

# **2009 Evaluation Report**

**for the**

## **Center of Manufacturing and Industrial Management (MIM) Institute of Mechanical Engineering (IDMEC)**

### **Executive Summary**

The Center of Manufacturing and Industrial Management (MIM) consists of internationally recognized scientists. The faculty members and the students are highly motivated, self-confident and enthusiastic. The research work is marked by technological innovation, scientific insight and R&D for industrial needs. The publication output is higher than the international average in manufacturing although the funding from third parties per publication is less than the international equivalents. MIM should be included into a national institute for manufacturing that is believed to boost even further the work in this field. The center is linked strongly with international major institutions and with the local industry. The space problem of the MIM must be handled in short term.

### **1 Evaluation Background**

This report is based on the site-visit as a member of the Scientific Advisory Council of the Institute of Mechanical Engineering (IDMEC) and LAETA from October 15 to 17, 2009 and the annual report of 2008 of the Center of Manufacturing and Industrial Management (MIM). Besides extensive discussions with the members of the MIM, an expedition to the laboratory and live experiments has served as the basis of this report.

Organizationally MIM is a unit within IDMEC that is a member of Associated Laboratory for Energy, Transports and Aeronautics (LAETA), the network of research in the fields of transports, energy and aerospace.

### **2 Research Activities**

The Center of Manufacturing and Industrial Management (MIM) lead by Professor Paulo Martins consists of five research groups: metal & polymer forming, metal cutting, joining, rapid prototyping and industrial management.

#### **2.1 Metal and Polymer Forming Group**

This group is headed by Professor Paulo Martins. Besides him 4 researchers with a doctorate are the backbone of the team. There three basic types of activities of this very active group:

1. Innovation in Forming Technologies: These studies are impressive and have outstanding international quality. Studies on incremental metal and polymer sheet forming, bulk forming of polymer tubes and polymer bulk workpieces (for instance by forging), forming of spheres (both from metal and polymer) by polymer mandrels, forming of metal and polymer pipes, micro forming of polymer parts and impulsive forming and high strain rate material characterization. Also new techniques for visio-plasticity analysis have been presented.
2. Analytical Models: New models for large strain polymer forming, damage and incremental sheet forming are developed. These scientific studies underpin the innovative work mentioned above.
3. Technological Studies: R&D studies conducted with industrial companies. A very impressive example is the forming of welded tubes.

Strong international collaborations have been with the TU Dortmund (Professor Tekkaya), DTU Denmark (Professor Bay) and the University of Reading (Professor Atkins) in this group.

## **2.2 Metal Cutting Group**

This group is headed by Assistant Professor Pedro Rosa. He is the only scientist with a doctorate in the group. The group has 5 doctorate students and more than 15 Master of Science students. Although founded in 2007, the progress of the research work of this group is remarkable.

Ongoing research projects are related to modeling of cutting. The special purpose finite element code is based on ductile fracture models developed in collaboration with international experts such as Professor Atkins mentioned above. For material characterization besides the drop-hammer a new magnetic gun with 1 kJ energy capacity has been developed. The former setup from 2007 had a capacity of only 0.3 kJ.

Another impacting work is tribology testing. A rather unconventional pin-on-disc test has been developed and applied for deriving new insight (especially for fresh metal surface friction) to the field of friction and wear in cutting but also metal forming.

Micro electro-discharge-machining ( $\mu$ EDM) as well as Micro Electro-Chemical-Machining ( $\mu$ ECM) is a further research field. The key issue here is that all machines and their control is developed in MIM and is fully known by the group.

## **2.3 Joining Technologies Group**

This group is headed by Associate Professor Luisa Quintino. Discussions have been conducted with Assistant Professor Pedro da Silva. The group has one further researcher with doctorate.

The field of friction stir welding (FSW) is one of the core fields in this group. As FSW is getting a mature technology, new innovative technologies in this subject are attacked. FSW of

thin sheets, new tool design, friction stir channeling, friction stir surfacing or more generally surface stir processing are investigated. Several patents have been generated in this group.

Besides FSW also arc welding technologies are improved and investigated. These studies are done basically with industrial companies. Ultrasonic welding technology for connecting cables further developed.

An interesting research field of this group is non-destructive-testing (NDT). For Eddy-current measurements a new design of the equipment allowed a three-dimensional measurement of defects on the surface of the specimen. Several patents have been received for this innovative work.

#### **2.4 Rapid Prototyping Group**

This group is headed by Assistant Professor Inês Pires. A further assistant professor is involved in this group. The current activity of the group consists of producing with an existing 3-D-Printing machine scaffolds that are bio-compatible. The samples presented indicate a possibility to produce structures with some micro-geometrical features that are not possible to be produced by other rapid prototyping machines. Bio-medical applications will be the future basic activity field of this group. The research is basically industrial driven.

#### **2.5 Industrial Management Group**

This group is headed Associate Professor Elsa Henriques. There are totally three researchers with doctorate in the group. Different than classical industrial management groups, this group has a strong connection to the manufacturing process. The manufacturing processes are not considered as black-boxes and process design is a basic goal. The link to industry is strong.

Within the EDAM-program a good cooperation has been established on educational basis with the MIT, Boston/USA. Several doctoral students are sent to MIT for lectures and working with industrial companies.

### **3 Concluding Evaluation**

The Center of Manufacturing and Industrial Management consists of one full professor, two associate professors (one with habilitation), nine assistant professors, three non-faculty researchers, one faculty engineer and one laboratory technician. Currently about 16 doctoral students and more than 20 master students are engaged in the center. The students are highly motivated and have identified themselves with the research topics. The faculty staff is compared to their international reputation rather young, but self-confident and enthusiastic. This is thanks the excellent working atmosphere in which the young researchers have freedom given by the head of the center to develop them and to fully dedicate them to research.

The scientific output in terms of journal publications in SCI-journals is 24 for the year 2008. This corresponds to 1.5 publications per research staff with a doctorate. This number is much above the international average in manufacturing engineering.

The total third party funding is for the year 2008 about 570,000 € or 44,000 € per Faculty member. This is around or slightly above the international average. The third party funding per SCI-publication is around 24,000 € that is much lower than in other countries (for instance for Germany the third party funding per SCI-publication in manufacturing technology is about 500,000 €). This last indicator underlies two observations:

- (1) Fundamental research of the Center of Manufacturing and Industrial Management is not sufficiently funded by national scientific associations.
- (2) Much of the equipment used in research is “home-made”.

The research is marked by innovation and analytical insight. The contact with industry is at a good level. International collaboration with top universities in USA, UK, Germany, Denmark and other countries is very good.

The space for the laboratories is spread over two buildings and over various floors of a single building. This seems to be a handicap for expansion.

#### **4 Recommendations**

Based on the discussions, reports and observations following items are exposed for consideration:

- a) The Center of Manufacturing and Industrial Management contributes significantly to the manufacturing industry in Portugal and represents a key research center. To increase the efficiency of this and the center in Porto, it is recommended to establish within LAETA an Institute for Manufacturing and Engineering Systems.
- b) National research funding institutions must support manufacturing research much more intensively in Portugal. The “funding per scientific output” is about one order of magnitude less than in Germany for instance.

Dortmund, October 19, 2009



Prof. Dr.-Ing. A. Erman Tekkaya