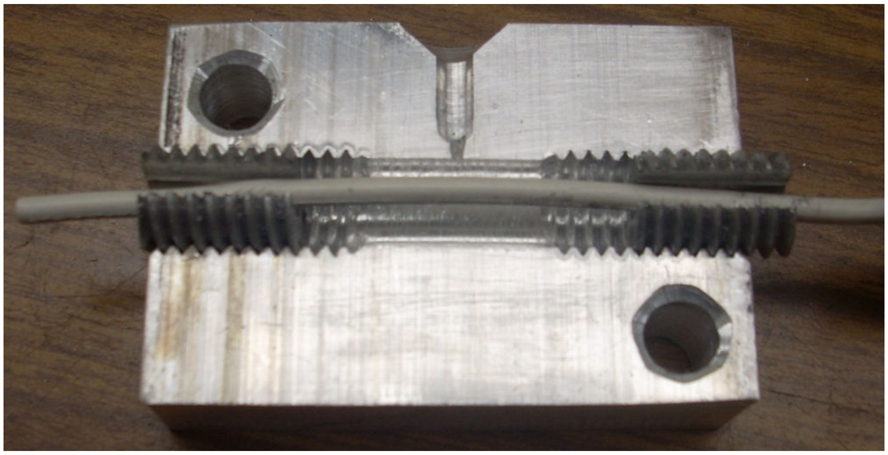
On occasion I splice a connector with associated wire to a “wall wart” that had a different connector on it. No matter how much heat shrink tubing I use, the connection is always mechanically weak. A cast cylinder of plastic around the joint would be nice.

Here is my first mold that can be used to pot a wire splice. At the top, center is the “sprue”. The funnel top fits the nozzle of my molding machine. The hole at the bottom of the funnel is 1/8” in diameter and goes down to within 0.1” of the molding cavity. I then ground a tiny slot. Corey tells me that this transition causes turbulence at the bottom of the 1/8” hole and speeds up the flow.

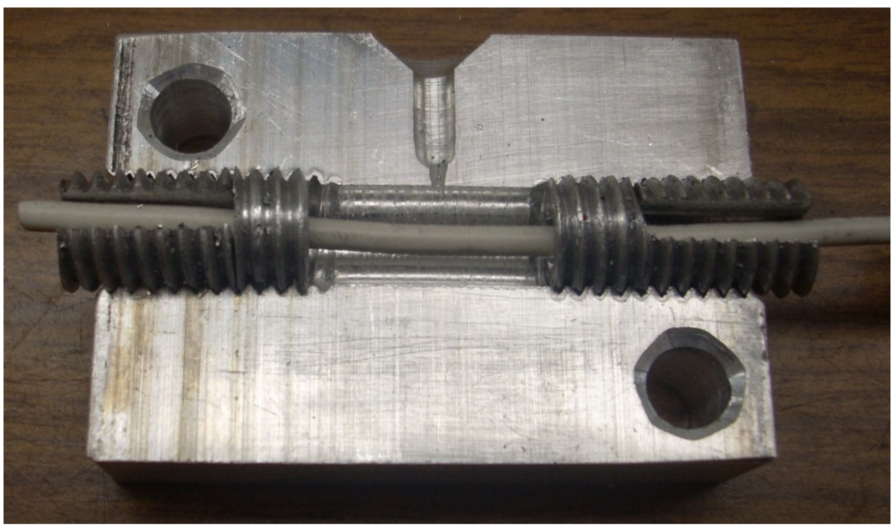
The molding chamber consists of a center section that is smooth and ends that are threaded.



I made a pair of threaded plugs that fit the mold. Each plug was drilled out with a 1/8” diameter drill and then I milled down to the hole with a 1/8” diameter end mill. The result is a slot in each plug. The plugs can be moved within the mold to vary its volume.



Here you see a wire placed in the slots.



A second set of slotted slugs can be dropped into the mold in front of the first set. They help to block the molten plastic from leaking out the slot.

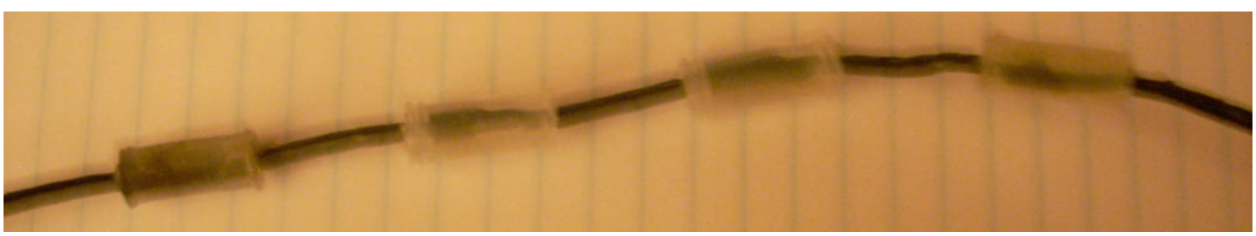
One major problem with this scheme is that the plastic pushes down on the wire during the molding process. I can pull the wire tight and overcome this force but if there was actually a splice, this force might tear it.

The mold was later modified so the sprue is at one end. The theory is that the wire is better supported in this area so less likely to deflect. It helped but did not eliminate the problem. It does limit my ability to make a shorter mold so I have gone back to the center sprue for now. A small length of 1/8" steel plugs the unused sprue.

People have suggested doing one molding that will support the wire and a second molding that will encase it. Early trials show that the first molding does not fuse to the second mold. You can barely see the gap in the mold around the red wire. This gap was filled with the sliver of plastic laying in front.

Others have suggested adding a spacer that clips onto the wire to support it. The wire support does work but more study is needed to perfect it.

In this sample I am using smaller wires plus this wire support. The defect is from the second molding hitting this wire support. The result is usable but not pretty.



Here is a series of four moldings using virgin plastic. While the used plastic is dark and dirty, the new plastic is translucent. In all cases here I did put tension on the wire and the wire remained centered in the mold.

What next?

I am barely beyond the start of this journey. I want to perfect molding splices in wires and then try my hand at molding around plugs. I bought some plaster molding material and want to try it out too.

Acknowledgements

I wish to thank Corey Renner for his help both with my molding machine and understanding what is going on inside the mold. I wish to thank Larry Gill for general insights on how to improve the machine and for editing this article. I would also like to thank members of homeinjectionmolding Yahoo group for further guidance.

I welcome all questions and comments. All of us are smarter than any one of us.

Rick Sparber

rgsparber@AOL.com