Manufacturing and Robotics Research at the Katholieke Universiteit Leuven, Belgium

by Daniel E. Whitney

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INTRODUCTION

The Katholieke Universiteit Leuven (KUL) is the main technical university in Belgium. It has 26000 students; 2700 are in engineering and of these 560 are in mechanical engineering (ME). (For the first time, this is more students than are in electrical engineering). The teaching majors in ME are production engineering and management, energy conversion, and (new and attractive to stu-dents) mechatronics. Professor Joris de Schutter is in charge of mechatronics.

Research activities focus on production engineering, machine design and automation, energy conversion, applied mathematics (structural analysis, their strongest area, was founded by the late and famous Prof. Snoeys), biomechanics, graphics, CAD / CAM (computer-aided design / computer-aided manufacturing), robotics, structural dynamics, flexible automation, and industrial management (meaning production control). Research laboratories I visited included:

- acoustics and active noise suppression;
- mold design and direct NC (numerical control) production of molds;
- stereolithography, including attempts to find better polymers and ways to level the liquid faster to speed up the process;
- EDM (electrodischarge machining) methods, tool design, and studies of the fundamental process to create faster cutting and optimized computer control; and
- flexible automation, including flexible robot assembly systems.

A few words on each of these follow.

ACOUSTICS AND ACTIVE NOISE SUPPRESSION

This work began years ago as acoustic experiments and measurements, but recently they have attempted to make stronger links with analysis by using the skills of the applied mechanics division. Some European Community (EC) projects include searching for materials and designs for aircraft interiors that will transmit less perceived noise to passengers. Long-term projects exist on automobile dynamics and noise, and attempts are being made to update and improve finite-element modelsfrom experimental data. A current project involves modeling both acoustic and fatigue behavior of composite aircraft panels. Because of the complexity of the structures they are trying to model, much of this work appears to be empirical despite efforts to systematize it.

MOLD DESIGN, STEREOLITHOGRAPHY, AND NC MOLD PRODUCTION

This work is in two parts, one being data-driven from a CAD (computer-aided design) model and the other being driven by digitizing a physical model, say of wood. Several problems have been pursued: getting error-free data [both IGES (International Graphics Exchange Standard) and DMIS (Dimensional Measurements Interchange Standard) cause problems], designing molds by using an expert system, and cutting molded shapes by using complex 5-axis machining so that the flank of the cutter follows the surface rather than the tip. Of some interest to me was the remark that coordinate measuring machine algorithms have been found to be weak here in Europe, just as they have in the U.S. Methods of automatically programming CMMs (coordinate measuring machines) sometimes give ill-conditioned algorithms. This laboratory has an EC project to improve this situation. Another weak area that has attracted their attention is the poor programming languages for stereo-lithography machines.

ELECTRODISCHARGE MACHINING

This study is looking at the fundamentals, including determining the effect of different pulse rates and pulse shapes. Apparently all of this is done empirically now, and little has been done to model it. The researchers have determined that even small details in the pulse shapes are important. Some economic modeling is also being done. The objective is to optimize the cutting rate without compromising tolerances.

ROBOTICS AND FLEXIBLE ASSEMBLY

Several projects are being and were done on high-speed robot control and sensing. I was also shown work on multijoint fingered hands driven by shape memory alloys. These joints appeared weak, but an attempt has been made to control the thermal behavior by using cooling oil. This allows thespeed of relaxation to be made faster and thus more similar to the speed of contraction. The European Space Agency is funding some of this work. It was noted that the oil system is heavy and consumes energy, thereby robbing the shape memory system of most of its advantages, especially for space applications. No solution has been identified.

Another laboratory contains a flexible assembly cell on which real-time control work is being done. The aim is to develop schedulers for systems that can assemble a variety of parts or products. The main concerns here are technical since the processes are not very robust: how to detect errors, how to reallocate work to other stations when one stops, and so on. The economics of such systems is not being studied, and the lack of robustness seems to be a function of the student's skill. I have a feeling that some of this research would be better done by industry. Some good industrial research is reported in an article about Telemechanique, a French automation equipment manufacturer (D. Whitney, "Systematic Design of Modular Products at Telemechanique," *ESNIB*, to appear).

This laboratory is best known for its work on robot force feedback, but there is little support for this at present. My recent article, "Robotics in Theory, Robotics in Practice: 1992 IEEE Robotics and Automation Conference," (*ESNIB*, 92-05) describes this research.

I also saw some interesting work on robot filament winding for composite parts. The part demonstrated is T shaped, making winding of filaments nontrivial compared to simple cylindrical tanks. Considerable robot programming and development of a special hand were needed. This hand is able to periodically remove the net twist that develops in the filament as the result of the gyrations of the robot and the independently moving T while the filament is being laid down.

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