COMPUTER INTEGRATED MANUFACTURING
THROUGH WORK-CELLS AND
COMPUTER NUMERICAL CONTROL MACHINES

EDUARD EDELHAUSER¹, ANDREEA IONICĂ²

Abstract: A work-cell consists of industrial robots and a collection of machines or peripherals. A typical cell might contain a parts feeder, a molding machine and a robot. The various machines are 'integrated' and controlled by a single computer or PLC (programmable logic controller).

DELMIA is one of the software that enables manufacturers in any industry to define, plan, create, monitor, and control all production processes. DELMIA (Digital Enterprise Lean Manufacturing Interactive Application) is the brand for digital manufacturing and simulation solutions from Dassault Systemes.

Visual Mill is CNC software that defines tool paths and run full machining simulations on part models already loaded. Once simulations are complete and tool paths are defined the software outputs G code to the machine tool and start cutting parts.

Key words: work-cell, computer numerical control machine, industrial robot

1. INTRODUCTION TO CIM, CAM AND FMS

Computer Integrated Manufacturing (CIM) in engineering is a method of manufacturing in which the entire production process is controlled by computer. Typically, it relies on closed-loop control processes, based on real-time input from sensors. It is also known as flexible design and manufacturing.

There are three major challenges to development of a smoothly operating CIM system: Integration of components from different suppliers (when different machines, such as CNC, conveyors and robots, are using different communications protocols), Data integrity and Process control.

Computer Aided Machines (CAM) is a programming tool that makes it possible to manufacture physical models using computer-aided design (CAD)

¹ Assoc.Prof. Ph.D. at the University of Petroșani, edi11ro2001@yahoo.com
² Assoc.Prof. Ph.D. at the University of Petroșani
programs. CAM creates real life versions of components designed within a software package.

**Industrial Flexible Manufacturing System** (FMS) consists of robots, Computer-controlled Machines, Numerical controlled machines (CNC), instrumentation devices, computers, sensors, and other stand alone systems such as inspection machines. The use of robots in the production segment of manufacturing industries promises a variety of benefits ranging from high utilization to high volume of productivity. Each Robotic cell or node will be located along a material handling system such as a conveyor or automatic guided vehicle. The production of each part or work-piece will require a different combination of manufacturing nodes. The movement of parts from one node to another is done through the material handling system. At the end of part processing, the finished parts will be routed to an automatic inspection node, and subsequently unloaded from the Flexible Manufacturing System.

A work-cell is an arrangement of resources in a manufacturing environment to improve the quality, speed and cost of the process. Work-cells are designed to improve these by improving process flow and eliminating waste. They are based on the principles of Lean Manufacturing as described in The Machine That Changed the World.

DELMIA is a premier brand for digital manufacturing solutions, focused on two unique software applications that can be used to streamline manufacturing processes. DELMIA automation provides solutions to digitally design, test and validate the control of a machine, work-cell, or entire factory line and DELMIA PLM provides the process and resource capability to enable continuous creation and validation of manufacturing processes as related to the product throughout the entire product lifecycle.

### 2. COMPUTER NUMERICAL CONTROL MACHINES (CNC)

Modern CNC mills differ little in concept from the original model built at MIT in 1952. Mills typically consist of a table that moves in the Y axis, and a tool chuck that moves in X and Z (depth). The position of the tool is driven by motors through a series of step-down gears in order to provide highly accurate movements, or in modern designs, direct-drive stepper motors.

Most machining progresses through four stages, each of which is implemented by a variety of basic and sophisticated strategies, depending on the material and the software available. The stages are: Roughing (this process begins with raw stock, known as billet, and cuts it very roughly to shape of the final model), Semi-finishing (this process begins with a roughed part that unevenly approximates the model and cuts to within a fixed offset distance from the model), Finishing (finishing involves a slow pass across the material in very fine steps to produce the finished part), Contour milling (in milling applications on hardware with five or more axes, a separate finishing process called contouring can be performed).

DELMIA Machine Tool Path Simulation enables NC programmers to verify,
modify and validate tool paths and material removal based on tool paths or ISO code to eliminate potential machine tool collisions upfront, during programming, thus reducing lead time. It provides a unique NC machining definition configuration that enables organizations to optimize machining operation definition. Through the integrated product environment, users have a seamless solution to address all their manufacturing environment needs. It easily validates the machining setup for selected machine tools and tool paths or ISO code upfront, during machining operation definition.

In Delmia we can associate a Numeric Control Machine Tool, used for the digital simulation of a manufacturing process. We will Insert a Resource. We can use Machine Management, and Jog a Device option, for a 5 axes simulation through a Jogmach mill:

![Figure 1. Choosing 5 axes NC MT.](image)

5 axes simulations for a Jogmach Mill 35.1 associated to a process

In Visual Mill as a fully functional 3D milling package from Mec Soft, a general purpose machining program is targeted at the general machinist. This product is ideal for the rapid-prototyping and educational markets where ease of use is a paramount requirement. Packed with sufficiently powerful manufacturing methods this easy to use software includes basic 3-axis milling and approximately 50 pre-built post-processors.

Visual Mill 5.0 configuration ushers in powerful, state of the art 3 Axis tool path generation methods to its flagship Visual Mill product suite. The program has excellent sorting capabilities—whether it is tool sorting, the ability to sort by coordinate systems (which makes it easy to optimize rotary motion), or hole sorting (which helps users organize their drilling routines). It should be noted that the new 5-axis capabilities are what is known as positional 5-axis (or 3+2), not continuous 5-axis; however, Visual Mill provides what most users need.

Visual Mill CAM features will be smarter thanks to gouge detection and tool-holder collision checks, a problem for one user I met. Fourth Axis Profiling and Pocketing will be supported, and drilling enhancements are also planned. A turning
package is expected to be added to the product lineup about the same time.

Fig. 2. CNC Machine. The graphical dialog box for the Horizontal Roughing command makes it easy to see what the options pertain to and is typical of Visual Mill’s machining tools.

Fig. 3. Stock and Simulator. A tool path has been created on the part using the Parallel Roughing command. On the right is the tool path’s line-by-line code.

3. INDUSTRIAL ROBOTS

An industrial robot is officially defined as an automatically controlled,
reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot). One of the defining parameter is the Number of axes – two axes are required to reach any point in a plane; three axes are required to reach any point in space. To fully control the orientation of the end of the arm (i.e. the wrist) three more axes (yaw, pitch, and roll) are required. Some designs (e.g. the SCARA robot) trade limitations in motion possibilities for cost, speed, and accuracy.

Most robot manufacturers keep their software hidden. It is impossible to find out how most robots are programmed. It is almost as if they had no software in many cases. This is because these companies do not intend their customers to do their own programming and they sell complete proprietary application packages rather than general purpose software. Regardless which language is used, the end result of robot software is to create robotic applications that help people. Applications include command-and-control and tasking software. Tasking software includes simple drag-n-drop interfaces for setting up delivery routes, security patrols and visitor tours. General purpose robot application software is deployed on widely distributed robotic platforms.

The DELMIA Resource Modeling & Simulation solution suite provides the tools to develop, create and implement resources, application routines and mechanical programming that are integral with the Process Planning and Process Detailing & Validation solutions. Within this set of solutions, resources such as robots, tooling, fixtures, machinery, automation and ergonomics are defined and infused into a complete scenario of manufacturing.

Complete advanced simulations such as:
- Factory Flow simulations;
- Robotic work-cell setup and OLP;
- NC Machining;
- Virtual Reality Scenarios.

DELMIA V5 Robotics is a powerful, integrated solution that enables manufacturing organizations to design, simulate, optimize and program robotic work-cells in a 3D digital factory environment. It offers a scalable, flexible, easy to use solution for tooling definition, work-cell layout, robot programming and work-cell simulation. It is much more than a basic offline programming system. It can capture the underlying philosophy of intent of the robot programmer, allowing the company to capture and reuse best practices, leverage programming knowledge and automate the repetitive work of robot programming. It is ideally suited for work in the Automotive Body in White industry, particularly robot spot welding and material handling operations. It can also be extended for use in other domains.

We will assign a Robot for simulating a lean manufacturing process using Activity Management and the Catalog Browser option. We have selected the PANASONIC AW 8010 Robot. Further we will simulate the robot movement through Machine Management, and Jog a Device option.
4. CONCLUDING REMARKS

Work-cells are designed to improve process flow and eliminate waste. In Delmia we can associate a Numeric Control Machine Tool, used for the digital simulation of a manufacturing process. We can also assign a Robot for simulating a lean manufacturing process using Delmia Robotics. In conclusion with Delmia we can design tooling definition, work-cell layout, robot programming and work-cell simulation, in a word digital manufacturing and simulation. Using a CNC Machine controlled by Visual Mill, we can do Horizontal Roughing command and Parallel Roughing command, which is typical for Visual Mill’s machining tools. So, it is advisable to use any CIM, CAD or CNC software, or combining them, for increasing the work efficiency.

REFERENCES

[5]. Morar, L., s.a., Machine, Robots and Equipments for Flexible Fabrication Systems, Cluj Napoca, 2006