J. Rapid, Low-Cost Tooling Development

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Objectives

- Assess status and need for low-cost tooling technologies for lightweighting materials.
- Evaluate state-of-the-art capabilities for rapid, low-cost tooling approaches.
- Determine the socioeconomic factors that are likely to significantly impact the development and implementation of advanced tooling technology.

Approach

- Conduct a workshop to solicit industry input. Follow the workshop by privately interviewing key participants throughout the value chain.
- Conduct energy analysis to estimate potential energy savings from improved tooling technology.
- Review tooling industry socioeconomics and potential impacts of technological change in the industry.
- Report key findings and plan the path forward.

Accomplishments

- Conducted two industry workshop sessions.
- Recorded preliminary findings from workshop sessions and published summaries on the web
- Performed energy analysis.
- Conducted follow-up interviews with key industry workshop contacts.
- Reviewed socioeconomic indicators of tooling industry health and potential impacts of technological change or lack thereof.
- Developed a plan to engage industry in roadmapping and collaborative technology development.
- Issued draft report to DOE.

Future Direction

- Work with industry to foster communication and collaboration, and to develop an "industry-owned" roadmap.
- Engage other interested government parties to co-sponsor research and development (R&D).
- Commence performing selected R&D.

Introduction

The introduction of advanced polymer-based composites and lightweight material manufacturing processes to commercial vehicle manufacturers and their supplier base is thought to be severely impacted by the high cost of tooling and long tooling development time. Often the use of lower-cost materials and less efficient structural designs is dictated by the fact that tooling for the manufacture of advanced composites and other lightweight materials cannot be justified from a cost-per-part basis, and from the long development times or procurement lead times that are required. In addition, the unique production volumes associated with commercial vehicles—which are significantly lower than automotive production volumes, yet well above aerospace production numbers—make current tooling design and development methods unsuitable.

An example of the cost and schedule challenges faced by commercial vehicle manufacturers is that a fully tooled door system for a Class 8 tractor can cost upward of $20 million and require over 24 months to fabricate and qualify the tooling. When advanced materials such as carbon fiber composites or lightweight metals such as aluminum or magnesium are considered, tooling design, material forming characteristics, and surface finish requirements make today's manufacturing approaches very high-risk. The result is often that manufacturers fall back on less efficient structures that use conventional steel and fabricated structural designs.

The purpose of this project is to assess current tooling technologies to identify key deficiencies in cost, prototype and fabrication methods, and design and modeling tools that prevent the increased use of lightweight metals and composites structures in low- and medium-volume commercial vehicles. Data have been gathered from government–industry workshops, published data sources, and numerous follow-up interviews with workshop participants and other key industry experts. The team intends to work with industry to develop a roadmap that will guide the development and implementation of advanced tooling technology that reduces the risk of using advanced lightweight materials in commercial vehicle applications.

Project Deliverables

In late FY 2004, the project team delivered to DOE a draft report containing findings from the industry workshop, follow-up interviews, energy analysis, and socioeconomics review. The primary future deliverables are a roadmap for tooling technology development and implementation, and a list of co-sponsors that will share the R&D costs with DOE.

Technical Approach

The technical approach for this project is largely based on gathering and analyzing information to enable informed decision-making regarding future R&D investments. A key part of the project has been to plan and conduct a workshop that served as a forum for soliciting information from industry experts and for networking among industry peers. The workshop was followed by interviews with selected key industry contacts, most of whom were attendees at one or more workshop sessions, to validate the workshop findings. Additionally, potential energy and socioeconomic impacts were analyzed. In the future, a roadmap and program plan will be developed.

Industry Workshop

Oak Ridge National Laboratory (ORNL) and Pacific Northwest National Laboratory (PNNL) co-hosted a two-session industry workshop entitled "Tooling Technology for Low-Volume Vehicle Production." The workshop scope principally addressed tooling needs for large, lightweight components or parts, manufactured in production volumes from 1,000 to 30,000 parts per year, using closed or twosided forming or molding processes. Topics covered at the workshop included

- Large class-A components
- Large structural components
- Computer-aided design/computer-aided engineering/computer-aided manufacturing/CIM (CAD/CAE/CAM/CIM) efficiencies
- Rapid prototyping
- Predictive modeling

The target audience included truck, bus, automotive, recreational vehicle, and marine original equipment manufacturers (OEMs) and suppliers; tooling suppliers and designers; tooling material suppliers; rapid prototyping suppliers; CAD/CAE/CAM/CIM suppliers and developers; and machine tool suppliers.

Session one, hosted by PNNL in Seattle on October 28, 2003, focused on identifying needs and goals. It was attended by approximately 30 industry experts with a high representation from truck OEMs and upper-tier suppliers. Session two, hosted by ORNL in Detroit on November 18, 2003, focused on roadmapping solutions and strategies. It was attended by approximately 50 industry experts, with a high representation from companies that were offering new technology that they consider applicable to the tooling industry.

Preliminary workshop observations included these:

- Tooling technology development does not have a home or champion.
  - OEMs and upper tier suppliers push it down the supply chain.
  - Tool suppliers are too small to accept the risk (see socioeconomics discussion).
  - The value chain is very fragmented, and there is poor up-down communication.
  - This workshop appeared to be the first forum that had fostered communication throughout the tooling value chain.
- Tool manufacturing is moving offshore.
- High tooling cost kills development projects.
- Improved tooling technology may lead to reductions in vehicle mass and aerodynamic drag.
- There are some novel technologies and ideas that merit further development.
- The business case can favor composites (and perhaps other lightweighting materials) at low vehicle production volumes.

To date, follow-up analysis has confirmed some of these observations and found others to be suspect. Workshop session summaries and invited presentations are posted on the worldwide web at http://www.pnl.gov/energy/tooling/default.htm.

Energy Analysis

An energy savings analysis was conducted by ORNL, using survey data from the workshop sessions. The results suggest that, at full market penetration, probable energy savings attributable to improved tooling are about 4% for heavy trucks and 6% for passenger cars. Details of the analysis, such as assumptions and sensitivity estimates, are available in the full report.[1]

Socioeconomics

A socioeconomics review was conducted to assess the tooling industry's health and impacts on U.S. economic prosperity. Key findings are discussed below.

The U.S. tool, die, and mold (TDM) industry consists exclusively of small businesses and is a deeply distressed industry. In 1997, more than 75% of the companies employed fewer than 20 people, and 92% employed fewer than 50 people. In 2001, there were only 16 companies with revenues of $20 million or more. The largest company had $80 million in revenues. In 1997, the industry had about 7200 companies and was losing about 200 companies per year—before the most recent recession. Though Commerce Department data are not yet available for 2002 and 2003, our industry interviews suggest that the shake-out of independent TDMs accelerated in those years as a result of the recession.

Apparent U.S. consumption of TDMs remained essentially flat during the 1997–2000 period at $15 billion before declining in 2001 to $13.8 billion. Imports and exports showed the same general trend, essentially flat during the 1997–2000 period, followed by a significant decline in 2001. In 2001, the latest year for which data are available, domestic TDM manufacture was $13.2 billion, imports totaled $1.7 billion, and exports accounted for $1.1 billion. In follow-up interviews, we found that those who were importing tools usually were importing from high-cost-of-labor countries that gained their advantage through technology. Although we do not doubt the workshop participants' concerns over imports, it is difficult to ascribe the industry problems to this source.

We discovered that during the 1997–2001 period, the TDM share of total U.S. manufactured goods value declined by 13%. It appears that U.S. manufacturers are reducing the value of TDMs in their finished manufactured products through TDM price reductions, longer use of existing tools, reduced prototyping, and fewer product changes. We believe that these reductions in TDM purchases are also related to increased stamping die production by the major automobile OEMs. Hence we conclude that the major source of the industry's distress is a fundamental shift in its market drivers.

Payment terms, which are driven by the OEMs, are a significant factor in the TDM industry's distress. The OEM often does not pay the first-tier supplier until production begins, which is usually 18 months or more after the TDM buys the tool material. The supplier frequently exacts the same terms from the tool maker. Hence the TDM is essentially compelled to make an interest-free loan to the OEM for several months. Being small companies, the TDMs will generally require bank financing, and banks discount the value of receivables over 30 days. The strain put on banking relations by the recession was certainly a factor in the high rate of TDM company failures during the recession. The truck OEMs and those transplant automobile makers that were interviewed generally have payment policies that are more beneficial to the TDMs than do the U.S. "Big Three" OEMs. However, the domestic automakers comprise the lion's share of independent TDM business in the United States; therefore, their procurement policies are a major factor in TDM industry health.

New technology can significantly reduce the unit cost of tooling. However, the equipment embodying the technology is expensive, especially for small businesses in "cash flow distress," and the resultant improvement in productivity increases the over-capacity in the industry. The reverse of this argument is that the survivors of the shake-out appear to have remained current with technology. This view was strongly reinforced in an interview with a small, but apparently successful, tool maker who suggested that if new technology could reduce tooling costs enough, that could change the paradigm and lead to more vehicle changes and more business for TDM builders. More vehicle changes translate into more rapid infusion of technology into the vehicles.

Given all of the above, and only minimal government support from the Department of Defense and Department of Commerce, the technology development firms are struggling to survive. The technology developers would like direct government support. However, lacking financial support, they would like to see some mechanism by which the risk of new technology is shared among the TDM builder, the supplier, and the OEM. They feel that the OEM discourages new technology by not being willing to share the risk. Clearly, the TDM builder is the least able to afford the risk of new technology but is one of its biggest beneficiaries. Further, given the lack of real communication in the supply chain, the OEM is essentially oblivious to the problem faced by the TDM builder in adopting new technology.

Conclusions

Tooling is a major expense in manufacturing vehicles, especially at low production volumes. The industry workshop sessions were well-attended, fostered a unique networking opportunity for industry, and provided important information. The energy savings analysis suggests that improved tooling technology should lead to appreciable reduction in petroleum demand. The socioeconomics review found a disconnected value chain, with the TDM manufacturing industry consisting entirely of small businesses and being in severe distress. The good news is that almost everyone with whom we have talked, including prospective co-sponsors such as other government agencies, wants to "do something." It appears that there are opportunities to make a difference with properly planned and targeted technology development and implementation. In FY 2005, we plan to engage the stakeholders to develop a roadmap and begin its implementation.

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References

1. R. L. Schmoyer and C. C. Eberle, "An Analysis of Energy Savings Possible Through Advances in Automotive Tooling Technology," ORNL/TM-2004/115, Oak Ridge National Laboratory, 2004.

Publication

R. L. Schmoyer and C. C. Eberle, "An Analysis of Energy Savings Possible Through Advances in Automotive Tooling Technology," ORNL/TM-2004/115, Oak Ridge National Laboratory, 2004.