Predicting Pattern Tooling Dimensions for the Investment Casting Process

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Objective: Determine die tooling dimensions for the investment casting process to produce casting parts at nominal dimensions within tight tolerances.

Background: Die tooling dimensions are determined by adjusting blue-part dimensions based on proprietary and plant experience.
To date, there are no industry-wide guidelines to tooling engineers for die dimensioning.

Approach: Develop plant procedures and computational models to determine dimensions for wax patterns, shell molds, casting parts, and die tooling.

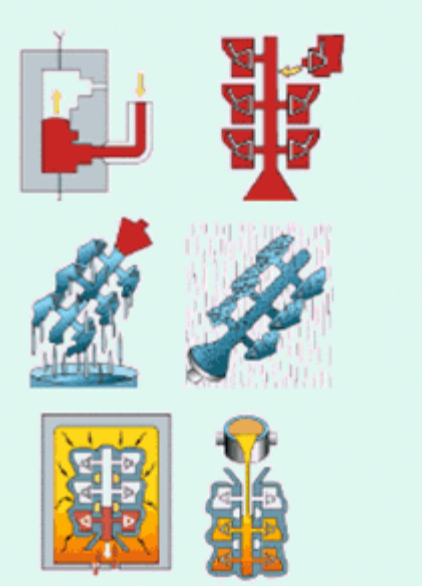


Figure 1. Schematic of the Investment casting process.

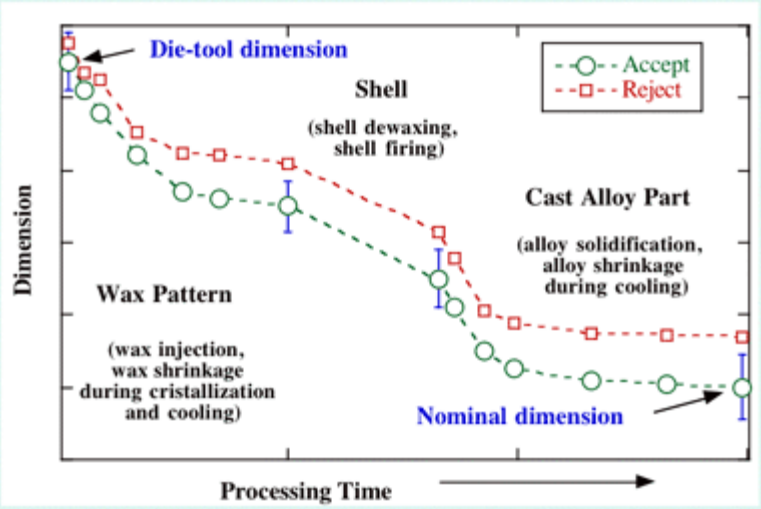


Figure 2. Dimensions during processing.

Accomplishments:

Wax: Pioneered the measurement of viscoelastic properties of waxes. Determined wax pattern dimensions using computer models.
Distortion of wax patterns can be qualitatively predicted using viscoelastic models.

Viscoelastic wax model.

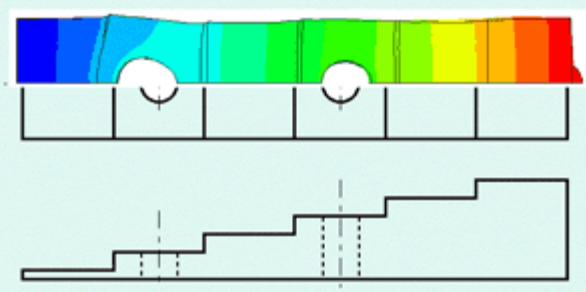
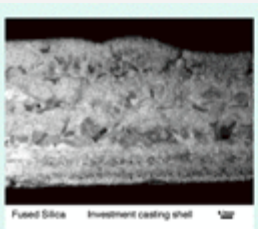


Figure 3. Schematic of stepped pattern. Wax pattern distortion after cooling.

Shell: Obtained constitutive equations for thermal radiation effects within the shell mold.
Casting temperature can be predicted with confidence using new thermal radiation models.



$$k = k_c + 4E\sigma d_p T^3$$

Constitutive equation for shell thermal conductivity.

Figure 4. Shell microstructure. Shell molds based on fused silica are semi-transparent. Shell mold is an optically thick media.

Benefits: Reduce scrap by improving dimensioning practices, reduce the downtime due to mold rework, allow the use of thinner walls, increase productivity of the design process. Projected benefits: Scrap deduction from 4% to 3%. Increase in yield from 55 to 65%.

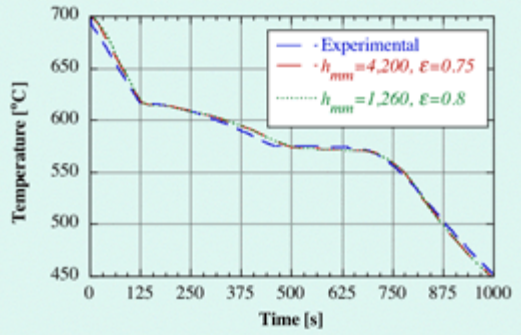


Figure 5. FEA results showing excellent agreement with experimental results for temperature in the center of the plate casting.

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