Mold Design for Injection Molding:  
A Successful Industry-University Partnership Case Study

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Abstract

In spring semester of 1999, a visit from Black and Decker Power Tool Division to Morgan State University’s School of Engineering and ensuing meetings resulted in establishing a partnership with tremendous success in a number of areas on which the partnership had focused. One of the areas, the mold design for the injection molding machine, was extremely successful and became a model for further work in that area. The project involved the use of the machines, equipment and tools of the Advanced Engineering Design Center (AEDC) with involvement of the Industrial, Manufacturing & Information Engineering program’s graduate and undergraduate students at Morgan State University and the help of faculty and staff. From Black and Decker, polymer engineers and experts, mold designers and machine shop experts were involved.

During the concept development meetings we decided that an actual part would be made for distribution in an upcoming conference. The logo of an upcoming conference was considered and a portion of the logo consisting of an odometer type shape to be developed as a design for a key chain. The requirements for designing and developing the mold for the injection molding process were identified and plans for developing necessary skills were devised. An experienced mold maker from Black and Decker held several sessions with the students to provide them with basic elements of mold design. The faculty held theoretical discussions separately. Additional training was provided on the operation of the Haas VF-2 CNC machining center. Using Mastercam, the appropriate design was developed for the two halves of the mold. The molds were then machined on the CNC machine; mold then was assembled and installed on a Cincinnati Milacron SX-85 injection-molding machine, which successfully produced the key chains. During the development phase, Black and Decker provided expertise in all aspect of the design. Help was provided in selection and acquisition of the polymers, design of the runners and gates, ejection pins and hot stamping of the key chains for an additional color.

Through developing a product from the concept to final product, those involved developed a better sense of understanding and appreciation for complicated manufacturing requirements of a rather simple product. The final product was distributed to all participants of the conference. This paper presents an account of the design process, with emphasizing the lessons learned, things to consider and those to avoid for a successful industry-university partnership.
Background

Morgan State University is a member of Historically Black Colleges and Universities (HBCU) located in Baltimore, Maryland. It is a designated doctoral granting urban institution offering diverse programs in liberal arts, education, business, engineering and more. The school of engineering was established in 1984 largely in response to increasing need to provide opportunities for minority students to pursue higher education in engineering fields. Since its first graduate class in 1990, engineering program in Morgan has been largely responsible for an increase of almost 16% (from 3% to 19%) of African-American students graduating from an engineering program in the state of Maryland. There are three programs within the School of Engineering, Electrical and Computer Engineering (ECE), Civil and Environmental Engineering (CEE), and Industrial, Manufacturing and Information Engineering (IMIE). The IMIE department is the smallest department with around 110 undergraduate enrollments. With the addition of graduate programs, Master of Engineering and Doctor of Engineering, since 1998 there are now an additional 12 students at the master’s level and 4 students at the doctoral level that are pursuing their education with concentration in Industrial Engineering fields.

With the first building of engineering school opened in 1991 and enrollment surpassing the expectation of state legislatures and government, a new building was planned and approved for the engineering program. The building opened in April of 1997 added new facilities and capabilities to the school bringing it into a state-of-the-art facility in line with an ambitious mission plan for the school. In the new building, the IMIE program had four new spacious labs with the equipments that faculty had recommended their procurement.

Advanced Engineering Design Center (AEDC)

Two of the new labs, Rapid Prototyping, Modeling, and Analysis Lab and Advanced Manufacturing Lab, were intended and designed, as Product Realization Labs and became the nucleus of Advanced Engineering Design Center (AEDC). They include a range of solid modeling, CAD/CAM, analysis and testing, and monitoring and control software. Some of these software are loaded on dedicated PC based high-end and Unix based SGI workstations to specific equipment and some on general high-end computers in the labs.

Major equipment in the two labs are 3-D Systems SLA 250 Stereolithography machine with its Post Curing Apparatus unit, complete sample preparation, testing and image analysis lab equipment by Buehler, Haas VF-2 CNC Machining Center, SX-85 Vista Cincinnati Injection Molding machine, Fanuc 1-aC Robocut Wire EDM, an Optical Comparator, a CMM unit, and a foundry.

AEDC is designed to support teaching and research needs of the students and faculty at the university. It is add furthermore intended to reach into the industrial community in the state in order to support the local industry and small businesses and to facilitate the needs of local entrepreneurs with help in the design, manufacturing, and testing of parts and products. In
achieving these goals, AEDC relies on funds generated from its own activities to support research and expansion of its activities.

Industrial Partnership

With over $1 million worth of hardware and software, it was clear to all involved that some formula for generating funds had to be established to support the maintenance and usage of the equipment. Since, any expectation from the departmental support was unrealistic, we turned our attention toward two possible sources of support, government funding agencies and private and public industrial manufacturing entities within the state.

In spring semester of 1999, a visit from Black and Decker Power Tool Division to Morgan State University’s School of Engineering and ensuing meetings resulted in establishing a partnership with tremendous success in a number of areas on which the partnership had focused. Black and Decker is a world leader in manufacturing of professional power tools with manufacturing plants in North America and Europe. The corporate headquarters is located in Towson, Maryland less than 5 miles from Morgan’s Engineering School. After the visit, we focused on several areas that we could work together. They were categorized in four groups.

1. **Technical Help**: Black and Decker engineers and technicians provided technical expertise in a number of areas including plastic engineering, solid modeling, injection molding and material science.

2. **Service**: AEDC created rapid prototyping models and wire EDM parts for Black and Decker.

3. **Capability Enhancement**: In a design-to-production effort, AEDC and Black and Decker produced a product for distribution in a conference.

4. **Proposal Writing**: A couple of joint research ideas were explored; proposals were submitted to the state funding agencies resulting in two grants.

Mold Design

One of the areas under the Capability Enhancement was the mold design for the injection molding machine. It was an extremely successful effort and became a model for further co-operative work. The goal of this effort was to produce a plastic part on the injection molding machine. Furthermore, we wanted to go through the whole process from the inception of the idea to manufacturing of the product. Since the major players of this partnership were also involved in another joint effort, Partnering 2K Conference, we finally decided to use a portion of the logo of that conference and make a key chain from it as it is indicated in Figure 1.
We also identified four key decisions that had to be made.

a. What skills were needed
b. Who was going to participate
c. What were each person's assignments
d. When were the individual assignments expected to be completed

Four undergraduate and two graduate students from the Industrial Engineering program participated in the effort. Based on levels of participants’ skills, reading assignments were prescribed. Furthermore, a bi-weekly meeting was held with a master mold maker from Black and Decker in which students were exposed to practical issues of mold making. Although, all students were participating in the mold making project, their individual reading assignments were different. While one student focused on plastics, another student concentrated on the design of gates and runners and yet another on the mold cooling and heating effects on the final part.

Several designs of key chain were studied and a final design among them was selected (Figure 2). We decided to use a MUD frame for the mold (Figure 3). Blank mold halves were obtained and due to the size of the key chain, two key chains were to be produced with each shot (Figure 4).

![Figure 2. Front and back of the final design of key chains for the Partnering 2K Conference.](image-url)
To make an efficient use of the mold halves, cavities were machined for inserts. Those inserts were then machined to fit the cavities on both sides of the mold (Figure 5). Runners were also machined in the mold halves and inserts for the flow of hot plastic. Cooling and heating lines had already been machined into the mold halves. Ejector pins and guide rods were added to finalize the mold design (Figure 6).
Figure 5. Back and front of several inserts with the special fixture made for their machining.

Figure 6. View of B side of the mold with the ejector pins and supporting back plate.
Throughout the whole process, Mastercam was used to generate the NC code, Haas VF-2 was used for machining parts and Cincinnati Milacron SX-85 Vista injection molding machine was employed to produce the final product. Key chains were made in blue and were hot stamped with orange color to represent the university colors. A text at the back of the key chain identified that the key chains were made at Morgan in partnership with Black and Decker. Rings were added to the key chains and each Partnering 2K conference participant received one with his/her conference package. During the development phase, Black and Decker provided expertise in all aspect of the design. Help was provided in selection and acquisition of the polymers, design of the runners and gates, ejection pins and hot stamping of the key chains for an additional color.

Conclusions and Recommendations

Through developing a product from the concept to manufacturing and distribution, those involved developed a better sense of understanding and appreciation for complicated manufacturing requirements of a rather simple product. Some of the important observations that we made were more of a general nature but too essential to ignore for success in any industry-academia partnership.

1. **Commitment:** There has to be a strong commitment to follow through the plans on both sides. This may seem trivial but it is the cornerstone of any successful partnership. Simply because there does not seem to be a considerable monetary or merit reward for those involved, there is a tendency to scrap joint projects. This has to be avoided.

2. **Pragmatism:** Each side should realize that the nature of work is different at other side’s workplace. Expectations must be set based on “who is available” for “what duration” and “to do what”. This is extremely important when students are involved and their schedule most of the time indicates lack of availability when the work needs to be done with a short turn-around time.

3. **Accountability:** Throughout this partnership, one thing ruled all of our efforts at AEDC, a commitment to do our best and be accountable for promises that we made and to the quality of work we performed. In turn, Black and Decker was an excellent partner in this effort providing technical help and limited funds for our efforts.

4. **Dissemination:** Since often several people at different locations are involved it is imperative that Internet and World-Wide-Web be used as a medium of communication as we used it extensively during our work.

5. **Rewards:** For both industry and academic institutions, it is necessary to take a hard look at the incentives that need to be placed on effort such as this that involve considerable time to be spent at the top of each person’s regular duties.
Acknowledgement

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Bibliography

1. URL: http://multimedia.eng.morgan.edu/p2k; Partnering 2K Conference Homepage.
2. URL: http://multimedia.eng.morgan.edu/~salimian; Dr. Masud Salimian’s Homepage.

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