

CLAMP Projects: Using Composite Materials to Create Lightweight Cars

Over the past two decades, the automobile industry has pursued a variety of technological developments and design strategies to meet increasingly stringent automobile performance requirements in the areas of fuel economy and emissions. In the College of Engineering and Computer Science, the Center for Lightweight Automotive Materials and Processing (CLAMP) has focused on reducing the weight of vehicles through the use of high-strength materials, including lightweight materials like aluminum alloys, magnesium alloys, and fiber-reinforced polymers. CLAMP's research considers design, testing, and manufacturing with these materials.

"Fiber-reinforced polymers, commonly referred to as composite materials, are being used in a large number of applications ranging from stealth airplanes and space shuttle components to tennis rackets and fishing rods," says Dr. P. K. Mallick, director of CLAMP and professor of mechanical engineering. "These materials are lightweight, strong, vibration-resistant, and easily processed. They can also be tailored to the design need. However, they are not yet as inexpensive as steel, the workhorse material in today's automobiles."

Two projects under way at CLAMP use composite materials in structural applications. One project focuses on improving the chassis of a vehicle; the other focuses on the vehicle body structure.

The first project hybridizes a glass fiber-reinforced epoxy with aluminum tubes in a novel way that increases crush resistance for the front end of cars. "We had people working with each of these materials in separate projects," says Mallick. "I thought it

would be interesting to combine the materials and see what we could do."

The tubes are made in the plastics and composites processing laboratory and evaluated in the materials testing laboratory to determine how easily they crush under certain circumstances. "We also combine structural foam with the tubes in order to make them sturdier," says Mallick.

The project, which started in 1998, has involved several students working consecutively. Mallick hopes to find additional funding for future research. "The ultimate goal of the project is to build a crashworthy space frame front-end structure for a vehicle," he says.

A second ongoing project involving composite materials at CLAMP is funded by the Department of Energy and concentrates on the manufacturing process development of thermo-plastic matrix composite beams and tubes, which could then be used in the construction of vehicle rail rails, door beams, and other body structures. They can also be used for body panels. "We chose this material because it offers many advantages," says Mallick, "including higher energy absorption, lower processing time, and recyclability."

"For this project, we're looking not just at the materials themselves but also into the cost benefits



P. K. Mallick holds some of the composite plates being tested for crashworthiness and impact resistance.

behind using them and what techniques could be used to mass-produce them," Mallick continues. "The manufacturing process we're developing is similar to stamping, which can be adapted relatively easily in today's automotive manufacturing plants. We're also looking into vibration welding as a novel method of joining fiber-reinforced polymers."

The second project began in early 2001 and has involved four students, two of whom continue to work on it today. "They build on each other's work," says Mallick, "continuing where the previous students left off."

"All the research we're doing filters into the courses that I teach," continues Mallick, "and hopefully ultimately out into the marketplace. The bottom line of everything we do here is to help industry create a more crashworthy, lightweight car."

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Al Ver

Al Ver is, in a word, practical. As Ford Motor Company's vice president of advanced and manufacturing engineering, Ver looks at "idea" cars and figures out how to make them happen. "I work for both manufacturing and product development," he says. "Product development works on all the advanced concepts up front that go into making a new vehicle. Manufacturing figures out how to build it."

Ver gives an example: "Let's say product development wants to start making Jaguars out of aluminum. That's a great idea. Manufacturing then asks: How are we going to do that? What process technology has to be developed or fine-tuned to make this happen? As the link between the two divisions, I'm the poster child for matrix management. It's a nice place to be."

Ver is also responsible for what he calls the "day-to-day stuff" involved in building the vehicles, including process engineering, equipment purchasing, and launching new models. "I spend the majority of my time overseeing execution of production programs," he says.

Although he spends a good part of his day in meetings, Ver most enjoys getting into the plants. "I've spent most of my life in a plant building, making something," he says. "Most of us in this business are here because we're car nuts. To see all our product concepts come together after four years and finally start coming off the line, that's

the highlight. A vehicle is a tremendously complex piece of equipment. To watch one roll off the line every 45 seconds and actually start and run is pretty amazing."

Engineering and computer science students and alumni from UM-Dearborn have played a considerable role in making that happen. "I've had a lot of experience with the students there," he says. "I've seen how the college does a great job of marrying the academic world with practical application." It's that combining of the practical and the academic that most impresses Ver about the school and helped influence his decision to join the CEEP advisory board three years ago.

He also feels an affinity for the students: "Like many of them," he says, "I got my master's degree while working full time. I understand the pressures of trying to do that. And the benefits, too; it's valuable to be able to apply what you're learning right away rather than have to wait until you're done. It makes you examine what you're learning and question whether it's really practical."

With more than 30 years in the automotive industry, Ver feels he's in a position to help both UM-Dearborn and Ford. "There's a real benefit to be gained in finding joint research projects to work on," he says. "The university benefits by doing real-world research, and the company benefits from the output of these activities."

Married for 35 years, Ver acknowledges his wife's importance to his career. "She's a great support in



CEEP Advisory Board member, Al Ver, vice president, Advanced Manufacturing and Engineering, Ford Motor Company

every way," he says. "There's no way you can do a job like this without that kind of support." His daughter and her husband are about to add a second grandchild to the family, while his son has recently discovered a new career. "He was a dot-commer in New York until 9-11," says Ver. "He went down to Ground Zero to help the Red Cross and was so impacted by the experience he ended up getting his paramedic degree." He adds

with pride that his son now works full time as a paramedic in San Francisco.

When not at Ford or playing with grandkids, Ver runs marathons. His most recent marathon was in Columbus, Ohio, where, he says, "my objective, as always, was to finish. And I did."

First Doctor of Engineering in Manufacturing

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Over the next four years, Jie completed 24 course credits and more than 40 research credits at both the Ann Arbor and Dearborn campuses. After passing a series of qualifying exams, he completed his dissertation research in the field of manufacturing, focusing specifically on failure criteria in sheet metal forming. "Sheet metal forming is an important technology in manufacturing," says Jie. "It's a multi-billion-dollar industry in the USA. Well-established failure criteria on sheet metal forming will help industry save a great amount of testing costs and accelerate the manufacturing process."

The creation of the degree program was motivated by a recognized need for technical leaders in the manufacturing arena. In particular, the program seeks to develop technical leaders who have depth in their own engineering disciplines, breadth across multiple engineering disciplines, basic management and business skills, the ability to lead project teams, and the skills to carry out high-quality engineering research and development.

"CECS has been interested in establishing doctoral programs at the UM-Dearborn campus for a long time," says P. K. Mallick, director of interdisciplinary programs. "This interest is based on the need expressed by local industry, students, and faculty. The doctoral research in this program is industry oriented and has been instigated by industry need. While we are working toward establishing our own doctoral programs, participation in the D.Eng. in Mfg. program has allowed us to gain some experience in doctoral education and interact with the UM-Ann Arbor faculty."

Students in the D.Eng. in Mfg. program can take up to two classes at the UM-Dearborn campus and have one UM-Dearborn faculty member as a dissertation advisor. "There are currently four other students in the program who are expected to graduate in the next couple of years," says Mallick.

Professors Gain "On-the-Line" Experience with DaimlerChrysler Internships

For the second consecutive year, faculty members from the College of Engineering and Computer Science spent the summer interning at DaimlerChrysler. During the summer, Ali Kamrani (former associate professor of industrial and manufacturing systems engineering) and Armen Zakarian (associate professor of industrial and manufacturing systems engineering) worked onsite on two separate projects for DaimlerChrysler's Jeep and Truck engineering department. It was the second year at DaimlerChrysler for Kamrani, who was the first faculty member from the college to participate in DaimlerChrysler's internship program.

"These types of internships are very rewarding for faculty," says Kamrani. "This was my second time at DaimlerChrysler, and I believe my work last year and this year helped to show what UM-Dearborn faculty can do for them."

Kamrani's work this year extended the project he started at Chrysler last summer. "Last year, we set up the framework for the simulation modeling of the axle loop at the Jefferson North Assembly Plant (JNAP) to examine the problem of manufacturing complexity and how to manage delivery and inventory," says Kamrani, who specializes in product design systems engineering and manufacturing systems. "This year, we collected data and completed the simulation model." He developed a model for Chrysler to examine the flow and complexity of the system it used to order and distribute inventory at a plant that installs axles in Jeep Cherokees. Kamrani then made recommendations to help streamline the process. "With our proposed new model, the axle loop operation could save approximately \$3.2 million a year. I was also able to get my students involved in this project, which was a great experience for them."

Armen Zakarian also worked in Chrysler's Jeep and Truck engineering department, but focused instead on equipment fault analysis and improvement of the production line "uptime." "I was asked to develop software that would help DaimlerChrysler to better estimate the variables in its production system," says Zakarian. "I used production line data

from Chrysler's JNAP and developed a software application that helps to quickly identify root causes of machine downtime and to fine-tune the line. I also provided a list of recommendations to Chrysler for improving throughput at the assembly plant."

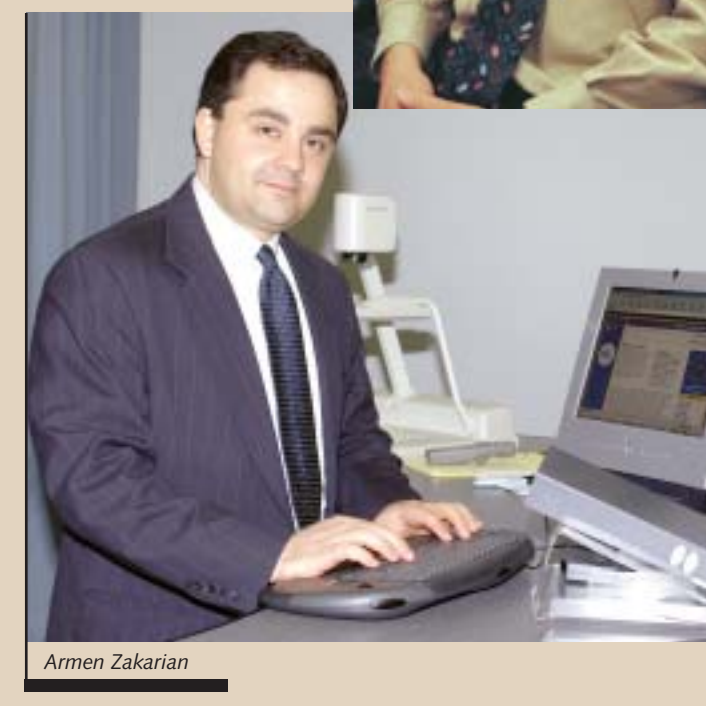
Both Kamrani and Zakarian found the internships rewarding. "We have a lot of DaimlerChrysler's students here in our engineering manufacturing programs," says Zakarian. "An experience like this keeps us more in tune with their actual problems. It also provides us with real-life examples we can use in the classroom."

Robert Hildebrand, director of the Center for Engineering Education and Practice, says this is a primary focus for the program. "It's similar to people in the medical field," says Hildebrand. "Every doctor is taught by people who are both practicing physicians and teachers. That's our objective as well, to get our faculty more engaged in industry through collaborative research, summer internships, and sabbaticals within industry. That's how they become acquainted with what actual engineering practice is all about."

"I really enjoyed the hands-on experience, the chance to get involved in some of Chrysler's day-to-day activities," says Kamrani. "I especially appreciated getting to see how the operator and



Ali Kamrani



Armen Zakarian

engineers managed the line, how they figured out their way around an issue. It was a great opportunity."

Zakarian also noted benefits to DaimlerChrysler. "They get very specific expertise to address their specific problems," he says. "Sometimes when you're inside a problem, it's hard to come up with a fresh perspective. People from the outside can be more objective, more independent, and are able to say what they really think."

Professor Zakarian can be contacted at zakarian@umich.edu or 313-593-5244

TACOM Awards \$1 Million to Rapid Manufacturing Project

Continued from page 1

to be commercialized. We plan to focus on both process as well as material development to overcome some of the inherent challenges of layered fabrication techniques."

During the first phase, the team will demonstrate the feasibility of its approach, using computer-simulated and actual physical demonstrations. In the second phase, the group plans to do more materials development and process evaluation research. The final phase will involve creating a prototype manufacturing unit.

As part of phase one, Armen Zakarian, associate professor of ISME, is developing an expert system. "Our goal is to create user-friendly software to assist rapid manufacturing of broken parts," says Zakarian. "Our software will allow Army engineers to search and retrieve broken part information from a relational database based on part geometry, dimensions, and other relevant part characteristics. Once part information is retrieved, the system we're proposing will produce step-by-step procedures for manufacturing the broken section of the part."

"Right now Dr. Shen and I are constructing the geometric modeling system for the project," says David Yoon, associate professor of CIS. "This software system needs to be able to infer the shapes of missing portions of broken parts along with their dimensions, which is what our current work will provide."

"My work will generate the thermal model for the spray process," adds Tariq Shamim, associate professor of ME. "This will help to optimize the process parameters."

The award came after Mohanty's team submitted a white paper summarizing its proposed research in response to a Broad Agency Announcement (BAA). TACOM invited them to submit a full proposal, which was then accepted. The team will work closely with TACOM program manager Aaron Hart and the associate director of the National Automotive Center (NAC) Benedict DeMarco.

"Down the road, we'd like to look at possible future applications," says Mohanty, "like coatings to protect against extreme wear and corrosion, armor materials, etc."

Low Mass Vehicle Program Has First Spin-Off

This past summer, while many students enjoyed a much-needed vacation, a team at the Institute for Advanced Vehicle Systems (IAVS) worked to design and develop an SUV version of the low mass vehicle (LMV). The low mass vehicle is the first major project of IAVS, which until now has been focused on the design of a car.

"Our goal with this project was to investigate the concept of building a different vehicle on the same small-volume assembly line as the LMV," says Dr. Roger Shulze, director of IAVS. "We wanted to learn the limits of building two completely different kinds of vehicles—the low mass vehicle, which is a small station wagon, and an SUV—on the same assembly line."

Ford Motor Company's Asia-Pacific group partnered in the project by sharing its marketing research for the Chinese market and by critiquing the SUV design. "We wanted to design the SUV with the special needs of the emerging market—mostly China and India—in mind," says Shulze. "We were interested in designing a vehicle that could be assembled profitably in relatively low volumes."

The team operated under three basic constraints. First, in order to make the new vehicle profitable, any additional investment required to build another vehicle design on the same assembly line had to be small. This meant that key structural differences between the low mass vehicle and the SUV had to be kept to a minimum. For example, the team decided to keep the floor pan, the wheelbase, and much of the space frame exactly the same for both vehicles.

Second, the two vehicles had to be distinctive enough to appeal to completely different customers. "It's hard to imagine two more different vehicles than a car and an SUV," says Shulze. "We needed to get both of them right, and minor sheet metal changes or appliques wouldn't do it. But that's why we chose the SUV as our new

vehicle; we wanted a challenge. It was our express mission to go as far as we could and maybe fail." Finally, both vehicles needed to meet all of the functional and safety requirements.

"A big win for us would be meeting all three requirements 100 percent," says Shulze. "A bigger win would be for us to discover the limitations as we attempt to meet all of the requirements. We would love to be able to share that with our corporate partners. For example, tires are a major plus for differentiating an SUV; how big can they get while keeping the same floor pan and minimizing rollover potential?"

The project had another but equally important goal: to teach students how to work effectively in an industry that asks its employees to answer precisely these types of questions.

The team included some of the students and faculty that created the low mass vehicle: industrial and manufacturing systems engineering professors Vivek Bhise and Ghassan Kridli; engineering students Shawn Devaraj, Huzefa Mamoola, and Anitha Pillai; Bryon Fitzpatrick, chair of the Industrial Design Department at the College for Creative Studies (CCS); and Roger Shulze. Joining the team this summer was Sungyeah Song, an undergraduate student from CCS.

"Normally, when a CCS student is asked to create a design for a new vehicle, the sky is the limit," says Shulze. "This project was different. In order to control costs, we gave Sungyeah a long list of constraints: Keep the same floor pan and wheelbase as the low mass vehicle's. Keep the same space frame from the beltline down. Keep the same seats and the same instrument panel. Retain the symmetry of the door design so that the same tooling could be used for the opposing front and rear doors." Each day Sungyeah submitted her emerging design to the engineering team, who tested it to make sure it was feasible.



Two views of the new SUV designed by IAVS



"We asked Sungyeah what attributes needed to be included in the design of the vehicle to make it a credible SUV," says Shulze. "She insisted on large tires. This created several problems, including stability and suspension travel. Higher ground clearance leads to more instability. She also insisted on rear-hinged rear doors in order to improve ingress and egress. Normally, that results in more cost and weight. But far from being discouraging, the result was impressive."

"I had a great experience doing this," says Sungyeah. "I was very satisfied with the way the SUV's design developed, and I am pleased to have had this opportunity."

Other team members concur. "I never expected to learn so much in a university environment," says Devaraj. "I doubt I would have learned as much in any other university at the master's level."

The project will be ongoing. "Not only are we not done, we are delighted that we are not done," says Shulze. "Now we have a nearly unlimited number of potential student design projects."

For more information on the SUV project, contact Roger Shulze at 313-583-6431 or rshulze@umich.edu

Engineering symposium highlights research on automotive materials

The Center for Lightweight Automotive Materials and Processing (CLAMP) hosted a one-day symposium on innovative automotive materials and processing on May 15, 2003.

"Researchers and practitioners looked at the status and applications of some recent research and development efforts focusing on making lighter-weight automobiles," according to P. K. Mallick, professor of mechanical engineering and director of interdisciplinary programs in CECS. "The symposium also provided a forum for exchanging information, expressing views, and developing dialog on the future research needs of structural automotive materials."

Featured presentations included developments in steel, aluminum alloys, magnesium alloys, polymer matrix composites, and other materials.

Participants of the symposium included engineers, managers, researchers, and students interested in learning about recent research at automotive companies, national labs, universities, and material suppliers.

"In addition to the invited presentations of experts, there was ample opportunity to ask questions and engage in informal discussions on related technical issues and concerns," Mallick said. "One of the objectives of the symposium was to promote interdisciplinary thinking about vehicle weight reduction."

CLAMP has received support from the Department of Energy to study materials that have the potential to reduce the weight of cars and light trucks. Reducing the weight of vehicles could help improve fuel efficiency and reduce pollution.



the Catalyst

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UM-D Team Wins National Mini Baja Championship

The Midwest Mini Baja competition in June capped off an outstanding year for the University of Michigan-Dearborn Mini Baja team. With two cars finishing in the top five, the team's overall scores for the year's Mini Baja events earned them the top spot and the Mike Schmidt Memorial Mini Baja Iron Team Award, given each year to the team with the highest combined scores from the three U.S. Mini Baja events.

The three Mini Baja regional events, sponsored each year by SAE International, are intended to simulate real-world engineering design projects and related challenges. Engineering students design and build off-road vehicles and test their mettle on rough terrain and water.

The Midwest Mini Baja took place in Troy, Ohio, June 5-8, 2003. Team members included James Perrin (co-captain), Jim Szymusiak (co-captain), Brandon Cline, Jessie Crozier, Pete Dolinski, Chris Howes, Rob Hyden, Brian Kuzala, Joe Malkowski, Meredith Serette, Josh Street, Andy Woodrich, and Aisha Yousef.

The first day of the competition, the team's cars passed a safety inspection that approved the cars for racing. That hurdle safely past, the cars then joined the lineup for the design judging. Cars were judged for appearance, serviceability, ease of mass production, suspension, ergonomics, and structural integrity. "We felt good about our position," says co-captain Jim Szymusiak. "At the end of the day when scores were read, car 49 was in twelfth place, and car 50 was in second." With a total of 120 cars in the competition, the team was doing well.

On Friday, the team tuned their cars on the test track. "After testing the new setup on the test track, car 49 was jumping beautifully and going through the rough stuff without any loss of speed," says Szymusiak.

Saturday's events included Acceleration/Top Speed, Sled Pull, Hill Climb, and Maneuverability. The team was most concerned about the latter contest. The longer wheelbase of their cars made the 360° loop and some of the tight switchbacks in the maneuverability course difficult. "Maneuverability looked

to be the challenge of the day," says Crozier, "and we figured if we were to hit fewer than five cones, we would be fast." Each cone represented a two-second time penalty. Their work on Friday paid off; car 49 ended the day with a rank of third. Car 50 dropped to twelfth place.

2003 Senior Design Competition

The seventh annual College of Engineering and Computer Science Senior Design Competition (SDC) was held in the spring of 2003. Kaveh Abani of Compuware Corporation, John Fiaschetti of DaimlerChrysler Corporation, and Bill Santos of Visteon returned to the campus to serve as judges for the competition and were joined this year by Charles Osterle of CEO Image Systems.

The 2003 senior design project collegewide award was presented to the mechanical engineering team for its windmill energy optimization design project. The group's new design will lead to a boost in efficiency that translates to providing power to over 10,000 additional homes in a market the size of Wayne County, Michigan.

The departmental award winners included:

Computer and Information Science (CIS)

Project: Image Refractor X
Team: Jeremy Condon, Adrienne Corbett, Chris Furton, and Chris Williams
Advisor: Professor Bruce Maxim

The CIS senior design team developed a software tool called Image Refractor X, which allows inexperienced systems administrators to use multicasting (sending a single message to a select group) to copy entire disk images or groups of files to an arbitrary number of computer work stations. Image Refractor X supports image copying under the MacOS, Unix, and Windows operating systems.



Above: Survivor Baja: Team member Chris Howes after a four-hour endurance event
Top Right: Formal Baja: Team members attend an SAE fundraiser

Sunday brought the high point of the competition, the four-hour endurance event, worth about 25 percent of the contest's total points. "We were very pleased heading into the endurance event, where we traditionally do very well," says co-captain James Perrin.

The first lap went well until another car bumped the rear end of car 49, which was forced sideways into the air and lost power when it landed. After a couple of minutes to fix the problem, the car re-entered the race.

It started to rain heavily about a half-hour into the contest, which turned the top dirt layer of the track to slick mud, with hard clay underneath. Cars began to slide and had difficulty cornering as tires became packed with mud. Good tire selection helped both of the UM-Dearborn team's cars stay on the road and keep up speed.

After their first scheduled pit stop, the track became even worse. "The track was getting real bad, just the way we like it!" says team member Bob

Hyden. "Both our cars approached the 20-foot-tall table top together. That's where many teams couldn't make it up the hill and ended up just sliding back down. But both UM-D cars wove their way through the traffic up the hill with no problem."

The cars were able to get in another half lap before the race was halted to see if weather would improve. But after waiting 45 minutes, the organizers decided that conditions were too dangerous to continue and the race was called.

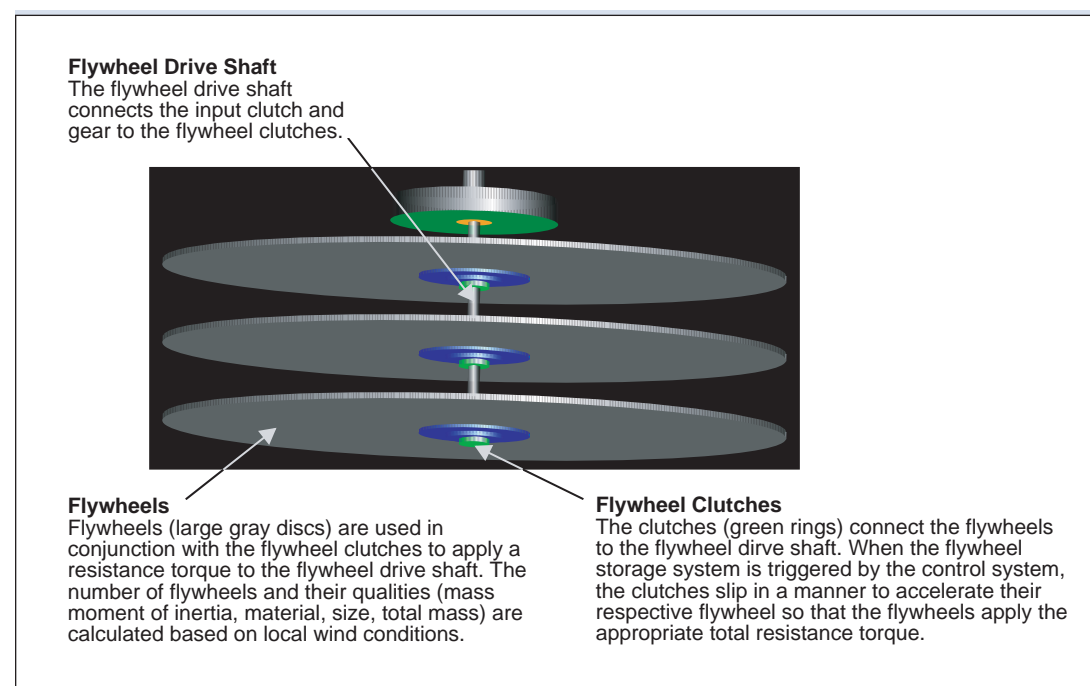
"We were disappointed in this decision because we were able to get up all the hills and jumps without assistance," says Szymusiak. "The half-point of the race is when we traditionally start picking up the pace and passing a lot of teams. But we had to go along with the organizers' decision."

Both UM-Dearborn cars did well in overall points for the competition. Car 50 finished fifth, and car 49 finished third, winning it the Midwest Briggs and Stratton Overall Performance Award.

"We were ecstatic to have both cars in the top five," says team member Pete Dolinski. Szymusiak adds, "Our persistence throughout the year helped us to achieve our overall goal of National Champs!"

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Part of the windmill energy optimization design's flywheel energy storage system

Mechanical Engineering (ME)

Project: Windmill Energy Optimization

Team: Chris Clark, Nick Schomer, Imran Shafi, and Doug Wainco

Advisor: Professor Alan Argento

The ME team designed a system that interfaces with existing windmills to capture and store excess wind energy during gusts. A series of large flywheels connected to a main drive by a clutch and drivetrain was developed to store excess energy. A control system transfers the energy back into the windmill's

primary driveline during times of low wind. This system increases the efficiency of 173kw windmills in typical wind conditions by 1.24%.

Throughout the competition, the judges noted that the senior design projects were becoming more interesting and the students more creative in developing and solving complex and realistic problems. Ali Kamrani, former SDC coordinator, agreed and added, "The projects are relevant. More students are seeking interaction with industry to develop their design projects so that they can work on real-world concerns."

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News from the College of Engineering and Computer Science



CEEP Center for Engineering Education and Practice



Welcome Friends

I am pleased to report that the Center for Lightweight Automotive Materials and Processing (CLAMP) is now four years old. During the past years, CLAMP faculty members have developed a new and unique curriculum for automotive materials education and have conducted many research projects related to this area. CLAMP has also organized a number of seminars and symposiums and has been instrumental in obtaining several valuable research and equipment grants.

CLAMP was started with a grant from the U.S. Department of Energy (DOE) as a Graduate Automotive Technology Education (GATE) Center of Excellence in Lightweight Automotive Materials. Its principal objective is to promote graduate education and research in lightweight automotive materials and processing. To this end, a series of graduate courses on automotive materials were developed and are now taught in the master's program in automotive systems engineering. Since its inception, CLAMP has offered several fellowships to graduate students interested in pursuing graduate studies on automotive materials.

Research projects and funding for the CLAMP faculty have come from a variety of sources, including Ford Motor Company, DOE, Oak Ridge National Laboratory, and USAMP. Equipment grants have been awarded by the Society of Manufacturing Engineers (SME) and the National Science Foundation (NSF). The SME Education Foundation funded the purchase of a formability testing machine, which is used for sheet metal forming as well as tube hydroforming. An NSF grant funded a scanning electron microscope, which improved CLAMP's capabilities in material characterization and failure analysis. The material testing and characterization facility has also been improved by the addition of a tensile testing machine, drop-weight impact machine, corrosion testing apparatus, and advanced metallographic equipment.

CLAMP has developed a web-based materials database exclusively for automotive materials, which can be accessed at www.engin.umd.umich.edu/lamda. Over the past few years, CLAMP has also hosted the DOE/University/Industry Symposium on GATE, the National Educators' Workshop (co-hosted with DaimlerChrysler), and the Symposium on Automotive Materials.

One of our future goals will be to build a closer relationship with industry through student and faculty internships, short- and long-term research partnerships, and our certificate program on automotive materials. Several avenues for achieving this goal will be explored, including forming a consortium of companies with common research and development objectives; conducting experiments or process simulation for individual businesses; providing assistance to companies on material selection, testing, and process development; and offering automotive materials courses at onsite locations.

P. K. Mallick, Ph.D.
Director of Interdisciplinary Programs and CLAMP

IAVS Institute for Advanced Vehicle Systems

TACOM Awards \$1 Million to Rapid Manufacturing Project

The U.S. Army Tank-Automotive and Armaments Command (TACOM) recently awarded a \$1-million contract, as part of a three-year, multi-million-dollar project under principal investigator Pravansu Mohanty, assistant professor of mechanical engineering. The Department of Defense has already approved the budget for the second year. This interdisciplinary project is being organized by researchers from mechanical engineering (ME), industrial and manufacturing systems engineering (IMSE), and computer and information science (CIS), and includes Professors Tariq Shamim, Jie Shen, Dave Yoon, and Armen Zakarian and Mr. David Kosikowski. Institute for Advanced Vehicle Systems director Roger Shulze is the administrative manager of the project.

TACOM is one of the Army's largest vehicle systems research and development organizations. Part of TACOM's mission involves working with the Future Combat Systems (FCS) program, which identifies promising systems and technologies that can further the Army's vision of a lighter and more mobile military force, named the "Objective Force."

"The challenges associated with Future Combat Systems are immense," says Mohanty. "Many of the Objective Force concepts—deployable, lethal, survivable and sustainable—come with weight, cost, and performance requirements that can be supported only by advanced materials and manufacturing techniques."

Mohanty's specialty is rapid manufacturing by thermal spray technology. The college's Center for Engineering Education and Practice, the Research Excellence and Economic Development Fund, and the National Science Foundation funded some of his initial research in the field. "Rapid manufacturing technology involves layered manufacturing," says Mohanty, "or making a component by adding



Pravansu Mohanty begins a demonstration of the supersonic thermal spray process for TACOM project collaborators.

one layer of material at a time. Successive layers are laid over the previous layer to build the entire component. This is automated by following a pre-set geometric path."

The project aims to use thermal spray technology to offer the military a new way to quickly replace or salvage damaged parts. "It's a very promising approach," says Mohanty, "but a technology that offers versatility in terms of product size, low cost, and the ability to fabricate production components rapidly is yet

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First CECS Doctor of Engineering in Manufacturing

In August 2003, the College of Engineering and Computer Science (CECS) graduated its first doctor of engineering in manufacturing (D.Eng. in Mfg.). Min Jie came to UM-Dearborn in 1998 as a research assistant in the mechanical engineering department. Prior to that, he studied in the field of solid mechanics, earning a bachelor's degree from the University of Science and Technology in China and a master's degree from Peking University.

The D.Eng. in Mfg. is awarded by the College of Engineering on the Ann Arbor campus but can also be pursued in part through the UM-Dearborn campus. This is what Jie elected to do. "I was attracted by the close

relationship of UM-Dearborn with the automotive industry," he says. "Also, the Center for Engineering Education and Practice offered me a three-year fellowship, which covered most of the expenses involved in pursuing the doctorate. This was a very competitive offer."

Jie's background as a visiting researcher at Hong Kong Polytechnic University and as a faculty member at Huazhong University of Science and Technology in China brought him to the attention of C. L. Chow, chair of mechanical engineering, who quickly recognized Jie's potential. In 1998, Chow encouraged him to enroll in the D.Eng. in Mfg. program and became a co-chair on



Min Jie

his dissertation committee. "Due to Jie's superior academic performance, I encouraged him to go for the degree," says Chow. "Since he had research experience in sheet metal forming that coincided with mine, we decided to work on the topic together."

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