Manufacturing Insights

Rapid Injection Mold Tooling

1 NARRATOR V.O.:

Manufacturing Insights . . .

Manufacturing Engineering magazine's

video series for process improvement.

2 NARRATOR V.O.(CONT'D)

This program explores several different

options available to engineers wanting to

produce "Rapid Injection Mold Tooling".

With the continuing development of rapid tooling processes,

The new product development cycle can

be shortened considerably. You will see

tooling created...

3 NARRATOR V.O.:

...At the Harrington Product Development

Center, where one of the most popular choices in

tooling is the epoxy process.

You'll see how epoxy tooling works

when the client wants 15 parts in actual

production materials.

4 NARRATOR V.O.(CONT'D)

At FISKARS Incorporated, where they used the Selective Laser Sintering, or S-L-S process, to produce functional prototypes.

Then, after prototyping, Fiskars used the same S-L-S machine to create mold inserts using the RapidTool process to get their product into the market place faster.

5 NARRATOR V.O.(CONT'D)

At ProtoCAM, where they selected the 3D Keltool process to produce core and cavity mold inserts for injection molding. In this example the 3D Keltool mold insert is used as the final production tool for a medical part.

6 NARRATOR V.O.(CONT'D)

And finally, we'll look at PROMETAL.

A new rapid tooling system with the ability to go directly from CAD data to a steel mold insert in under two weeks.

FADE TO BLACK

7 NARRATOR V.O.

In the Tooling phase of a plastic product development cycle,

there are many different tooling
processes available to make injection molds.
Although most tooling is machined from solid metal, we found in
some cases it is possible to save money and time using rapid
tooling processes.
Rapid tooling can be used to develop more innovative
products in a shorter time while using
fewer resources. However, each of the processes
has some limitations.

11 Interview, Bob Flint.
Robert Flint, Executive Vice President,
Prototech Engineering
INTERVIEW
Some of the limiting factors in
rapid tooling are that the machines
are not as accurate as conventional
tooling and they are not as reliable
as conventional tooling. Those are
the two major issues. As long as the
conventional toolmakers see those
limitations, they have no use for those
processes. Whereas you have the rapid
prototyping people that don't have all the
blinders on, so to speak, that the

conventional toolmakers have, they are willing to take those chances, but they reinvent the wheel in such a way that I have to do it ten times different ways to prove something that the other guy already said it couldn't be done. However, as we will see there are companies out there that forget about the conventional tooling methods and combine and have shown tremendous success at these processes.

FADE TO BLACK

12 NARRATOR V.O.(CONT'D)
The Harrington Product Development Center in Cincinnati, Ohio has been in the prototyping and product development business for fifteen years. The company provides prototype services for plastic products.

13 NARRATOR V.O.(CONT'D)
Harrington offers a number of prototype services including Room Temperature Vulcanizing Rubber or R-T-V molds, Spray

Metal Tooling, CNC Machining and Epoxy

Tooling.

14 NARRATOR V.O.(CONT'D)

Recently, Harrington was approached to

make fifteen prototype diffusers to be used

in a new water pump that was still under development. The

customer wanted a 3-dimensional version of the

newly designed part in the actual production material for pump

capacity testing. Harrington chose the Epoxy Mold tooling

process.

15 Interview with Erik Murphy.

Erik Murphy, Production Manager,

Harrington Product Development Center

INTERVIEW:

One of the main factors was the customer's

interest in exploring epoxy tooling.

They do quite a bit of R&D work with

different diffusers and seal plates

and all of their components for their

pumps. They were looking for a relatively

inexpensive, cost-effective way to produce

production material parts in a timely manner

instead of going through the conventional

method of using aluminum or steel tooling,
they are looking for something that had a
quicker turn around time.

16 INT. Erik at computer
NARRATION (VO)
Several different methods of rapid
prototyping were employed to get to
the final part.

17 Interview with Erik Murphy
INTERVIEW
First of all we used CAD, we used
mechanical desktop to go through and
create the actual part design, then
we went through and created the solid
model, from the solid model we used
stereolithography to create the original
master pattern. Once the master pattern
was created, we used RTV rubber silicone
tools to reproduce a urethane master pattern.
From the urethane master pattern, we made an
epoxy injection mold, which is housed in an
aluminum housing and we injection molded the
parts.

18 INT. Epoxy filled mold

NARRATION V.O.

The epoxy used was a Ciba material that can withstand high temperatures during the injection molding process. This high temperature property was important because the plastic production material has a melt point of six hundred degrees Fahrenheit.

19 Interview with Erik Murphy

INTERVIEW

From start to finish once we were supplied with the initial design on the Mechanical Desktop, it took us about two days to get the CAD work to solid model completed. Then we looked probably six to eight hours actual build time in the stereolithography machine, then there was about a day's worth post processing, bench work, sanding and priming* of the master pattern. From that we did two day's worth of work RTV molding to create a mold to generate a urethane master pattern which we would actually use in the

epoxy tool. *We saved the stereolithography
master pattern, we never used that in
molding just so that we always have
something to go back to in case there
is a problem in the molding process.
Once we had a RTV silicone tool, it
took us about four hours to get a
urethane master pattern cast and
cleaned up, from there we did probably
four day's worth of work as far as
the epoxy mold.

20 INT. PART CLEAN-UP WITH DRILL

NARRATION V.O.
The number of parts required for the job is one factor that
helped decide what kind of tool to use.
Interview with Erik Murphy
INTERVIEW
Quantities in epoxy tooling vary
depending on the geometry of the part,
depending on the production material
whether it is a glass filled material
or if you are looking at the polypropylene,
which is an easy material to shoot.
So your mold life is really going to

vary depending on the geometry of the
part and your materials. You can expect
15 to 20 parts of some highly glass filled
materials of a very complex shape or you
could expect upwards of hundreds of parts
out of like a polypropylene and a simple
geometry.

NARRATOR V.O.
At all stages of the rapid tooling
program, the engineer must compensate
for shrinkage.

23 Interview with Erik Murphy
INTERVIEW
We take into consideration that
when we make an RTV silicone mold
that there is going to be shrinkage in the
silicone. When we create these urethane
casting of that part, we know that there is
shrinkage involved in the urethane as well
as within the production material that the
parts are going to be actually shot in.
So we take all of those shrink factors
and apply those to the original model

so that by the time we get to the epoxy tooling, the shrinkage is just right for the production material and the patterns are going to come out to the correct dimensions.

24 INT. PART IS FLIPPED OVER

NARRATOR V.O.

Harrington estimates a cost savings of fifteen-hundred-dollars and a week of development time for the customer by choosing epoxy tooling over aluminum tooling.

FADE TO BLACK

25 INT. PRODUCT SHOT (Fiskars)

NARRATOR V.O.(CONT'D)

When Fiskars, Incorporated of Madison, Wisconsin, was developing a portable battery system, they turned to S-L-S RapidTool for two reasons.

26 Interview with Herb Caloud.

Herb Caloud, Sr. Process Development Engineer, Fiskars, Incorporated

INTERVIEW

Speed and quality were definitely
most important. Speed is allowing us
to get into the marketplace quicker.
Quality of that particular rapid prototyping
tooling method allows us to shoot
injection-molded product in demanding
engineering resins such as glass-filled
nylon.

27 INT. Rapid tool inserts
NARRATOR V.O.
DTM'S Selective Laser Sintering, or S-L-S
RapidTool process, produces a durable mold insert
that can withstand injection molding
conditions.

28 Interview with Herb Caloud.
INTERVIEW:
The quantity of parts that we could
produce in a rapid tool is a function
of the geometry of the parts being
produced and the material. In this case
we are using a PCABS-blend material and
feel that we are going to produce tens of
thousands of parts with these tools.

29 INT. HERB AT THE COMPUTER

NARRATOR V.O.

The first step of the RapidTool process is to create digital models of the core and cavity geometries.

30 INT. MAN AT DTM MACHINE

NARRATOR V.O.(CONT'D)

S-T-L files of the core and cavity are sent to a Sinterstation for fabrication in a powder material.

31 NARRATOR V.O.(CONT'D)

The powder consists of mild carbon steel particles that are coated with a thin layer of polymer.

32 Interview with Herb Caloud.

INTERVIEW:

To construct the tooling insert original ProE part files are used in pro-mold to be split into core and cavity configurations. At that time, drafts are verified and shrinks are factored in for

the final injection molding material.
Those core and cavity inserts are turned into
.STL files, which are transferred to
the sinter station and built in the LR1
material. That core and cavity, after sintering,
is then dipped in a polymer and dried and
then infiltrated in a furnace at a high
temperature with copper. After coming out
from the furnace we have secondary
operations to perform which square the
insert, establish a parting line and put
in ejector pins and the insert is then
ready to be put in the companion insert
and placed in the molding machine to
produce parts.

33 INT. DRAWING BOARD
NARRATOR V.O.
Fiskars estimates they saved approximately
30 percent in time and money to
develop the tools for the product launch,
compared with tools produced from a
traditional approach. However, Fiskars did
learn some of the rapid tooling process
limitations.

34 Interview with Herb Caloud.

INTERVIEW:

The types of geometry that we've learned that we have to be careful of in using the rapid tool process evolve around establishing a parting line and we try to select parts that reflect a flat, easy-to-develop parting line. As parting lines become more complex and organic in shape, being able to seal those off inside the tool is more of a challenge.

35 INT. PARTS

NARRATOR V.O.

For this project, the RapidTool Process met the expectations of the product development group at Fiskars. According to the client, it was difficult to see any difference between the RapidTool molded part and a part produced through traditional production tooling. However, Fiskars has realized not every project is right for a rapid tooling approach and must be evaluated on a case by case basis.

36 Interview with Herb Caloud.

INTERVIEW:

...But, the hardest thing to
learn and the biggest learning curve
you have to go up is, how do you
select the right process for the
project and that has to do with how
many pieces do you want to get, what
material are you going to run it in
and what configuration is that geometry.
If it is a geometry that is well suited
for CNC machining and you can access
all of the areas of the tool, then by
all means, machine it. If you have
that in-house capability of running
the CAM software and running the
machine, I think that is more than
viable. We do that here also.
But where rapid prototyping, I think,
has an advantage is when you need to
grow complex geometry that is not
easily machined where it has to be
EDM burned.

FADE TO BLACK

37 INT. PROTOCAM MACHINE

NARRATOR V.O.

ProtoCAM in Northampton, Pennsylvania
has been using 3D Keltool to provide
hard tooling core and cavity inserts for
injection molding. As a service bureau,
ProtoCAM says using the 3D Keltool process
has helped to cut project lead time by half.
Recently, ProtoCAM was called on to help
develop a part for the medical industry.

38 INTERVIEW W/ BELKNAP

Ron Belknap, Managing Partner & ProtoCAM.

INTERVIEW

We weren't really told exactly what
is used for, but it is used for, in
the medical industry, it actually snaps
into another mating part. We call it the
ice-cube tray.

NARRATOR V.O.

The customer wanted to upgrade an existing
part, however, they had no drawings or CAD files.

40 INTERVIEW W/BELKNAP

INTERVIEW

... so we had to number one,
reverse engineer the part and secondly
use that information to create the
model. At that point, a model was
created using the stereolithography process
for customer approval. Once the customer
approved the actual part, with those
enhancements, we took that file and using
Pro-Engineer's mold design, creating the
core and cavity for the Keltool process.

41 NARRATOR V.O.

The SLA mold inserts were shipped to 3D Keltool in
California, and were used as
patterns to make the metal mold inserts.

42 NARRATOR V.O. (CON'D)

To repeat the insert's geometry and to
get an accurate mold for the 3D Keltool
material, an RTV mold must be created
for each insert pattern. A box is
built around the insert, then an
RTV compound is poured.

45 INT. MOLD MAKER REMOVING CURED RTV MOLD

NARRATOR V.O. (CONT'D)

After the RTV material cures, the box and base plate with the SL master are demolded.

47 INT. METAL MIX SECTION

NARRATOR V.O. (CONT'D)

The correct amount of metal mix
is weighed and mixed to evenly distribute
the A6 and tungsten carbide particles in the
metal powder.

NARRATOR V.O. (CONT'D)

Next, resin and hardener are measured,
mixed, then added to the metal mix,
which is then mixed to create the slurry.

49 INT. METAL MIX SECTION

NARRATOR V.O. (CONT'D)

The RTV molds are filled with the slurry, which then cures to form the solid inserts.

NARRATOR V.O. (CONT'D)

The "green" inserts are removed

from the RTV molds and inspected
to ensure consistency
with the original stereolithography
pattern measurements.
The inserts are then sintered in a hydrogen
reduction furnace, and afterwards are measured to
ensure process control and uniformity.

53 INT. INFILTRATION

NARRATOR V.O. (CONT'D)
After sintering, the inserts
are infiltrated with a thermally conductive copper alloy to
create fully dense, completed inserts.

NARRATOR V.O. (CONT'D)
The finished inserts are generally equivalent
to P20 tool steel. The inserts can be
reworked, machined, edm'ed, welded,
textured, ground, heat treated, or
otherwise treated similarly to ordinary tool
steel.

55 INTERVIEW W/ BELKNAP

INTERVIEW
Well we found the Keltool process which

is its main feature, is casting very
detailed parts, was ideal for this, a
lot of pockets, a lot of very tight areas
that would take a lot of machining or a
lot of EDM burning and the Keltool
process doesn't really care if it is very
detailed or very flat. This made it an
ideal process for the 3D Keltool.

56 INT WORKING ON THE MODEL

NARRATOR V.O.
Working with the 3D Keltool process, ProtoCAM
estimates it saved about a month in development
time. The model is fairly complex with fine
features inside and side snaps that added
to the difficulty of the project.

57 INTERVIEW W/BELKNAP

INTERVIEW
Going through the Keltool process, one
thing we found with the Keltool process
is a learning process and we actually
initially cast some features that we would
have inserted at a later date. There is a
very detailed snap feature in here that we

cast initially and we found that we needed to make adjustments to the snap feature. Using inserts were easy to adjust versus a solid part you cannot. One thing that we've learned at ProtoCAM is when to cast features and when to not cast them and insert at a later date. That's a key thing to the Keltool process.

58 INT. B-ROLL - True Precision Plastics

NARRATOR V.O.
The inserts were sent back to ProtoCAM and installed into a mold base. ProtoCAM did a few secondary operations and then sent the mold to True Precision Plastics ,a custom injection molder, for the production run.

59 INT. PROTOCAM MACHINE

NARRATOR (V.O.)
On another project, ProtoCAM, was collaborating with a client to develop an electronic eraser for a white board.

60 INTERVIEW WITH RAY BIERY

INTERVIEW

Actually what it does is it erases
and feeds back into the computer
database exactly what has been erased
from the white board. It uses radio
frequency and it's the latest in technology
in this particular type of application.

61 INT. ERASER

NARRATOR (V.O.)
ProtoCAM boasts a two week turnaround time,
however, on this project, the service bureau says
speed was not the main concern.

62 INTERVIEW WITH RAY BIERY

INTERVIEW
During this particular project, the
two that were absolutely the most
critical were cost and quality. The
idea is to be able to produce a part
that fit together and you are looking
at a number of pieces. The components
that had to fit together were of critical
dimensions and so quality was important as
well as, the finish and the feel of the
product. The second aspect was cost.

We were comparing the rapid tooling, the rapid prototyping methodology to a standard CNC machining and we fell significantly below that. Then of course the timing, we were able to reduce the amount of time that was also used in producing this.

63 INT. SOLID MODEL

NARRATOR V.O.

ProtoCAM used the 3D solid model provided by the client to create a stereolithography master.

64 INTERVIEW W/ BIERY

INTERVIEW

The stereolithography master was then evaluated and design criteria were evaluated using that, including, form fit and function, as well as, clearance checks and see if actually all of the components would fit together properly. Beyond that, then we used a second technology which is RTV molding, or Room Temperature Vulcanization molding

where we provided the customer approximately
25 pieces, 25 individual sets of parts
that he could use and do a marketing
research, an evaluation. Again, doing
further testing devices, making sure that
the fit was proper, the ergonomics of the
product were proper and then the last
step is actually creating the production
tooling using your rapid prototyping
technique called 3D Keltool.

65 INT. ENGINEER AT COMPUTER

NARRATOR V.O.

ProtoCAM says the development process
took less than a month to complete. The Computer-Aided-Design
software used was Pro-Engineer. Considering the
complexity of this project, Biery says
it was a challenge.

66 INTERVIEW W/BIERY

INTERVIEW

There, as you can see, there are
a lot of surfaces, a lot of features,
a lot of involvement with fits and I
would classify this to be about a

medium grade, medium to difficult
in that the parts had to fit together
and meet the criteria of tolerancing
that was needed to make sure this
product worked.

67 INT. PART
NARRATOR V.O.
Once market research and testing was complete on the
prototype, modifications were made to the
original design. Next ProtoCAM made the
production tool insert using 3D Keltool.

68 INTERVIEW W/BIERY
INTERVIEW
That process is very similar, you start
with the stereolithography model. In
this case, we do the full design using
Pro-mold and once we have the core cavity
for that part, we produce the
stereolithography master of it. That
stereolithography master is then
sent to 3D Keltool. (Tight edit)
That insert is then sent back to us,
we finish the insert and then mount it

into a mold base. (TIGHT)

69 INT. FINISHING WORK

NARRATOR V.O.

Biery says once the inserts were completed, ProtoCAM spent a lot of time finishing and polishing, so the money saved was minimal. However, the client was still very pleased with the result.

70 INTERVIEW W/ BIERY

INTERVIEW

We've achieved, I would say, 100 percent satisfaction, in that, we are able to offer a service that will allow their personnel, to visualize their product in a short period of time and stereolithography, typical lead time for a stereolithography part is three weeks. A typical lead time for RTV mold is about two weeks until they are actually holding parts in their hand. In terms of rapid tooling and producing a part that as an injection molded piece and that permanent injection piece that

will produce production parts, that is about a five to six week time frame. The critical aspect, the one that our customers come to us, is that they need a part sooner than their competition and they recognize this. So when they come to us, whatever we can provide in terms of processes or services that reduces the overall product development time, is greatly appreciated. So we've developed a lot of processes we use a lot of different methods to help them do that.

FADE TO BLACK

71 PROMETAL- INT.

NARRATOR V.O.

Extrude Hone’s PROMETAL Division in Irwin Pennsylvania, says it can deliver a technology that brings products to market faster while providing engineers the flexibility to create advanced tooling for plastic molding.

72 INT. PROMETAL machine running

NARRATOR VO (CONT'D)

PROMETAL says its machine, that moved out
of the R&D laboratory and became
commercially available in 1998, can create functional
metal prototypes, or metal tooling inserts.

73 INT. PROMETAL MACHINE

NARRATOR VO (CONT'D)
A solid freeform fabrication machine tool,
called the PROMETAL RTS-300 Rapid Tooling
System, directly translates 3D CAD data to
metal components by selectively binding
metal powder, layer by layer. The technology
was developed at MIT as part of the
3D Printing project.

74 INT. C.U. POWDER COMING OFF PART

NARRATOR VO (CONT'D)
The RTS-300 can produce metal
components as large as 12"x12"x10".

75 INT. PRINT HEAD OVER POWDER

NARRATOR VO (CONT'D)
The image of the current slice of
the solid model is printed with
an ink jet printhead depositing

320,000 droplets of binder per second.
After the layer has been printed,
it's quickly dried.

76 INT. E.C.U. PRINT HEAD

NARRATOR VO (CONT'D)
The elevator platform drops to the level
of the next slice, and a new layer of
powder is quickly spread over the
previous layer. The next slice of the
CAD solid model is printed on top of
the previous layer.

77 INT. REV.ANGLE OF PRINT HEAD

NARRATOR VO (CONT'D)
This process repeats itself until the
part is completely printed.

78 INT. PART BEING TAKEN OUT

NARRATOR VO (CONT'D)
Once finished, the printed component
is removed from the machine by hand.
Residue powder on the component is
easily removed, leaving a porous
steel skeleton of the desired shape

bound by the polymer binder.

79 NARRATOR VO (CONT'D)

At this point the part

is fused into a porous steel skeleton

that has a density of about 60%.

80 NARRATOR VO (CONT'D)

The final furnace cycle infiltrates molten

bronze into the steel skeleton, bringing

the component to full density ready for final finishing.

81 FADE TO BLACK

82 Summary

NARRATOR V.O. (CONT'D)

The advances made in the rapid injection mold

tooling processes over the last few years are

overwhelming. However, despite these advances, the rapid

injection mold tooling processes are a long way

from replacing conventional tooling. The

experts warn before you venture into rapid

tooling territory, consider the number of

parts required, part size, complexity and

material needed to see if it is appropriate

for the rapid tooling process. And, even after taking all that into account, there is still the issue of accuracy.

With rapid tooling the issue comes down to reliability and why is reliability such an issue with rapid tooling? It comes from the standpoint that right now, they're still trying to work on the actual process so that when they go through the firing process, that the tool maintains its original geometry. What they have had problems with in the past, the tool has a tendency to creep, warp, curl. It doesn't maintain its original flatness. From that standpoint of view, if you are going to start making, even though the material is extremely hard relative to Direct AIM or even aluminum, it's a harder material than aluminum, if I'm going to make 1,000 to 10,000 parts, whether that be a prototype run or a production run, I don't want to have to make up for the consequences of not having a flat tool, especially since not having a flat tool

requires additional machining just to get it

into the press.

84 NARRATOR V.O.

Remember, it's not enough to look only at the

tooling cost, you must factor in the cost to

clean and maintain a tool, especially when planning

on making thousands of parts.

Clearly, rapid injection mold tooling is

not a "one size fits all," solution. Most engineers

familiar with rapid tooling agree that before

you decide on your tooling method, know your

limits on cost, quality and speed, and be sure

you and your business partners fully

understand what is reasonable to expect

from the tooling process you select.

If rapid tooling passes your tests, you can look

forward to faster design reviews in the

tooling phase of your product development cycle.

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