By Tomaž Švagelj,
DELO

Modern modelling and prototyping at the Faculty of Mechanical Engineering in Ljubljana

Recording at a Speed of up to 30,000 Points a Second

Anyone who wants to get a new product on the market as quickly as possible has to make a series of difficult calculations and technological operations, one of the most interesting of which is the automated production of very accurate replicas of physical objects. In Slovenia there are still difficulties in the transfer of knowledge from the academic sphere to the sphere of business and marketing, but it cannot be said that nothing is happening in this field.

Slovenia already has, for example, a series of (research) "centres of excellence" that supplement or are "complementary" to the networks of excellence in the 6th EU Framework Programme. Their aim is to establish and ensure the efficient operation of at least eight international competitive centres of excellence in priority spheres of research and technological development.

Each centre of this type must have a top-level multidisciplinary team of researchers from the academic sphere and from business, in other words a critical mass of knowledge with a suitable research infrastructure to allow the breakthrough of the centre to the very peak of world science and/or its inclusion in an international network of excellence. In the present period over three billion tolars have been earmarked for centres of excellence in Slovenia (the co-financing period is 2004–2006 with the possibility of drawing funds up to 2008).

From idea to prototype

In line with this project, the Faculty of Mechanical Engineering in Ljubljana has recently conceived a Global Product Realisation Centre (GPRC) within its Laboratory of Computer-Aided Design (LECAD), where research will focus above all on product development in the PLM (Product Life Cycle Management) system. In technical terms it is fully equipped to monitor a product throughout its life cycle, from the first idea to "back to nature" removal from service. The centre is headed by Dr Jože Duhovnik.

In terms of both hardware and software, the centre is conceived in such way that it is capable of performing all operations, from initial idea to the elaboration of a prototype. Before developers can really begin a prototype, there is a great deal for them to do, from analyses of functions and functionalities, via measurements of shapes and design of models, to virtual display in real space. In the case of more demanding forms from harder materials, the faculty's cutting laboratory LABOD, run by Dr Janez Kopač, leaps to their assistance.

In the analysis of a product's functions, they use a range of software some of which is developed in-house and some of which is purchased. They scan and measure the shape with a movable mechanical arm fitted with a laser measuring device. This can scan up to 30,000 points a second (!), which is sufficient not only for the surfaces of a variety of technical products up to 3.5 metres long, no matter how complex, but also for objects of animal or vegetable origin, archaeological finds and even for the elaboration of exact copies of old statues. For example, one of those from Robba's Fountain. First they would scan it with the laser, so as to obtain a digital spatial model of it. Then, on the basis of this model, they would make an exact replica from some synthetic substance and finally follow the instructions of art historians to fill in the missing parts. But this is not all, since there is also the possibility of direct milling of a replica in stone.

Of course it is easier and quicker with a synthetic substance, since a model made from ABS polymer measuring up to 200 x 250 x 200 millimetres can be made in as little as 48 hours or even, in exceptional circumstances, 24 hours.

6-axis FaroArm (left).

Part of the LECAD Lab team in the background.

Photo: Tomaž Švagelj

If the requirements in the case of a plastic or aluminium model are stricter with regard to accuracy, they can make prototype of an accuracy of up to 0.05 millimetres. If they only need the external form, to an accuracy of up to 0.5 mm, they use a warm jet of a synthetic substance up to a size of 600 x 600 x 400 mm.

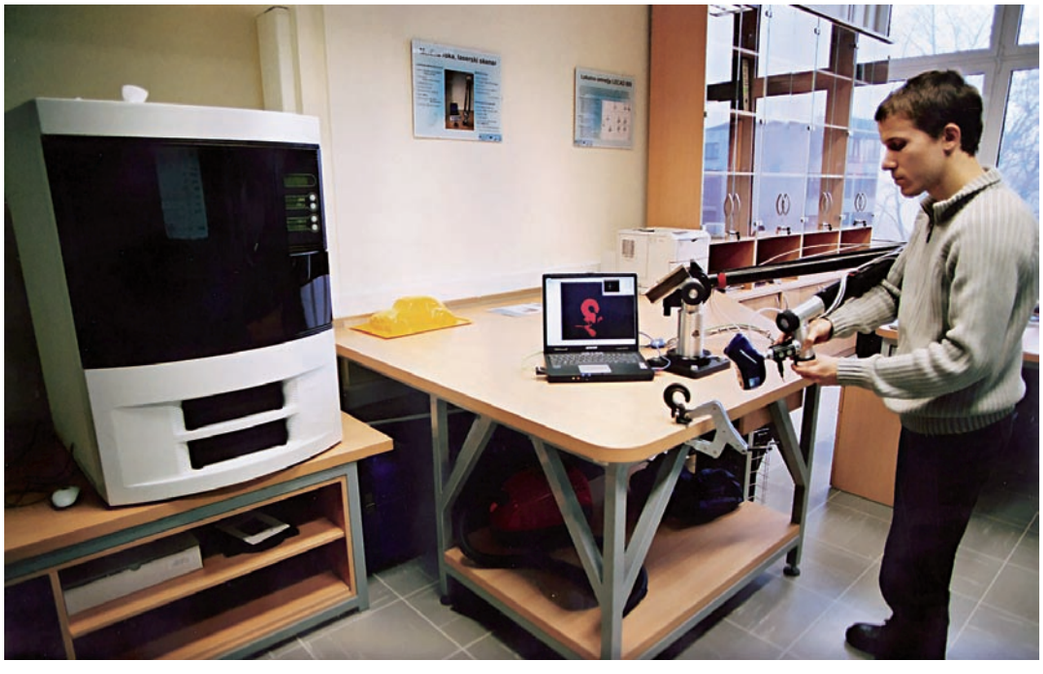
Suitable systems for all

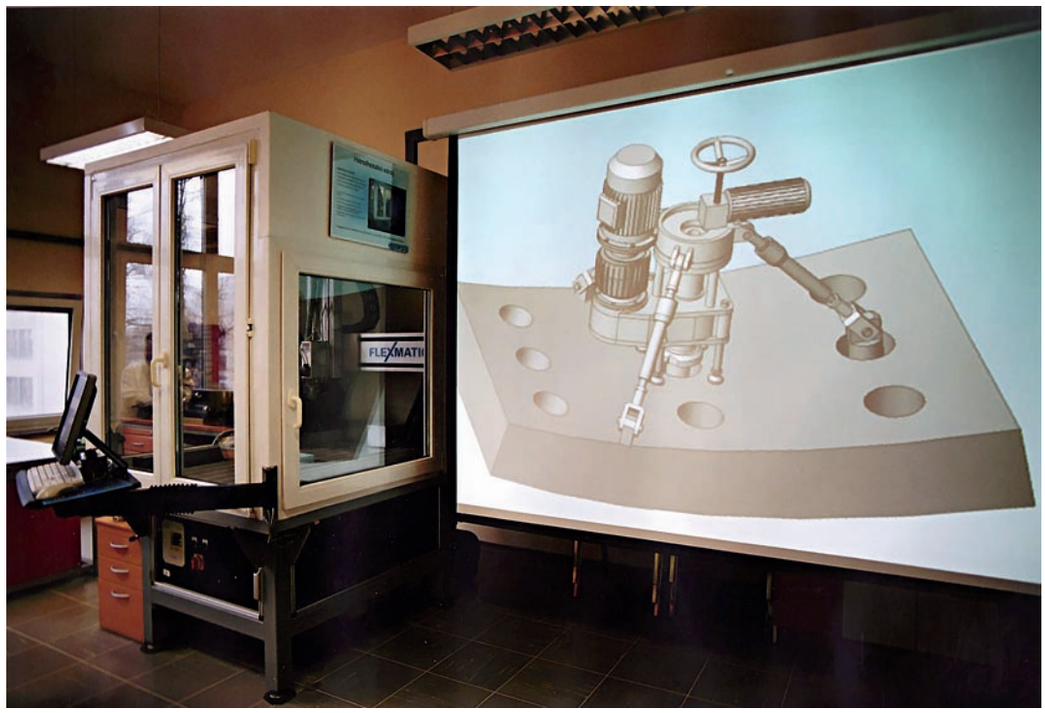
The GPRC is particularly suitable for ad hoc groups of experts from various fields. It already has four years' experience in international collaboration with groups for mechanical engineering and microelectronics, industrial designers and economists specialised in business economics. It is equipped with two video conferencing systems whose transmission speed is more than adequate for direct participation in a virtual room.
There are currently three active groups in the centre, devising new projects within the framework of two domestic projects and one international project. However it has sufficient capacity for at least three more groups up to the end of April 2006, when it will be occupied for six months by the participants in two other international projects. The businesses already collaborating with the centre are Niko and Domel Železniki, Iskraemeco Kranj, LIV Postojna and BSH Nazarje; the centre also collaborates with universities in other countries: Luleå University of Technology in Sweden, Delft University of Technology in the Netherlands and Wrocław University of Technology in Poland.

Powerful hardware and software.

Through the use of new technologies, businesses can significantly improve their work and their products. The question is: how to facilitate suitable systems for different types of enterprises, including small and medium-sized enterprises. Large enterprises need very powerful PDM systems, which as well as being expensive require many additional activities such as maintenance, introduction, training, integration into business and production systems; small enterprises can make do with cheaper and simpler PDM systems. In a small development group there are no difficulties with communication among the members, while on the other hand a simple PDM system also enables easier archiving, simple use and maintenance, access via the internet, has a specific method of work built in, and so on. The new possibilities offered by the internet come into their own: work takes place via a generally distributed browser and the client does not need to install any new programs. These are the positive sides of simple PDM systems. The negative sides include above all limitations in adapting the configuration. A simple PDM system is based on a database of files to which users' access depends on the development phase of the project and their role. Not only can they search the data in the database, they can also modify it. Access to the server is via a web browser, the only program client needs. The systems are developed in their entirety by the international association of laboratories of the LECAD Group based in Ljubljana.
When a product has been developed, it goes into production and finally appears on the market. There its market value immediately begins to fall because of rival products, although this can be successfully limited through constant product development and supplementation. An extended selling period naturally increases its success on the market, since the development of a new family of products is very expensive. This framework includes minor repairs and also the preparation of totally new versions.

FaroArm measurements. 3D printer on the left.





3D model of a mobile tool designed for milling parts of a vacuum vessel for the ITER experimental fusion rector.

The aim of a PDM (Product Data Management) system, also known as PLM (Product Life Cycle Management) is to shorten as much as possible the path that begins with the conception of a product, passes through the phases of sale and service, and ends with the retirement and recycling of the product. It is vital to be able to control and review the necessary data at all times and deliver them to those who need them (and when they need them). In such a system key data are only stored once in one place, i.e. in one "copy", so that they cannot be altered or deleted by unauthorised personnel, while at the same time it is possible at all times to control, track, verify and of course save all permitted changes. Copies of these data circulate freely in the design, construction and analysis departments and among the participants in the working process, while modified or new data come back to the safe storage location. Every time something is changed, the modified copy, signed and dated, is stored in a "digital safe" alongside the previous copies, which remain in their original form as permanently archived records.

tion, especially at higher voltage. The fundamental question is that of the effect of individual components on the critical speed. Two additional questions, explain Dr Duhovnik and Dr Jože Tavčar, are linked to the usefulness of individual methods for the analysis of resonant frequencies and the effect of the properties of the components on vibrations during operation.

To end with, a brief overview of rapid modelling and prototyping. The original stereolithography technique was followed by laser "burning" of metal powder. Metal powder with a melting point of 400 to 500 degrees Celsius is locally heated with a laser beam so that it begins to melt and the particles stick together. In essence, then, the technique involves a form of local welding. All that is required is to trace the model and to switch on the laser only in those places where the model is full. Laser "burning" was followed by "powder technology", where ordinary powder, which may also be ceramic powder, is used. Liquid plastic in layers of a thickness of 0.07 to 0.15 millimetres is sprayed on to it, and then "they wait for it to react nice and slowly". If they want to speed up the process and consolidate, they additionally heat the model. This is powder technology. At the GPRC they use an artificial substance, thermoplastic ABS, which they melt and then spray in small quantity through a nozzle and with a computer-controlled 2D device apply it in the form of contour lines.

Hand tools corner.