FMS MAINT: MAINTENANCE FOR THE FUTURE

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1. INTRODUCTION

An increasing number of Flexible Manufacturing Systems have been installed in Europe during the past few years. The general experience is that the availability of installed FMS's is not as high as was originally expected because of unanticipated disturbances and malfunctions in components, machine tools and peripheral equipment, lack of systematised follow-up for various causes of downtime, poor reliability in mechatronic devices, and uncontrolled wear and friction in mechanical parts. Only to some limited extent are machining process monitoring systems and maintenance modules commercially available. In general, workshops follow the status of their production machinery poorly, or in the worst cases not at all.

The purpose of the project is to develop measurement methods, monitoring systems and software and to integrate them into a modular condition and machining process monitoring system, which will increase the availability of Flexible Manufacturing Systems and stand-alone machines. A high priority objective is to improve the use of existing monitoring features.

Because of the widely varying needs and requirements of individual factories, it is difficult to develop a single solution that helps everyone. In addition, current technology is well suited to solve some problems but not always cost effective for other problems. After considering a wide variety of problem areas and possible solutions, the project has focused on a number of critical areas where the current technology can make a contribution immediately. Each of these sub-solutions are being developed in co-ordination with the other systems to ensure that the total architecture can be integrated and the modules work together. The result of this strategy is a number of sub-systems that fit important business needs for the industrial partners. These needs have also been judged to have wide spread applicability throughout manufacturing today.

A major emphasis of the project is to develop practical solutions that have been proven through factory usage rather than only high level conceptual strategies. All of the primary modules within the system have been tested within one of the factories of one of the partners.

2. FMS MAINT PROJECT

In order to address the above goals, the FMS MAINT project is structured into six primary task areas. The modules being developed by the partners in these task areas are being further tested in four production factories, two in Finland and two in the UK, as well as in several manufacturing development facilities located within the University partners.

The primary task areas are as follows:

- Statistical data analysis
- Condition monitoring
- Diagnostic expert systems
- Advanced user interface
- Maintenance planning
- Automatic data collection
- Quality control

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The project participants are as follows:

FINLAND	UK
Bretec Oy	Intelligent Applications Ltd (IA)
Finn-Power Lillbacka	British Aerospace (BAe)
Valmet Transmec Ltd Oy	Holroyd Machine Tools
Tietolinja Oy	Reflex Manufacturing Systems Ltd
Technical Research Centre of Finland (VTT)	Systems Guidance Ltd (SG)
Lappeenranta University of Technology (LUT)	University of Wales College Cardiff (UWCC)
Tampere University of Technology (TUT)	

3. DIAGNOSTIC EXPERT SYSTEMS

Determining why a machine tool has just failed is difficult for a number of reasons. With increasing new levels of automation and the increasing number of sophisticated features, machine tools themselves are becoming very complex and require extensive training times in order for operators to become familiar with them. At the same time, operators are tackling a wider variety of machines, and expected to perform a wider variety of skilled tasks. All this means that the relative difference in knowledge between the operator and the machine is getting greater and greater. What is needed is a software module that is able to capture the necessary expertise to determine why a machine tool has just failed and allow this to be used by someone with relatively little training.

The work within this workpackage is to develop a knowledge based diagnostic system that can capture the necessary expertise so that a relatively low skilled person with little training, can determine the cause of the machine failure. There are two primary focuses for this work:

The first, based on the Test-It system developed by Intelligent Applications, can capture a wide range of knowledge and procedures, and guide the operator or maintenance technician through a troubleshooting sequence. The second, using Petri-nets developed by the University of Wales College Cardiff, uses a model of the sequential actions of the machine tool to rapidly isolate where a fault or problem has occurred.

There is a wide variety of approaches to developing expert or knowledge based systems. Although many powerful tools are available with the ability to model very sophisticated knowledge, the problem is that generally they are far too difficult for an operator or maintenance technician to use. Very often the troubleshooting process is viewed as a decision tree with steps to be performed and possible outcomes. Rather than use a sophisticated expert system environment, Intelligent Applications developed Test-It.

Test-It is essentially a decision tree oriented tool with a very easy to use user interface. The basic diagnostic procedures are represented by a question or set of instructions with a set of possible answers or outcomes. The great simplicity of Test-It is what makes it useful to engineering and maintenance staff. Very importantly however, is that Test-It adds other supporting functionality. This supporting functionality is critical to its usefulness.

The Test-It diagnostic steps are linked with multi-media help and linkages direct to the on-line manuals. This permits the operator to get a deeper understanding of the instructions or part of the machine being referred to.

In addition, Test-It automatically keeps fault history statistics. These are used to indicate the most likely cause of fault during the diagnostic process. They are also used to generate Pareto charts showing the most common failures. By using Test-It to diagnose problems and then generating monthly reports of the most common failures, an organisation can identify the root causes of their most common failures and take longer term action in order to remove these difficulties.

knowledge based systems development background.

The second approach uses Petri-net models which have been widely utilised as a process monitoring and control mechanism. They are a powerful tool, enabling users to graphically design and monitor complicated manufacturing or process based activities in a simple yet comprehensive manner. They consists of a series of events which are linked together by conditions which are required to be satisfied before the event can take place. They are therefore ideally suited to the application for which they are used for, namely in the monitoring of machine tool related operations and procedures.

Using the Petri-net approach any logical process can be represented as a set of places, or states, events and transitions. The conditions necessary for any related event, the associated places and transitions are linked together. The resulting models are easily understood. As conditions are satisfied events proceed. If more than one condition is applied to a specific event then that event cannot proceed until all conditions are met. To aid the understanding of the process, the Petri-net model may be viewed at any time to provide an indication of the current status of event element within the system being monitored.

Using a Petri-net Analyser, which has been developed as part of this EUREKA FMS MAINT project, it is possible to represent elements of any machine tool. The developed model may then be interfaced to the machine tool being monitored. This is normally achieved by linking directly in the PLC controlling the machine. Monitoring the developed Petri-net can then indicate the current status of any part of the machine tool. It is then possible to match actual machine or system or sub-system status to required status. Hence fault conditions may be indicated, and in conjunction with the Diagnostic Expert System outlined above, any associated recovery action can be initiated.

4. PROJECT PILOT FACTORIES

Various modules of the system are being tested and evaluated in four factories in regular production as well as several laboratory development facilities.

4.1 Bretec

Bretec Oy is the world's leading manufacturer of breaking attachments for hydraulic excavators. Bretec's operations also include after-sales service and consulting.

4.2 Finn-Power

The other Finnish pilot is the FMS for sheet metal working at the Harma factory of Lillbacka Co. The FMS is used for producing sheet metal parts on turret punch press and hydraulic presses in one-piece batch and in small batches. Sheet thickness vary from 1mm to 5mm.

4.3 British Aerospace

The Military Aircraft Division of British Aerospace Defence Limited is located in Brough, England. Long associated with the British Aerospace Hawk, Brough is now the design authority for the aircraft and responsible for the design of all new versions ordered, including the British Aerospace part of the US Navy T45 Goshawk, being developed in collaboration with McDonald Douglas.

4.4 Holroyd Machine Tools Ltd

Holroyd Machine Tools and Rotators based in Rochdale, England, design and build a range of CNC machine tools for the production of Helical screw rotors and associated manufacture and inspection equipment. Machines and rotors are supplied world-wide to the worlds top air compressor refrigeration and air conditioning system manufacturers. They are constantly pressured to produce rotors of higher accuracy and with closer tolerances.

5. CONCLUSIONS

The primary focus of the FMS MAINT project has been the variety of problems that reduce the availability of machine tools and flexible manufacturing systems. A single solution would not be cost effective, or portable from big companies to small companies. Instead, various 'islands' of software assistance have been developed. These provide a cost effective way to address the problems most suitable for current technology and automation techniques. They also provide the flexibility needed to allow them to be applied to companies from the largest to the smallest.

The systems that have been developed: automated data collection of utilisation and failure data, automated analysis of historical problems, condition monitoring, diagnostic expert systems, multimedia information systems, quality support including methodology, statistical process control, and ball bar diagnostics, and maintenance planning have all been tested at four pilot sites covering large and medium sized companies and from users to machine manufacturers.

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6. REFERENCES

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