Tool management in the context of the serial production

GERENCIAMENTO DE FERRAMENTAS NO CONTEXTO DA PRODUÇÃO SERIADA

Luciomar de Abreu Campos
Fiat-GM Powertrain – GM Powertrain Ltd.
Manufacturing Engineering Department
Antônio Maria de Souza Junior
Fiat-GM Powertrain – FA Powertrain Ltd.
Manufacturing Engineering Department
Wisley Falco Sales
Pontifical Catholic University of Minas Gerais – PUC Minas
Manufacturing Research Centre
Mechanical and Mechatronics Engineering
John Bonney
London South Bank University - LSBU
Machining Research Centre
Department of Engineering Systems

ABSTRACT

A tool management system can be defined as an organized tools database, which can interact with other data banks of the system to provide means of optimising production costs and processes. This study looks at the basic principles of tool management in the context of serial production. Considering the hypothesis that the idea of design software should be preceded by perfect understanding of the system that interrelates the object of the administration in the extension of its complexity. After that, the system manages the way that departments such as Planning Engineering, Production, logistics (reception, storage, distribution, etc), and purchasing relate themselves in the context of execution of the corporative objectives: costs, quality, agility and readiness of the information. Some illustrations and equations would be analysed as well as the main variables involved which must be considered to validate the efficiency of the system. Also procedures used to develop the tool management system as well as some practical demonstrations used on the shop floor is considered.

KEYWORDS

Tool management. Optimisation. Costs. Logistics.

RESUMO

Um sistema de gerenciamento de ferramentas pode ser definido como um banco de dados de ferramentas organizado, que interagindo com os demais bancos do sistema de manufatura proporciona meios para otimização dos custos do processo. O principal objetivo desse estudo é demonstrar os princípios básicos do gerenciamento de ferramentas no contexto da produção seriada. Considerando a hipótese que a idéia de se desenvolver um software deve ser precedida pela perfeita compreensão do sistema que inter-relaciona o objeto do gerenciamento, em toda sua complexidade, e a maneira como os departamentos envolvidos se relacionam sejam eles, Engenharia de Planejamento, Produção, setores de Logística (recebimento, armazenamento, distribuição, etc.) e Compras, para o cumprimento dos objetivos corporativos: custos, qualidade, agilidade e disponibilidade das informações. Figuras, diagramas e equações serão analisados bem como as principais variáveis envolvidas, as quais poderão ser consideradas para analisar a eficiência do sistema. Além disso, esse artigo mostrará os procedimentos empregados para desenvolver um software de gerenciamento bem como algumas demonstrações práticas de aplicação no chão de fábrica.

PALAVRAS CHAVE

Gerenciamento de ferramentas. Otimização. Custos. Logística.

INTRODUCTION

In the last decades production has been geared towards minimum cost of the product, and maximum profit, while at the same time not compromising the quality of the product (Novaski, 1991). These challenges are even growing due to the globalisation phenomenon and manufacturing organisations are striving to increase their competitiveness and productivity, which will ensue they survive.

Optimisations of processes are required, which can be achieved by the reduction of the costs of materials, reduction of the non-productive times (time of line, movements, etc.) and quickly implementing the modifications of the production processes driven by manufacturing strategies (Baptista, 2000). Improvements can be achieved by the implementation of new resources (tools, machineries, devices, etc) and the definition of new configuration of the conditions and process planning, or the revision and reconfiguration of parameters to maximize the efficiency of the physical resources available.

According to Boehs et al. (2002), the search for technological improvement started in the 60's with the development of the versatile CNC machine tools. This made it possible to machine complex shapes from different materials. To achieve this require high level of information, which is well managed by a specialist administrative tools. Castro (2004), reported that costs, productivity, flexibility, agility are some of the themes that will contribute to draw attention to the use of tool management systems by companies.

Tool management systems were introduced into Brazilian industries in the 70's and 80's especially in the automotive industry for serial production. Having an organized production system the advantage of strengthening the manufacturing departments. For instance, a problem of production line stoppage due to non availability of tools in stock, already shows the inefficiency in the system: "The Application Engineering specified the tools incorrectly. The Programmer did not specify the materials required properly. Purchasing always involve slow bureaucratic processes. The maintenance was not properly carried out and the consequence of this is machine tool break down. And suppliers are seen as opportunists in the distrust scenery". In that context, a software control system is the answer: system for inventory control, tools control application, control of machine and equipments maintenance, purchasing, etc, each one of the system is isolated in their own sections and might no be compatible with other systems in the organisation and will not provide efficient savings.

The next movement, initiated in the 90's, in industry was characterized by the influence of university research activities, which introduced scientific methods of investigation and working on varied subjects, and also, maintaining the balance between the use of hardware and software to establish connectivity and modulation of procedures.

The present situation is characterized by the presence of major tool manufacturer. They achieve such status by dissolutions and associations with other manufacturers, which in practice results in the constitution of a small amount of conglomerate, self-sufficient and capable of possessing its own "domestic competition". These conglomerate defend the outsourcing of the whole structure involved in the tool management of the companies (Planning and Application Engineering, Regrinding Shop and Preset (tool set up) Area, Materials Programming and Purchases) promising the unwanted "variation of the fixed costs of manufacture". One of the most important items of marketing by these groups is to use their software's managers.

Tool Management Definitions

According to Nogueira and Ribeiro (2000), tools management is a process of interaction between planning, execution and the functions of tool information flow control.

Industries, which process satisfactorily information about tools on time and at the right place, are too rare. The following are some examples of these inefficiencies:

- Lack of knowledge of the tools available in stock;
- Permanence in stock of obsolete and unproductive tools;
- Unnecessary purchases, based on inadequate procedures;
- Problems with the super or sub levels of stock;
- Inefficacy of the attendance control and tools movement during the work;
- Process of purchases with no synchronized with productive needs;
- Deficient information flow among planning, production, engineering, purchases and inventory;
- Lack of criteria that facilitate the selection and use of the tools;
- Difficulty of tool identification, due to diversity shape, materials and of suppliers;
- Lack of a systematisation in the control of tools changes.

A management system has the following goals:

- To establish a common vision among all the involved professionals generating synergy;
- To help negotiation and specification of requirements;
- To represent, to evaluate and to refine concepts

of the process;

- To make possible the computerization with the establishment of clear business rules;
- To treat the complexity of its concept in abstraction levels, beginning for the most generic vision and descends to visions progressively more detailed;
- To promote quantitative indications of the scope and of the complexity of the problem.

Basically the main benefits of the computerized system can be separated in three categories:

- Direct savings: rationalization of the use of labour; reduction and elimination of the cost with forms.
- Measurable benefits: larger efficiency in the process of definition of the purchases; optimisation in the dimensioning of the stocks.
- Intangible benefits: larger power of decision; better use of the efforts; better system of information.

CONSIDERATIONS TO ACQUIRE TOOL MANAGEMENT SOFTWARE

The tool management does not just consist of promoting the administration of inventory and its movements. It is not correct to judge that having all the logistic information and therefore production line is run continuously mean that the system is efficient. A good organization of the company is performed using a software, which contain intentions disguised to justify “out sourcing” or “in sourcing” of the team involved in the administration. It is also not correct to judge that to efficient tool management means modernisation of the personal micro-processes: to handle, conditioning and distribution of tools (e.g. use of “tool dispensers”, electronic storage in “ships” of information, etc.). Management of tools have a wider conception. It is the know-how in administration, which assume the integrated management of several specialities, according to Fig. 1.

The system and software concepts are completely different. System is defined by concepts, ideas or group of rules, and software is a technological resource employed to automate the system processing information of their specifications. To acquire software, a company has two options: First, buy according to the available options on the market, weather it was developed by tool manufacturers or research centres. And, secondly, they can hire the software from the software manufacturers. In the first option, of software

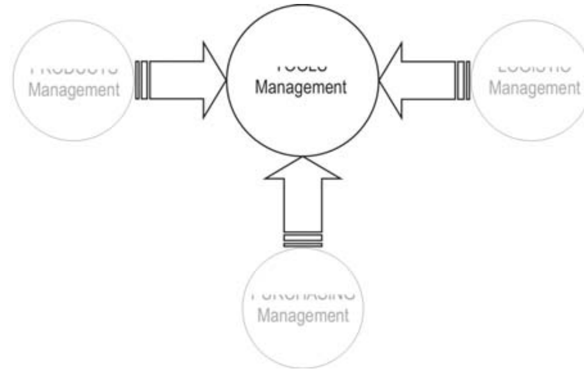

Figure 1 – Integration of the tool management with other specialties

acquirement, the company will be buying a concept, that is compatible or non-compatible with their own system model. In the second option, the company maintains their own concept, and can promote an evolution and improvement. The choice between one or another model is particular, and it depends on a discerning analysis of the current scenery and of the plan of goals.

RATES OF TOOL CONSUMPTION

In mechanical production industries there are two classes of materials employed, which constitute the cost of materials: The Direct Materials, are those that constitute the manufactured final product, they are pieces that can have external origin (buy) or manufactured in their own factory (make). The other class is Indirect Materials. These are employed in the transformation of raw material into final products (direct materials). Examples of indirect materials can be mentioned: cutting or hydraulic oils and cutting tools, etc. Examples of direct materials are cylinder heads, gear cases, gears, piston, etc.

Each one of those two types of materials employed in manufacture receives different fiscal and tax treatment on the part of the government organisations. In this study the information flow for cutting tools (indirect material) will be analysed, and the consumption and demand in function of the use and job of the direct materials. The cutting tool information system is illustrated in Fig. 2.

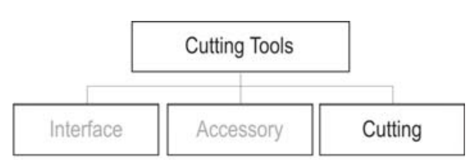

Figure 2 - Tool Classification according to practical criteria

Example of the consumption tax calculation of the cutting type tools. Consider a tool, which is used to produce 1,000 pieces, and that in a certain period there was the need to machine 27,000 pieces. 27 tools will be needed for this job. For the calculations of the tax it is indispensable that the tool life criteria be thoroughly defined, in that way the values will be optimised.

TOOL LIFE

The tool life can be defined as the time in work of tool without losing it cutting edge or until a criterion of life reached, which is previously established. This is usually established by the degree of tool wear. The level of wear will depend on factors, such as (Mills and Redford, 1983):

- Prevention the cutting edge break due to the wear;
- Excessive temperatures reached by the tool;
- The dimensional tolerances of components produced;
- Unsatisfactory surface finish;
- Excessive increase of the machining forces and consequently increase of power consumption.

To control of these factors in a machining process, it is desirable to known when the tool must be substituted or reground. In addition, economical factors can also define the level of wear accepted (Machado and Silva, 1999). Criterion of tool life can also be expressed in several ways (Machado and Silva, 1999):

- Cutting time (min);
- Cutting length (km);
- Feed length (mm);
- Volume of material removed;
- Number of pieces machined.

In serial production the criterion usually employed is the number of pieces machined.

DOMAINS OF THE TOOL MANAGEMENT

To define the number of tools needed to produce specific number of components, it is necessary to establish boundaries according to the production flow chart, as shown in Fig. 3.

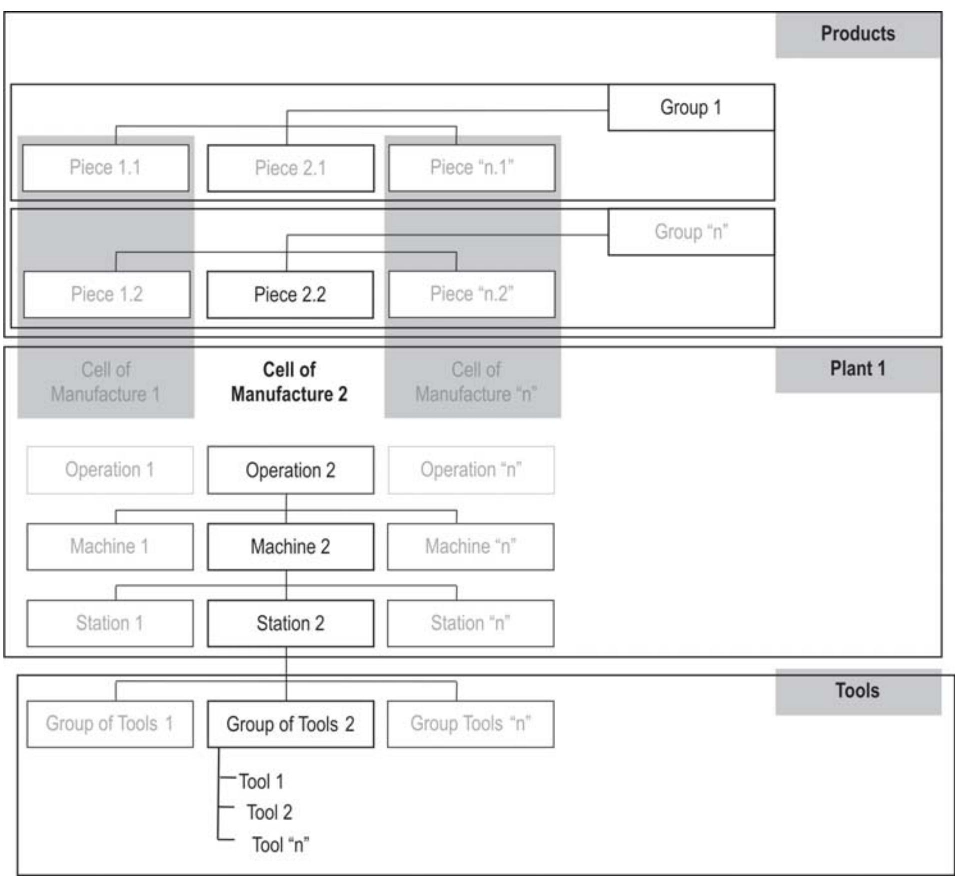

Figure 3 – Tools job point

Other function of the tool management system control and monitor specific tools on a given job. This control allow to which group the tool is set up to be known, as well as the type of machine tool it is loaded onto, that is, if it is a transfer machine, in which station it is and the manufacturing cell the machine tool is located, and finally, in which group of products does the piece belong. The group of attributes (product, plants, cell, operation, machine, station and tool group), that inform where the tool is used is called job point. Knowledge of the tools applications is the first point of optimisation of the processes because it is possible to re-apply items for the other functions thus reducing new items proliferating in the attributes.

Figure 4 shows other domains of the system in relation to the areas involved in the activity of tool management. It is important to have sharing of information, each group of specialised areas has to make their information available for global processing. It is not possible, for instance, which the application engineer, linked to production, to do process optimisation if he cannot access the final values negotiated by the purchasing team. On the other hand, the team of purchasers needs to know the volumes of tool consumed in order to negotiate and define the contracts with suppliers. In some cases it is necessary to interfere by the administrative management to minimize or to solve the disagreements among the manufacturing sections. The strategic administration is multidisciplinary; it can provoke high investments in the function of analyses of the situation involving tools, such as acquisition and substitution of equipments, alteration of the model of the productive flow, organization restructuring, etc.

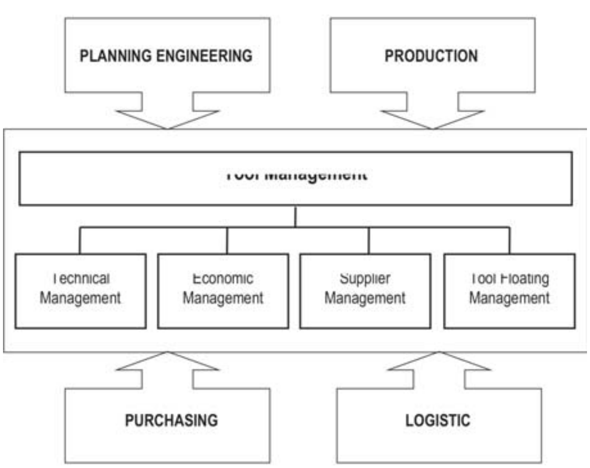

Figure 4 – Focuses of the tool management

Figures 5 to 7 shows another angle to represent the domains of the system where they show three different tool life cycle models, or turn of tools in the factory. Figure 5 shows a model in which turn of tools of the cutting type interchangeable has to be mounted and preset on the machine tool.

Figure 6 represents a model of turn of tools in which the interchangeable cutting type need to be previously assembled and then preset to be used on the machine tool.

Figure 7 represents a model of turn of sharpened tools of the cutting type that is previously assembled and than preset.

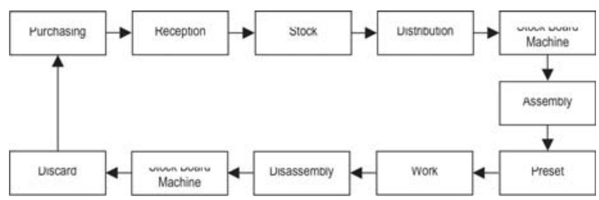

Figure 5 – Model of turn of interchangeable tools without previous preset

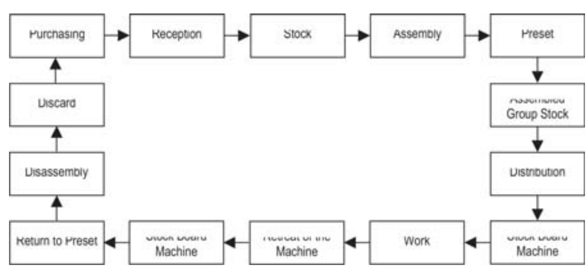

Figure 6 – Model of turn of interchangeable tools with previous preset

Observations of these models shows that if the activities of assembly, presetting, distribution, analysis of wear and regrinding would be optimised these could minimise the tool inventory in the process (storage, assembled group stock, stock board machine, tools for regrinding).

Gains with the Implementation of the System

Gains with the logistic planning

The possibility of costs reduction can be verified with the establishment of a general costs map of the industrial process. One of the options to promote that reduction would be to optimise the size of the turn

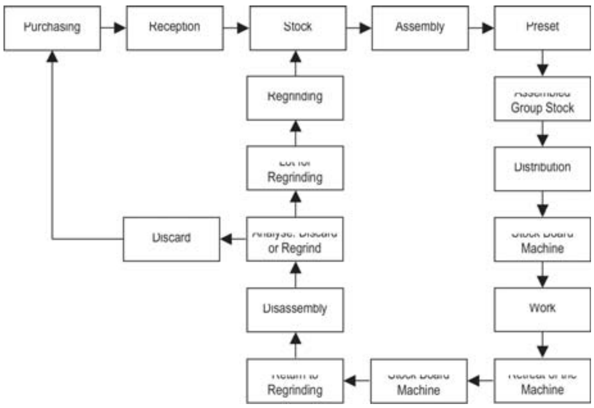

Figure 7 – Model of turn of sharpened tools with previous preset

inventory. The stocks can be calculated by Eq. (1), (2), (3), (4) and (5), as follow:

$$P_d = \frac{P_m}{D} \quad (1)$$

where:
P_d = daily production;
P_m = monthly production;
D = number of days in the month.

$$Q_{fm} = Q_{cm} \times Q_{fc} \quad (2)$$

where:
Q_{fm} = quantity of mounted tools;
Q_{cm} = quantity of groups of mounted tools in the machine;
Q_{fc} = quantity of tools in the group.

$$F_n = \frac{P_d \times Q_{fm}}{P \times A \times (A_f + 1)} \quad (3)$$

where:
F_n = daily quantity of necessary tools;
P = quantity of pieces produced by a cutting edge (Tool Life);
A = quantity of cutting edges of the tools;
A_f = quantity of reshaping of the tools.

$$E_{\min} = F_n \times D_{\min} \quad (4)$$

where:
E_{min} = minimum stock;
D_{min} = minimum quantity of covering days.

$$E_{\max} = F_n \times D_{\max} \quad (5)$$

where:
E_{max} = maximum stock;
D_{max} = maximum quantity of covering days.

The minimum and maximum quantities of covering days are associated to the periods in which the material programmer needs to request an item and to receive it indeed to make available to the production. In addition, the following tasks are included:

- Bureaucratic: emission of purchases requests;
- Commercial: negotiations, competitions, emission of contracts;
- Tool production;
- Tool delivery.

Analysing these equations, there are ways to minimize the passive capital in the company (immobilized in stock):

- To optimise the amount of pieces produced by a cutting edge of the tools (P) with the consequent decrease of the daily amount of tools necessary (F_n);
- To choose use standard tools in relation to special projects;
- To reduce the amounts of covering days.

To decrease the covering days there is the need to settle down contractual forms with covering period extended or amount of pre-established items (open request), with the maintenance of safety stock in the manufacturer's plant, eliminating the bureaucratic and commercial activities inside the validity period. To reduce the delivery period's one alternative would be the allocation of the safety stocks of the supplier in the purchaser's plant (convenience stores).

Due to these possibilities exemplified, it is easy to understand that an efficient tool management system has to provide information about the negotiated amount of tools by each supplier, that is being immobilized in the process (stocks), indicate the need of contractual treatment, economical and differentiated logistic.

Gains with technical planning

In item 2.2 a simple calculation of the projection of tool consumption in a period was exemplified, accomplishing the inverse calculations the reference information (tool life) used can be checked if the calculations were defined correctly or, if it is necessary to analyse the whole of process. The variables that can influence the variation of the estimated tool life are:

- Mechanical and electro-electronics state of conservation of the machine;
- Supply conditions of the raw material (dimensional and material);
- Cutting fluid conditions;
- Supply conditions of the cutting edge of the tool;
- Conditions of the tool material, etc.

In case of variation in some of these items and also when this variation is not a transitory event, the value of the Tool Life should be altered.

Example of Tool Life calculation for Cutting type tools. Consider a specific period when 27,000 pieces were machined and using 54 units of a certain cutting type tool. It can be calculated that the real life of this tool is 500 machined pieces.

Confronting this productivity (500 pieces / tool) with that used in item 2.2 to project the consumption during the period (1,000 pieces / tool), a discrepancy of 50% is realized. Situation like this indicates the need for further investigation.

Example of Software Development

The authors of this paper worked in the "SGF" ("Sistema de Gerenciamento de Ferramentas" - Tool Management System) developed in the FA Powertrain Ltd. This software was developed in partnership with ATTps and GVS. Its specifications was based on the old software in use and of countless interviews with representatives of all areas involved in the development process.

The decision to develop the software based on the fact that there was no software's in the market that corresponds to the requirements diagnosed previously by FA Powertrain Ltd. It was verified that each software available at the market assisted in differently ways, according to its specialty, to those require of the developed software.

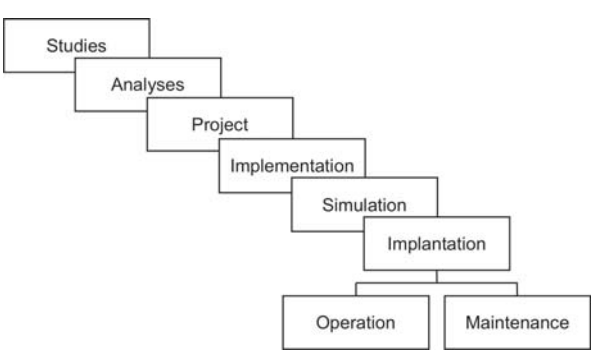

Figure 8 – Phases of the system development

The "SGF" development lasted 3 years and it has been in operation since July 2004. It was verified that beside the inherent difficulty of development there is also the difficulty in the manual input of the data, and is also extremely specialized. The benefits of the software, is that it was developed in stages as shown in Fig. 8.

Conclusions

- It is important that a company posses software to automate its management system, because of the high volume of information to process.
- The initial gains with the improvement or implementation of a management system is related to the optimisation of the inventory (rotate and obsolete), later with the monitoring of the tool life with the objective to stabilize the process.
- The management system can be a powerful tool for monitoring the conservation state of the machines.
- The software is just a processor and it does not substitute for the specialise professional's who execute the decisions based on their analyses of the situation and strategies.

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