Convergence of R&D, Industry, and Government for Market Growth

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Introduction

Advanced Manufacturing is a pillar industry of the United States, whose future is tied to its manufacturing heritage. Current trends show that manufacturers nationwide are outsourcing at a rapid pace. These trends are leading to a serious knowledge gap within companies, primarily in the design area. In the past, organizations performed all the necessary functions related to product specification, design, manufacturing, and maintenance under one roof. This allowed knowledge to be housed within a functional unit. But with the specialization in engineering functions that is occurring, the trend in outsourcing has led to a distributed knowledge base. As a result, designers and engineers making design decisions at Original Equipment Manufacturing (OEMs) such as General Motors (GM), Daimler Chrysler, and Ford often have spotty knowledge of the requirements of each interface in the supply chain. However, they are making design decisions which impact the choice of materials and processes along with part geometry and its implications for cost, manufacturability, and tooling. ***Studies have indicated that the cost of product design is only around 5% of the total product cost, while decisions made during the design stage affect as much as 70-80% of the final product cost[1].***

Market Study

A recent survey done by Purdue University of designers' knowledge of manufacturing processes indicated that more than 90% know little or nothing about casting processes such as die and investment casting[2] [3]. In addition, the study revealed several important facts about engineers and designers and their knowledge:

- They are forced to make material and process decisions early on when the quality of information is relatively low.
- They learn about process selection from:
    - School (< 5%)
    - Mentoring
    - Trade Publications
    - Seminars
    - Company Technology Lab
    - Direct Supplier Contact (most popular)

The study also showed that there was no consistent approach in teaching the engineers/designers manufacturing processes or material selection.

The study noted the factors which provided downstream manufacturability issues and cost impact about which the engineers and designers wished they had more knowledge:

- Part complexity (fingerlike protrusions, thin or thick sections, number of surfaces on part, harsh transitions of geometry)
- Part and whether it can be made near net shape
- Lowest cost/volume and payback (including tooling and piece price)
- Tolerance precision required

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[1] Ullman, D. G., "The Mechanical Design Process," McGraw Hill, NY, 1992.
[2] Bishop, R., "Huge Gaps in Designer's Knowledge Revealed," Eureka, October 1985.
[3] Karthik, S., Chung, C., and Ramani, K., "Rapid Application Development of Process Capability - Supplier Models," ASME 2003 International Design Engineering Technical Conferences, Chicago, Illinois, September 2-6, 2003.

- Dimensional Stability
- Material availability at the current supplier
- Surface finish required
- Adaptability of part to draft limits
- Simplicity of parting line – can it be envisioned at conception of a part
- Cost of process
- Volumes of other parts to combine with – i.e., if a supplier has volumes of a similar part, it may save money to select that process
- Material imperfections – i.e., sand casting can leave sand in part, die casting may have high porosity, etc.
- Ability of the part to be inspected – some castings may require secondary operations to create a datum of measurement
- Edge conditions with respect to assembly – for example, if customer use requires assembly, part may require an edge breaking process
- Ability of part to have a marking cast-in (like part number)
- Parts that need
    - Increased draft
    - Thicker sections
    - Gate witness
    - Ejector pin
    - Parting line
    - Flash locations in critical function
    - Esthetic areas

Convergence of University, Government, Association, and Small Business

Realizing this knowledge gap, the U.S. Defense Logistics Agency (DLA), with the help of the American Metal Casting Consortium (AMC), funded the American Foundry Society (AFS) to manage a research project that would develop a casting advisory system in the beginning of 2001 to assist designers and engineers in early design. Purdue University's PRECISE lab was selected to conduct research in this area. The initial findings in consolidating the knowledge base revealed that there were nearly 40+ casting processes with contrasting capabilities. Therefore, a system and methodology needed to be developed to help designers/engineers evaluate the suitability of various casting processes with respect to part design. Additionally, the system needed to be easy-to-use and integrated into the popular design tools used in the industry. The system also had to link to 2400+ foundries across the United States, most of which are AFS members. The link to the suppliers had to be based on capabilities and, furthermore, enable collaboration or dialog with OEM and Suppliers. Most importantly, the AFS' objective was to enable casting to be considered for every product design.

The research project at Purdue University developed the methodology and initial prototype, which showed promise. The paper "Methodology for Metalcasting Process Selection" can be obtained from the Purdue University PRECISE lab website – http://tools.ecn.purdue.edu/~cise/publications.html.

It was evident that in order to incorporate the objectives identified by DLA, AMC, and AFS, the research project had to find a commercialization avenue. Imaginestics, which develops Knowledge Reuse Management (KRM) systems and is located at the Purdue Research Park, partnered with Purdue University's PRECISE lab to help realize the vision. Imaginestics, with the help of initial Small Business Innovative Research (SBIR) funding from the National Science Foundation (NSF) developed a prototype, which was introduced to companies manufacturing large amounts of

castings, such as Dana Corporation, a Tier 1 Automotive supplier, and GM. The response was very positive and plans were immediately established to begin integrating into mainstream design systems. The objectives for these are:

- Enable engineers/designers to make informed decisions in the early design about processes and part/tooling for manufacturability
- Serve as an on-demand "what-if" and manufacturing educational tool for engineers/designers
- Reduce non-value added features so optimal and economical processes can be considered, thus lowering tooling costs
- Provide relative cost advice, which will be integrated dynamically with design features
- Minimize the risk in the quotation process for both OEMs and tooling firms
- Allow for design that is manufacturable within a supplier's capabilities
- Match supplier capabilities to design requirements
- Develop curriculum within Universities to introduce the concept in engineering and technology programs
- Develop AFS instructed classes to help members maximize their influence and provide methodology to introduce new processes, material properties, and techniques into the system

The above action items will enable designers/engineers to consider castings during early design in cases where they may not have been previously considered. This will allow the casting market to grow significantly as new processes and materials are introduced and capabilities improved.

Next Steps

Although systems such as these are important to help provide global or industry knowledge during early design, it is even more important to develop a framework that allows companies to easily incorporate local or company specific knowledge. Since the local knowledge is what enables companies to be competitive, imaginestics, with the help of Purdue University's PRECISE lab, is developing a framework for companies to easily enter this mostly implicit knowledge.

Conclusion

The realization of the full vision that was initially set forth is still a year or two away; however, an important achievement has been made. The convergence of University, Government, Association, and Small Business has been realized through the execution of this vision to impact market growth.