**PSF RAPID TOOLING PROCESS**

Precision Spray Forming – Quality tooling with rapid prototyping timing

**AN INNOVATIVE RAPID TOOLING PROCESS**

Many mass-produced parts ranging from cell phone shells to automotive components are made by using metal moulds or dies through such processes as die casting, stamping, die forging, injection or compression moulding, extrusion, or blow moulding. Manufacturers are always searching for ways to cut down the great costs and long lead times in preparing and changing the tools. VTT has been developing a rapid tooling process, Precision Sprayforming (PSF), which combines advantages of sprayforming and ceramic rapid prototyping techniques. The principle of PSF is illustrated in the picture.

**SPRAYFORMING PLANT IN VTT**

- An Osprey type sprayforming plant, as shown by the photo above
- 50 kg N₂ shielded induction furnace which can make any commercial or special tool steels and other alloys
- Deposition rate 30 kg/min

**SPRAYFORMING TECHNOLOGY**

- Direct forming from melt to near net shape
- Great variety of high alloyed steels which are difficult for conventional ingot process
- Rapid solidification leads to fine microstructure without segregation, leading to high workability and wear performance

**PROCESS STEPS OF PSF**

- Start with an insert design in a CAD file
- The CAD file is converted to a pattern, which is normally made of a kind of plastics by CNC milling, stereo-lithography (SLA), silicone rapid prototyping, or other methods
- A ceramic mould made with the pattern, a new ceramic moulding process developed
- Sprayforming special tool steel or other alloys onto the ceramic mould
- Minor finishing work and / or surface polishing if needed in some cases.

An example of making a forging die insert is shown in a group of photos next page.
TECHNO-ECONOMICAL BENEFITS

- Remarkable cost benefit derives from converting molten alloy directly into a (near) net shape die insert. Die costs are reduced by 30-50%, comparing to traditional processes.
- Lead times for making an insert can be shortened from months to a few days.
- New mould steels and hot work steels are developed, which impart the die inserts with sound microstructure and high wear resistance, as-sprayformed hardness reaches up to 61 HRC, longer tool life times have been achieved in hot forging production tests.
- PSF process is able to make conformal cooling channels in the die inserts during sprayforming, improving tool functions at elevated working temperatures.
- Dimension accuracy of +/- 0.05 mm, and mirror surface finishing can be reached in some cases without machining.

MATERIAL BENEFITS OF PSF PROCESS

- Rapid solidification, thus refined microstructures and nearly no segregation.
- At least 25% higher tensile strength and 50-100% more ductility comparing to traditional process.
- Capable to make special high alloy steels which are difficult for conventional steel making. For example, over 3% V causes serious segregation and coarse carbides in ingot process, while PSF process easily makes 12%-V tools.
- No need of high temperature hardening, saving time and minimising distortion of dies in heat treatment.

Composition of A11 and D2 tool steels

<table>
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<tr>
<th>Steel type</th>
<th>C%</th>
<th>C%</th>
<th>V%</th>
<th>Mo%</th>
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<tr>
<td>AISI A11</td>
<td>2.45</td>
<td>5.25</td>
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<tr>
<td>AISI D2</td>
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<td>0.8</td>
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Because of higher vanadium content, A11 offers 3-5 times longer wear life than D2 steel.

Microstructures of cast (upper) and sprayformed (lower) 12-V steel.

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