Bożena SKOŁUD, Ryszard KNOSALA

The Institute of Machine Technology
Silesian Technical University, Gliwice, Poland

THE TOOL MANAGEMENT IN A FLEXIBLE MANUFACTURING CELL (FMC)

Summary. The paper presents our research of tool management in real time in FMC based on Polish equipment (turning lathe TZC 32N and industrial robots IRp60 for workpiece handling). The system gives the possibility of data exchange between different layers of cell controls and gives the possibility of contact with surrounding of a system (for example system operator, staff preparing tools, etc). Appropriate structuring and processing of the information gives us the possibility of controlling the cell making true the thesis that "tool management in real time have influence for make full use of machines". The problem is tool exchange without disturbing flexibility of FMC.

1. Configuration of the cell

The model for investigations consists of 2 lathes TZC 32N2 manufactured in Chocianów, the industrial robot IRp-60, input and output storages and reorientations stands properly for every lathe, the robot gripper's storage and security railings. The stand for simulation consists of one computer working on the highest level of control, next two computers as lathes, one as industrial robots and the last one, set of DIP switches (simulating input/output storages, reorientation stands, positions in the grippers' storage and security railings this may simulate parallel as well as serial production.

2. The tool management system as one module of the cell control system

According to Vincent Paul Rovito from Cincinnati Milacron (Ohio,USA)[7] "The tool management is the capability of having the correct tools on the appropriate machines at the right time so that desired quantities of workpiece are manufactured while maintaining acceptable utilization of assets".

The tool management system can best be defined by five major component function:
- Tool room support deals primarily with the activities involved in preparing the tools for the production schedule in a timely fashion.

- Tool allocation which is an easy task as long as assumption such as infinite tool inventory, infinite tool capacity at the machine and instantaneous service of the tool matrix and valid.
- Tool distribution function address the problem of moving tools between the tool room and the various machine matrices.
- Fault detection function handled at each machine and monitored by the machine control. The function involves detection of the absence for tools and detection of worn broken tools.
- Tool data flow function interacts with each of the other four tool management functions.

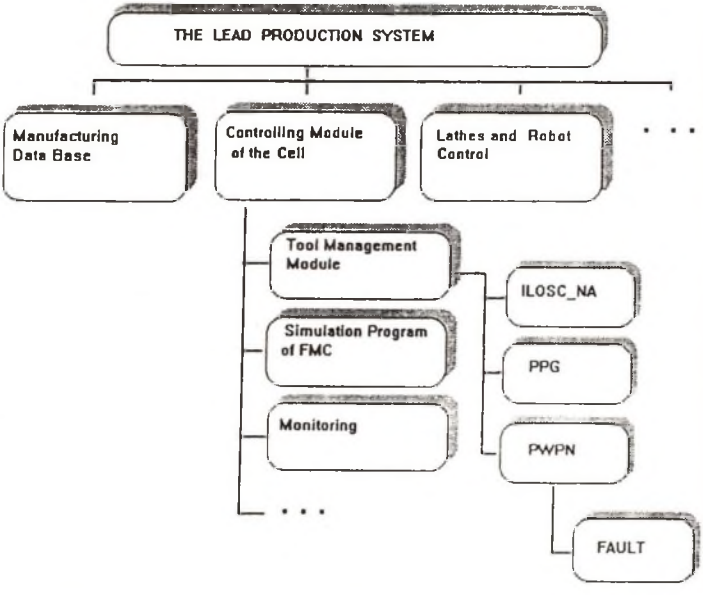

Fig.1. The tool management system as one of the modules the cell control system.

Tool allocation presents the most challenging problems of any the five functions of tool management based on the part process plan, workpiece mix, and production volumes, an assignment of tool to machines must be made.

FMC tool management system procedure should consider the following steps:
- collect all current and possible future user and system requirements,
- analyze the system,
- design appropriate structure and data base for describing tools,
- specify and design programs that are capable of accessing this data base as well as communicating with the real time production planing and control system of the FMC.[6]

For us the most interesting is the connection between process control and participation of the tool

management system in this process and the connection between FMC its operator and staff from tool management view point. The tool management system fulfills special task controlling the tool demand and informing the cell staff about the necessity of preparing the tool to carry out the production schedule and informing about necessity of carrying out the planned tool exchange [8].

The tool management system is one of many modules of cell job controlling and in hierarchy of control system it has a position shown in figure above.

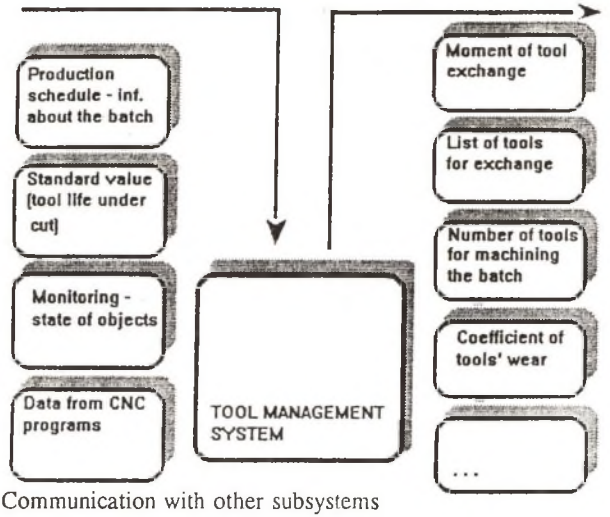

Fig.2. Communication with other subsystems

This is a very important off-line process planing activity. The information source about the requested tools a list that is sent via network to the tool preparation facility, where the actual tool are prepared (assembled or preset).

3. The structure of the tool management system

The tool management system is designed hierarchically. The tool managing main program (MGN) is called many times during cell work by the cell control system. The main tool management program MGN recognizes the reason of call and caries out various functions depending on that reason [8].

3.1. The first call takes place after starting the first workpiece of machining of the new batch according to the production schedule. The MGN program calls subroutine ILOSC_NA call which counts the number of all tools of all types necessary for making all workpieces of the production batch on the corresponding lathe according to the equation:

$$L_{ij} = P_{ij} \frac{t_{pot-N_i}}{T_i} / W_{kij}$$

P_{ij} - number of workpieces in the batch
t_{pot-Ni} - time of work of the tool in the CNC program
T_i - tool life under the cut
w_{kij} - coefficient

The coefficient W_{kij} is updated in previous batch of the same assortment

$$W_{kij} = \frac{\sum_{n=1}^{j} t_{Nj}}{\sum_{n=1}^{j} T_{ij}}$$

t_{Nj} - time of tool work
T_{ij} - tool life under the cut

In this call the subroutine PPG (presetting for new assortment) counts the time after which it is necessary to prepare the preset tools and tooling for the new assortment machining and generates a list of tools and tooling. The list contains all types of the tools which are planned for that assortment.
Subroutine PWPN (planed exchange of tools) counts two types of time period: first when the staff has to start with preparation of tools for planed exchange because of reaching the tool life and secondly when the staff has to start with exchange tools.
Value of the time is written as a number of manufactured workpieces and is written down to first position of MTOA table. Always if value is less then "0" the program writes "+1" that means that the staff has to start with tools preparation immediately.

$$\text{number of workpiece} = \frac{\text{time}}{T_{CNC-program} + T_{IR-program}}$$

In the second position in the MTOA table the time is written when the panned exchange of tools is necessary (number of finished workpieces).

3.2. An actual information must be given always after every tool change for preparing the new tool stating when the next tool change will take place and which tools must be prepared for replacement in a task of the list of tools. The planned replacements of tools are foreseen when the first cutting tool reaches wear the extent equal to WN2*(tool live under cut), and occasionally other tools with wear ranging from WN1 to WN2 will be changed and that tool will be placed on the list for changes. Then we have to check whether the tools from the prepared list did not finish the batch

before reaching the coefficient WN2. In this case the tool is eliminated from the list for exchange. The real coefficient of tool wear is written to the table and used for counting the tool demand for new batch.

3.3. After machining the number of wokpieces pointed in 3.2 the list of tools for change will be checked once more to eliminate errors which could appear because of tool fault (break down). The presetting of the tool is done based on actual list most probably a slightly different than prepared in previous step.

3.4. The new list of tooling will be prepared before the tooling change connected with assortment batch change. The list would be different than prepared during the first workpiece batch because the tools which are planned for the new assortment will be eliminated but only under the condition that the consumption of the tool is less then WN3 * (tool life under the cut)

3.5. Tool fault is a very specific situation recognized by diagnostic system of machine and the scheduled exchange not only the break down tool but the other which are used more then WN1* (tool live under the cut). This operation eliminates the next operation of tools exchange soon to come.

All the subroutines are called with parameter equal "1 " for CNC no.1 and appropriately "2" for CNC no.2.

Every action of staff in the tool set on the lathe must be confirmed by writing the number of the tool and number of the position - it is important especially when the operator replaces a broken tool. In this case it is enough to exchange it and write down its new number and position.

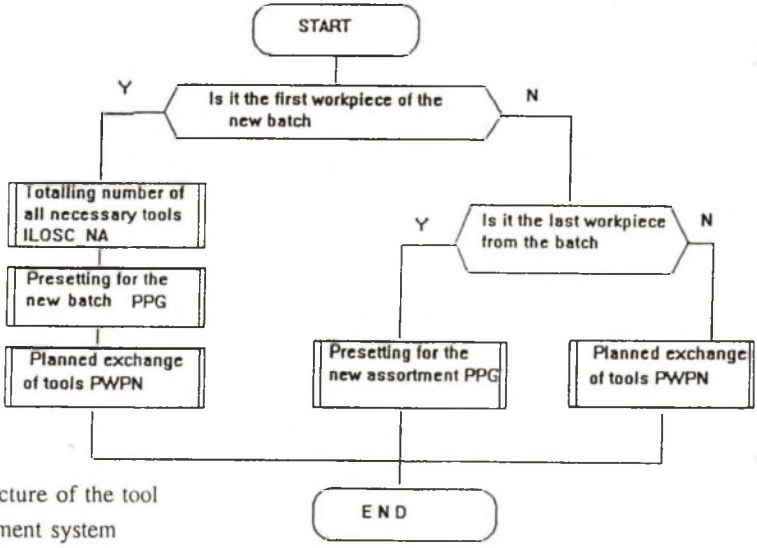

Fig.3. The structure of the tool management system

4. Communication with other subsystems.

To carry out the tool management, the relevant system need many actual information from the control system of the cell and from the manufacturing data base [1].
Most of the information are taken from the monitoring system. It is information we may find:
- number of workpieces manufactured on the lathe during the actual batch realization,
- number of the workpieces manufactured by every tool,
- states of the objects in the cell.

Standard values:
- time for preparation of tools,
- time for preparation tooling and grippers,
- tool life under the cut for all tools used in FMC.

Technological data:
- tool work time within the NC machining program,
- unite NC program time,
- time of robot program ,
- number of workpieces in the batch,
- list of tools for batch manufacturing

and others data.

Tooling information in Flexible Manufacturing Cell is used by several subsystems including production planing, process control, dynamic scheduling, part programming, tool preset and maintenance [5]. The tool management system uses many information from these systems, as well.

5. What kind of results we expect, how it will be tested

We expect shortening of the time of maintenance connected with tools replacement by use and exchange the tool management system in cell with industrial robot. The system leaves the staff free unless it is necessary to prepare the tool for exchange due to the system message. The reports are transmitted to staff in suitable moments pointed by the control system (earlier computed by MGN module of control system.)
We think that this kind of control in turning cell will let us use the tool management system working in the real time in a single cell as well as in the Flexible Manufacturing Systems consisting of some few cells of that type [2,4].

REFERENCES

[1] Auer J. "Einsatzmoeglichkeiten und Rationalisierungspotentiale moderner Tool- Management-Systeme" - VDI-Z Special werkzeuge Spt '93 p.56-61

[2] Eversheim Walter, Koenig Wilfried, Hamburger Rainer, Rentsch Christopher, Aachen "Austausch und Nutzung von Werkzeugdaten" - VDI-Z Special werkzeuge Spt '93 p.30-36

[3] Eversheim W. Kals H. J. "Tools Management. The Present and the Future". Annals of the Cirp Vol 40/2/91

[4] Harstorff M., Holleman Ch."Kennzahlengestuetzte Einfuehrung und Bewertung rechnerunterstuetzten Werzeugmanagements" - VDI -Z Special werkzeuge Spt '93 p. 56-61

[5] Materials of firms: "BALLUFF", "PHOENIX CONTACT", "SECO TOOLS", "SANDVIK"

[6] Ranky Paul G. "A Generic Tool Management System Architecture for Flexible Manufacturing Systems (FMS) - Robotica 1988 Volume 6 pp 221-234

[7] Rovito Vinceny Paul, Hankins Steven Lee - "The Impact of Tooling in Flexible Manufacturing systems" - firms materials of Cincinnati Milacron

[8] Skolud B. Knosala R. - "Computer simulation of Flexible Manufacturing Cell Control" seminary "Analisi e controllo di sistemi complessi"- Naples Italy 12 November 1993 - us unpublished

Revised by: Jan Szadkowski