

**Manufacturing Insights**

Rapid Castings:

Rapid Prototypes for Metal Casting Processes

SCENE 1.

**RC12A**, CGS: Investment Casting  
**MI BKGD**, MI background  
**RC12B, RC06, 07:42:55:00-07:43:15:00**  
zoom in, pouring investment casting mold

SCENE 2.

continue previous shot  
**RC13A**, peter carey revised narration  
**RC13B, RC06, 07:25:50:00-07:26:00:00**  
pattern assembly dipped in slurry  
**RC13C, RC06, 07:19:14:00-07:19:21:00**  
zoom in, pattern assembly coming out of  
burnout furnace  
**RC13D, RC06, 07:40:17:00-07:40:30:00**  
zoom out, shell mold being poured  
**RC13E, RC16, 23:16:22:00-23:16:31:00**  
shell mold broken away from part  
**RC13F**, CGS: Tom Mueller  
Owner/Partner  
Express Pattern  
**RC13G, RC03, 04:25:48:00-04:26:10:00**  
tom mueller on camera

**NARRATION (VO) :**

INVESTMENT CASTING SACRIFICES A PATTERN  
AND CERAMIC SHELL MOLD FOR EACH METAL  
PART THAT IS MADE. THE WAX PATTERN IS  
DIPPED IN A CERAMIC SLURRY SEVERAL TIMES  
TO BUILD-UP THE MOLD THICKNESS. THE MOLD  
IS THEN HEATED TO MELT OUT THE PATTERN,  
WHICH LEAVES A CAVITY INTO WHICH METAL  
IS Poured. AFTER COOLING, THE CERAMIC  
SHELL IS BROKEN AWAY FROM THE PART. TOM  
MUELLER EXPLAINS THE ADVANTAGES OF THIS  
METHOD.

SCENE 3.

continue previous shot  
**RC14A, RC03, 04:26:17:00-04:26:35:00**  
tom mueller on camera  
**RC14B, SME3041, 04:19:40:00-04:19:48:00**  
investment cast part  
**RC14C, SME3041, 04:20:20:00-04:20:26:00**  
investment cast part  
**RC14D, SME3041, 04:21:20:00-04:21:26:00**  
investment cast part  
**RC14E, RC16, 22:02:29:00-22:02:52:00**  
zoom in, investment casting molds going  
into burnout furnace

**TOM MUELLER (ON-CAM) :**

The investment casting process is one of  
several metal casting processes, like  
plaster casting or sand casting. It has  
an advantage in that it can handle very  
complex designs and yield good accuracy  
and good surface finish...  
...Because there is no need to get the  
pattern out of a mold, it's basically  
melted out of the mold, we can handle  
complexity with things like through  
holes, internal passages and such, that  
would not be possible with a sand cast  
part.

SCENE 4.

**RC15A, SME3035, 21:10:36:00-21:10:48:00**  
investment casting process  
**RC15B, SME3041, 04:13:51:00-04:14:13:00**

**NARRATION (VO) :**

WHILE INVESTMENT CASTING CAN PRODUCE

wax pattern coming out of tooling  
**RC15C, SME4287, 05:07:38:00-05:07:56:00**  
zoom out, machining of tooling

COMPLEX PARTS, THERE IS ONE DILEMMA.  
TOOLING IS NEEDED TO MOLD THE WAX  
PATTERNS, AND AS DESIGNS GETS MORE  
COMPLEX, THE COST AND LEAD TIME FOR  
TOOLING SWELL.

SCENE 5.  
**RC16A, RC03, 04:11:47:00-04:12:21:00**  
tom mueller on camera  
**RC16B, RC03, 04:47:54:00-04:48:26:00**  
zoom in, sanding rapid prototyping pattern

**TOM MUELLER (ON-CAM) :**  
It can take several thousand dollars and several weeks to get the mold before you can make the first casting. That adds a lot of risk in the product development process. Unless the design is exactly right, you may have to make changes to that design later on, which is going to involve either remaking the tool or reworking the tool to incorporate those design changes. By using rapid prototyping patterns, we can create patterns without making a tool, which lowers that risk and allows people to evaluate the design, make sure it's right before they make that large investment.

SCENE 6.  
**RC17A, CGS: Bruce M. Barron**  
President & CEO  
Barron Industries  
**RC17B, RC04, 05:11:50:00-05:12:07:00**  
bruce barron on camera  
**RC17C, RC06, 07:14:48:00-07:15:15:00**  
cad image of pattern  
**RC17D, RC06, 07:16:57:00-07:17:23:00**  
stl file of pattern being generated  
**RC17E, RC05, 06:51:29:00-06:51:52:00**  
rapid prototyping being cleaned up  
**RC17F, RC04, 05:12:19:00-05:12:27:00**  
bruce barron on camera  
**RC17G, RC04, 05:12:32:00-05:12:47:00**  
bruce barron on camera

**BRUCE BARRON (ON-CAM) :**  
We take that same electronic data that the customer gave us. Instead of using it to drive the CNC machine to cut an aluminum cavity into a mold to inject wax, we use that data and generate what is known as an STL file...  
...Then I can produce a rapid prototype pattern replica of the metal part we want...  
...in as little as 2 hours. Two, three, four, five, six hours, and I have a pattern that I can then immediately put into my process, my production process.

SCENE 7.  
**RC18A, RC03, 04:30:24:00-04:30:51:00**  
tom mueller on camera

**NARRATION (VO) :**  
TOM MUELLER OFFERS AN EXAMPLE.

SCENE 8.  
continue previous shot  
**RC19A, RC03, 04:30:59:00-04:31:22:00**  
tom mueller on camera

**TOM MUELLER (ON-CAM) :**  
Investment casting is really good for complex designs like this part. You can see this has some internal flow passages, some ports on the inside, there's a race that goes around the

inside. These are features that are pretty difficult to manufacture...  
...This is one where rapid prototyping plays an ideal role. Even to make a wax or investment casting, there are at least three different tools that have to be made. One for each of the two soluble cores, and one to mold wax around the whole thing, and that's going to be a fairly complex tool. We can make this part all on one part and deliver it in a couple days.

SCENE 9.

**RC20A, RC01, 01:28:32:00-01:28:51:00**  
zoom in, wax patterns being cleaned up

**NARRATION (VO) :**

TOM EXPLAINS THE PRIMARY APPLICATION AREAS FOR RAPID PROTOTYPING PATTERNS, WHICH HE CALLS DIRECT PATTERNS.

SCENE 10.

**RC21A, RC03, 04:12:26:00-04:12:47:00**  
tom mueller on camera  
**RC21B, CGS: Prototype Patterns**  
**RC21C, RC03, 04:12:50:00-04:13:41:00**  
tom mueller on camera  
**RC21D, RC01, 01:08:23:00-01:08:43:00**  
zoom out, finishing large rapid prototyping

**TOM MUELLER (ON-CAM) :**

There are four major areas that people use direct patterns in investment casting. And that is exactly the way it sounds. It is not to make a production casting but to make a casting that can be used to test the design to make sure it is appropriate for its intended purpose...

...People used it to make a prototype so they could test it and make sure the design was right before they would make a much larger investment in wax pattern tooling...

SCENE 11.

continue previous shot  
**RC22A, CGS: Process Development**

**TOM MUELLER (ON-CAM) :**

...The second area is in process development. There is an awful lot of investment casting process that can't be optimized until patterns are available. Things like determining the final shrink rate, not all designs shrink at exactly the same rate. If one area freezes off sooner than another, it's going to change the apparent shrink rate in the metal. Typically you don't know that until you cast the first part. And that may change the design of the pattern you want to use. You may have to make some areas larger than other areas to get the right size casting at the end.

SCENE 12.

**RC23A, RC03, 04:14:10:00-04:14:30:00**  
tom mueller on camera  
**RC23B, RC05, 06:44:38:00-06:44:49:00**

**TOM MUELLER (ON-CAM) :**

Other things like gating trials to determine where the gate ought to be on the pattern, what size the gate ought to

zoom out, gated rapid prototypes  
**RC23C, RC05, 06:48:58:00-06:49:17:00**  
rapid prototype being attached to tree

SCENE 13.

**RC24A, RC05, 06:24:10:00-06:24:45:00**  
zoom out, cutting rapid prototypes from  
build platform

SCENE 14.

**RC25A, RC04, 05:25:46:00-05:26:20:00**  
bruce barron on camera

SCENE 15.

**RC26A, RC05, 06:19:03:00-06:19:18:00**  
pan of numerous rapid prototypes

SCENE 16.

**RC27A, RC03, 04:14:44:00-04:14:53:00**  
tom mueller on camera  
**RC27B, CGS: Bridge to Production**  
**RC27C, RC06, 07:36:46:00-07:37:17:00**  
investment casting operation  
**RC27D, RC03, 04:15:11:00-04:15:22:00**  
tom mueller on camera

SCENE 17.

**RC28A, RC03, 04:15:40:00-04:16:04:00**  
tom mueller on camera  
**RC28B, CGS: Low-Volume Production**  
**RC28C, RC01, 01:40:36:00-01:41:06:00**  
zoom in, rapid prototyped part being  
sealed

be, how the pattern should be oriented on the tree, all that stuff is done after patterns are available. By using direct patterns the founder can do a lot of that stuff while they're waiting for the tool to be built.

**NARRATION (VO) :**

BRUCE BARRON AGREES THAT MANY FOUNDRIES USE RAPID PROTOTYPED PATTERNS TO OPTIMIZE THE PROCESS BEFORE A TOOL IS EVER BUILT. HE OFFERS ONE EXAMPLE.

**BRUCE BARRON (ON-CAM) :**

In order to produce this part in the time frame we had, we produced a rapid prototype pattern first of an SLA quick cast. We actually produced three of them. We put them through our process with three different gating systems, and successfully produced a rapid prototype part for the customer, which not only could they use to try out in their system and validate design, but it also gave us the opportunity to develop a production process.

**NARRATION (VO) :**

THE BALANCE OF THE FOUR APPLICATION AREAS MOVE OUT OF DESIGN AND INTO MANUFACTURING.

**TOM MUELLER (ON-CAM) :**

The third area, and this is the area that we do most of our work in now, is initial delivery of production castings...  
...Foundries now will order rapid prototyping patterns to create initial production castings while they are waiting for the tool to be delivered...

**TOM MUELLER (ON-CAM) :**

...The last area that is really starting to take off now is in low-volume production. There are a lot of low volume investment casting applications where there are only going to be a few dozen to a few hundred patterns made. And very often now it's less expensive

SCENE 18.

**RC29A, RC05, 06:06:08:00-06:06:21:00**  
pan of rapid prototyping machines

to build those as rapid prototyping patterns than to ever build a tool.

**NARRATION (VO) :**

TO MAKE ITS DIRECT PATTERNS, BARRON INDUSTRIES USES A VARIETY OF TECHNOLOGIES.

SCENE 19.

**RC30A, RC04, 05:04:07:00-05:04:43:00**  
bruce barron on camera  
**RC30B, RC05, 06:13:15:00-06:13:30:00**  
zoom out, rapid prototyped parts on build platform

**BRUCE BARRON (ON-CAM) :**

For our operations, we utilize the prototype pattern making technologies—stereo lithography, fuse deposition modeling. We utilize those patterns that are produced in wax, corn starch, polycarbonates, and some other materials that are replicating our production wax patterns, only in a way in which no tooling is required, and out of materials that have some of the similar properties to our wax material.

SCENE 20.

**RC31A, RC05, 06:02:35:00-06:02:54:00**  
zoom in, barron industries projet system operating  
**RC31B, RC02, 02:27:08:00-02:27:23:00**  
pan, wide, multiple rapid prototyping machines at express pattern

**NARRATION (VO) :**

BARRON'S IN-HOUSE TECHNOLOGIES ALSO INCLUDE PROJET, WHICH INK-JETS A WAX MATERIAL...  
AT EXPRESS PATTERN, THERE IS A LONG HISTORY WITH OTHER RAPID PROTOTYPING SYSTEMS.

SCENE 21.

**RC32A, RC03, 04:04:26:00-04:04:32:00**  
tom mueller on camera  
**RC32B, RC03, 04:04:35:00-04:04:45:00**  
tom mueller on camera  
**RC32C, RC02, 03:01:27:00-03:01:38:00**  
wide, thermojet being started  
**RC32D, RC02, 03:24:45:00-03:25:11:00**  
zoom out, thermojet printing wax patterns  
**RC32E, RC03, 04:07:39:00-04:08:03:00**  
tom mueller on camera

**TOM MUELLER (ON-CAM) :**

We use two different technologies to create rapid prototyping patterns for investment castings...  
...The first is the thermojet system, which is the system created by 3D Systems in the 1990s. It uses an inkjet printing technology to create wax patterns...  
...The thermojet uses a wax developed specifically for jetting applications. It works very well for that. It is a little bit lower melt temperature than many of the investment casting waxes, so we have to treat it slightly differently, but in general it's very easy for foundries to use. They can use pretty much exactly the same process

SCENE 22.

**RC33A, RC03, 04:04:59:00-04:05:17:00**  
tom mueller on camera  
**RC33B, RC02, 03:17:40:00-03:18:15:00**  
stereolithography process  
**RC33C, RC01, 01:12:55:00-01:13:06:00**  
zoom out, quick cast prototype being  
finished

SCENE 23.

**RC34A, RC05, 06:10:18:00-06:10:34:00**  
zoom out, rapid prototyped patterns  
**RC34B, RC04, 05:06:30:00-05:07:57:00**  
bruce barron on camera

SCENE 24.

continue previous shot  
**RC35A, SME3041, 04:13:28:00-04:13:40:00**  
injection molding of wax pattern  
**RC35B, SME3041, 04:04:13:00-04:04:35:00**  
patterns manually assembled to tree  
**RC35C, SME3041, 04:06:51:00-04:07:08:00**  
tree being dipped for first time  
**RC35D, SME3041, 04:08:42:00-04:08:53:00**  
first coat covered in particles

SCENE 25.

**RC36A, RC04, 05:18:12:00-05:18:33:00**  
bruce barron on camera  
**RC36B, RC04, 05:08:39:00-05:08:49:00**

they use day in and day out for their  
molded wax patterns.

**TOM MUELLER (ON-CAM) :**

The other technology we use is  
stereolithography, and we create quick  
cast patterns, which are hollow  
stereolithography parts that can be used  
as investment casting patterns. That is  
by far the most popular technology in  
use today to create direct patterns for  
investment casting, at least in the  
United States.

**NARRATION (VO) :**

TO BE SUCCESSFUL WITH RAPID PROTOTYPING  
PATTERNS, THERE ARE SOME CHANGES TO THE  
PROCESS. TO DESCRIBE THESE  
MODIFICATIONS, BRUCE BARRON BEGINS WITH  
A SUMMARY OF THE STANDARD PROCEDURES.

**BRUCE BARRON (ON-CAM) :**

...we inject wax, about 130 deg., into  
this hollowed out female mold aluminum  
cavity, and open up the tool and remove  
a wax pattern replica of the metal part  
that we want to produce. ~~So if I want to~~  
~~produce 100 parts of some widget per~~  
~~month, I have to inject 100 wax~~  
~~patterns.~~ Then I take those wax patterns  
and I glue them onto usually a vertical  
sprue of wax, ~~on six sides of this~~  
~~vertical sprue,~~ and I create a tree, a  
cluster of wax patterns. I take that  
cluster of wax and bring it into an area  
where I begin a repetitive dipping  
process, immersing the wax cluster into  
ceramic slurry, draining the slurry,  
rain falling fine sand over the wet  
ceramic, and then putting on a conveyor  
to dry. The first dip is eggshell thin,  
but over time I'll put on eight coats of  
ceramic. I'll dip it, sand it, and let  
it dry, usually 3-4 hours between coats.  
At the end of that time I have about a  
3/8 inch shell of ceramic that I've  
built up over the wax patterns...

**BRUCE BARRON (ON-CAM) :**

...The completed shell goes into a  
dewaxing oven, a flash fire dewax oven.  
We take that now wax-filled ceramic

bruce barron on camera  
**RC36C, SME3041, 04:22:48:00-04:23:05:00**  
dewaxing process  
**RC36D, SME3041, 04:25:46:00-04:26:05:00**  
mold fired before pouring  
**RC36E, SME3041, 04:25:08:00-04:25:20:00**  
investment casting operation, alternate  
shot  
**RC36F, RC04, 05:08:12:00-05:08:33:00**  
bruce barron on camera

SCENE 26.

**RC37A, RC06, 07:10:07:00-07:10:17:00**  
tilt, rapid prototypes attached to tree  
**RC37B, CGS: Pattern Set-Up**  
Shelling  
Burnout

SCENE 27.

**RC38A, RC04, 05:12:59:00-05:13:08:00**  
bruce barron on camera  
**RC38B, RC05, 06:42:17:00-06:42:54:00**  
zoom out, rapid prototyped parts being  
gated  
**RC38C, RC06, 07:02:49:00-07:04:00:00**  
wide, gated rapid prototype attached to  
tree  
**RC38D, RC04, 05:13:09:00-05:13:24:00**  
bruce barron on camera

SCENE 28.

**RC39A, RC04, 05:40:38:00-05:40:49:00**  
bruce barron on camera  
**RC39B, RC07, 08:14:23:00-08:14:37:00**  
rapid prototyped tree shell being dipped  
**RC39C, RC07, 08:17:01:00-08:17:12:00**  
rapid prototyped tree rolled in sand

SCENE 29.

**RC40A, RC04, 05:13:39:00-05:14:04:00**  
bruce barron on camera  
**RC40B, RC16, 22:02:36:00-22:02:52:00**  
zoom in, rapid prototyped molds going into  
dewax furnace

SCENE 30.

**RC41A, RC04, 05:40:09:00-05:40:23:00**  
bruce barron on camera  
**RC41B, RC16, 22:08:11:00-22:08:35:00**  
rapid prototyped molds coming out of dewax  
furnace

shell, put it in an oven at 1600 deg.,  
and melt all the wax off very quickly...  
...So now you can picture that I have a  
hollow ceramic shell, and anywhere there  
was wax there is now an open cavity,  
into which I can pour metal.

**NARRATION (VO) :**

WHEN INCORPORATING PROTOTYPES, THERE ARE  
NUMEROUS PROCESS CHANGES INCLUDING  
PATTERN SET-UP, SHELLING AND BURNOUT.

**BRUCE BARRON (ON-CAM) :**

Typically the gating systems and things  
that are used on a rapid prototype part  
are sort of over-engineered...  
...Because essentially you have one shot  
to develop your process and make a  
perfect part. So when we put our rapid  
prototype parts through the process, we  
put much fewer parts on our sprue or  
tree. Perhaps only one part...

**BRUCE BARRON (ON-CAM) :**

...It also may be necessary to build up  
a thicker shell to withstand those  
burnout pressures.

**BRUCE BARRON (ON-CAM) :**

...at the actual flash fire dewax, or  
flash fire burnout, since that RP  
pattern might not be wax, we will  
frequently vent the mold, drill small  
holes in it to allow the trapped gas  
that will come from vaporizing that  
pattern material to escape, so we can  
maintain the integrity of our shell...

**BRUCE BARRON (ON-CAM) :**

The dewaxing or burnout cycle that takes  
place prior to the preheat of the  
molding casting, for rapid prototype  
patterns you are typically using longer  
cycles...

SCENE 31.

**RC42A, RC07, 08:12:20:00-08:12:40:00**  
zoom out, rapid prototyped tree shell  
being dipped

SCENE 32.

continue previous shot  
**RC43A, RC03, 04:34:12:00-04:34:20:00**  
tom mueller on camera  
**RC43B, RC03, 04:34:46:00-04:34:58:00**  
tom mueller on camera  
**RC43C, RC01, 01:17:59:00-01:18:18:00**  
zoom out, rapid prototyped part being  
finished  
**RC43D, RC03, 04:34:59:00-04:35:19:00**  
tom mueller on camera

SCENE 33.

**RC44A, RC04, 05:31:43:00-05:32:10:00**  
bruce barron on camera

**NARRATION (VO) :**

BUT, THESE MINOR ADJUSTMENTS ARE  
  
WORTHWHILE IN LIGHT OF THE BENEFITS.

**TOM MUELLER (ON-CAM) :**

One of the real advantages of using  
rapid prototyping patterns is we don't  
have any sunk cost in tooling...  
...You can create a design very quickly  
and relatively inexpensively cast it,  
evaluate that design, make some changes,  
go back and change it completely...  
...in fact, now we're seeing people  
coming with 3 or 4 alternative designs  
that they process at the same time. They  
can test them, choose the best one, and  
maybe do 3 or 4 variations of that, and  
really reach an optimum design very  
quickly. It was just too cost  
prohibitive and time prohibitive to do  
that in the past.

**BRUCE BARRON (ON-CAM) :**

I can think of one project for a 30-  
pound steel precision casting where five  
days after we got the data from the  
customer we were producing rapid  
prototype machined castings and  
delivering for weeks via rapid  
prototyping methods, while a tool was  
being built that could provide the  
production parts.

--- TOUCH BLACK ---