Int J Adv Manuf Technol (1999) 15:562–565

The International Journal of Advanced Manufacturing Technology

Development of a Tool Database Management System

G. Subrahmanyam[1], A. Gunasekaran[2], S. Arunachalam[3] and P. Radhakrishnan[1]

[1]Department of Mechanical Engineering, P.S.G. College of Technology, India; [2]Department of Management, University of Massachusetts, North Dartmouth, MA, USA; and [3]Manufacturing Engineering Subject Group, Coventry University, Coventry, UK

This paper describes a systematic approach to the design and development of a tool management system for the valve production unit of Bharat Heavy Electricals Limited (BHEL) located in Trichirapalli, India. The salient features of the design and development of a centralised database for tools that contains information regarding tooling, tool location, allocation, tool flow, tool storage and retrieval, parts, machines, etc. are discussed. It is estimated that the system being developed will significantly reduce the downtime of machines due to unavailability of the appropriate tools.

Keywords: Decision support system; Flexible manufacturing system; Material requirements planning; Tool requirements planning

1. Introduction

Tool management has become an area of increased research activity in the 1980s and 1990s. With the advent of computerised manufacturing systems, and in particular, flexible manufacturing system (FMS), it has become evident that tooling is a major constraint that prevents manufacturing systems from realising their full flexibility. Several approaches to tool management systems have been proposed [1–6]. To increase the efficiency of tool use in a flexible automated manufacturing system, it is necessary for the tool database to support information used in the whole tool life cycle and in tool use. A management system sharing some tools in some machines, and using them efficiently, can make the best use of tool capacity. For the realisation of this system, the tool user needs information to select the tool and to deploy it in the appropriate place just in time, based on tool status and machining schedule.

Mitsui et al. [6] dealt with a design method for a tool database to be used in tool use planning. They constructed an activity model of such a system for an FMS for clarifying requirements for a tool database. Later, they designed such a tool database for satisfying the requirements with the help of an object-oriented method using software such as EXPRESS, C++, and an object-oriented database system. In FMSs, the initial investment in cutting tools and fixtures may be up to 25% of the total FMS investment. Seven to ten times more money is spent on tools, jigs, fixtures and consumables than on capital equipment during the useful life of the machines. Veeramani et al. [5] advocate tool requirements planning (TRP) as an information management tool for planning and controlling tool use. They suggest that TRP performs well in a closed-loop manufacturing control system driven by material requirements planning (MRP) and supported by complete shop floor control. The TRP is supported by a database whose files include tool master, tool bills, etc. A comprehensive and effective tool management system is essential in flexible manufacturing systems.

Ranky [3,4] discussed the design of an FMS turning-tool database and tool-management system and a robot-tool-management system for flexible assembly systems (FAS), both based on common principles, resulting in a generic system architecture. Besides explaining the methodology, based on hierarchical decomposition principles, both turning-tool and robot-tool-management system designs, and sample database runs are illustrated to highlight the common and diverse features and to point out the CIM specific design and implementation goals.

Garapati and Wang [2] presented a decision support system (DSS) for tool management in FMS. Considering the fact that FMS should be able to accommodate a variety of different parts in random order, tool management at cell level, and tool transportation, tool data management, tooling data collection, tool maintenance, and manual and/or robotised tool assembly at an FMS level, are all very important. Tooling information in FMS is used by several subsystems, including: production planning; preset maintenance; robotised and/or manual tool assembly; stock control and materials storage. Ranky [3,4] summarised the major tasks to be solved when developing tool-management systems for FMS, as well as giving a solution for describing the data structure of a tool database integrated with a generic tool description method, and showed an example of the way the FMS real-time control system can access and use this database.

Correspondence and offprint requests to: A. Gunasekaran, Department of Management, University of Massachusetts, North Dartmouth, MA 2747-2300, USA. E-mail: agunasekaran@umassd.edu

Tool management is very critical for effective and uninterrupted operation of computer-integrated manufacturing systems (CIMS) and is especially important for high productivity and flexibility in FMS. Shanker and Gopinath [1] dealt with the tool planning and control (TPC) aspect of the tool management, and described a computer-aided procedure for the integration of functions of assigning the tools to various operations, procurement and replacement of tools, and scheduling the sharpening of tools. The need for automated tooling in flexible machining, assembly, and sheet fabrication systems should be addressed. ElMaraghy [7] discussed the various methods of implementing these systems, their benefits and drawbacks. The author also described the basic modules of automated tool transfer, storage, loading/unloading and management, together with the appropriate level of automation for each module.

This paper describes a systematic approach to the design and development of a tool-management system for the valve production unit of BHEL. The company has undertaken modernisation of the valve production unit with the aim of improving productivity, and quality and reducing the cycle time, by the installation of the latest CNC machines. About 19 new CNC machines are being introduced in the shop, which, with 30 existing CNC machines and other conventional machine tools, is expected to enhance the manufacturing capability. The objective of this work is to design and develop a centralised database for tools that contains information regarding tooling such as tool location, allocation, tool flow, tool storage and retrieval, parts, and machines. The above database is required for the timely flow of information for high performance of the total manufacturing system. With the increasing diversity of components handled in the above production unit, there is a need to devise a computer-aided tool-management module in order to ensure the right deployment of the right tool at the right place at the right time. It is estimated that the system being developed will significantly reduce the downtime of machines owing to the non-availability of the appropriate tools. The proposed system will minimise the duplication of tools purchased and facilitate the forecast of tool requirements based on tool consumption and lead time, besides ensuring a substantial reduction of tool inventory.

2. Information System

In a large organisation such as BHEL, the database system is typically part of a much larger information system that is used to manage the information resources of the organisation. An information system includes all resources within the organisation that are involved in the collection, management, use, and dissemination of information. In a computerised environment, these resources include the data itself, the database management systems (DBMS) software, the computer system hardware and storage medium, the personnel who manage the data, the application software that accesses and updates the data, and the application programmer who develops these applications. Hence, the database system is only a part of a much larger organisational information system.

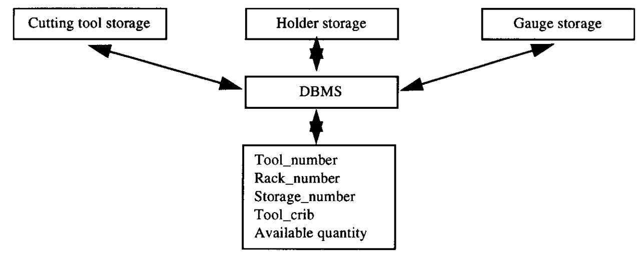

Fig. 1. A DBMS as the sole source of data.

2.1 Data Model

When data is added to a database, it becomes a “model” of that part of reality to which the data refers. As there is an increased need for up-to-date information, an automated DBMS was developed based on groups of formalised data modelling rules called data models. A DBMS is a central controller of tool data. All applications must request data from the DBMS. The DBMS permits direct access to the data. Figure 1 shows the structure of the DBMS centralised data.

2.2 Relational Database Structure

A relational database model was used to design the database. The relational database eliminates the need to follow predefined access paths to reach the target data, and makes the data access more flexible. Hence, this database facilitates uninterrupted queries and is well suited to the manufacturing environment. The module was developed using ORACLE (V7.1) as a back end and DEVELOPER/2000 as a front end. ORACLE supports the largest of databases by providing access for a large number of concurrent users. The database server or back end is used to manage the database tables optimally for multiple clients and also concurrently requests the server for the data. It also enforces data integrity across all client applications and controls database access and other security requirements. A client or front end database application also interacts with the database by requesting and receiving information from the database server. It acts as an interface between the user and the database. Furthermore, it also checks for validation of the data entered by the user.

2.3 Oracle Forms

Oracle allows users to insert, update, delete and query data using a variety of interface items, presents data using text, images and VBX controls and controls forms across several windows database transactions.

3. Tool Coding

The tools used in the shopfloor were classified into eight different groups, namely, cutting tools, jigs, fixtures, templates, gauges, dies and others. The following eleven digit coding system has been designed to address the various tools used in the shop floor of BHEL, Trichirapalli, India.

Table 1. Sample data requirement list.

ENTITIES	ATTRIBUTES
C_TOOL	Tool number, type, name, material, supplier, status, condition, maximum speed, minimum speed, maximum feed, minimum feed, depth of cut, machine number, holder, drawing number, accuracy, life, quantity, etc.

XX	XXXXX	XX	XX
e.g. 30 – reamer 31 – drill	e.g. 05000 – reamers used for valves subjected to 5000 p.s.i.	e.g. 10 – roughing reamer	serial number of tool e.g. 12

Table 1 shows a sample entity–attribute data requirement list for a cutting tool (C_tool). Similar data requirement lists were developed for tool holders, jigs, fixtures, gauges and issue.

3.1 Relationship Matrix

A relationship matrix is drawn and the names of the entities on both sides are labelled as shown in Table 2 (1–1 denotes a one-to-one relationship).

With the entities, the associated attributes and relationships were identified and an entity relationship diagram of the general database design was prepared. Figure 2 shows the entity relationship diagram for the database design.

4. Development of User Interface

An exhaustive ORACLE database comprising twelve tables capturing real-time tool information was developed and the various tables prepared are listed below:

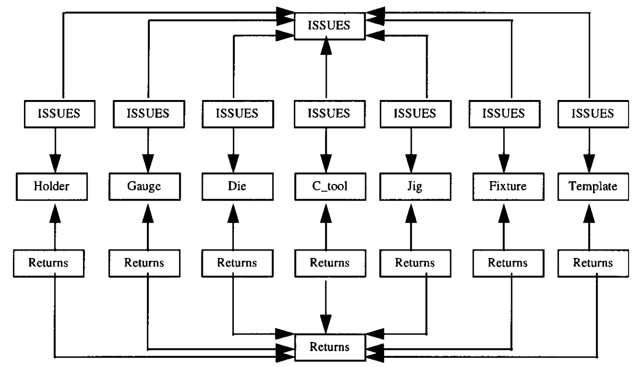

Fig. 2. An entity relationship diagram.

Eight tables each one pertaining to a particular group of tool, i.e. C_Tool, fixture, jig, template, holders, die and gauge.
Two tables to consolidate data pertaining to issue and return of tools.
One table to highlight the updated list of tools issued.
One table for storage of password information.

The data pertaining to one of the tables created, i.e. that for C_tool is given in Table 3.

4.1 Front End Details

The main forms that are created are the tool data entry form, tool issue form, tool receiving form, tool life details form, tool assignment form, tool storage form, accessories and the help form. By clicking the push buttons, the users can navigate to the respective forms. The above-mentioned relational database can be accessed using the front end of the module developed using DEVELOPER/2000. The key forms that have been developed for various transactions include:

A main form to access the various forms of the module, such as data-entry form, tool issue, tool return form, etc.

Table 2. Relationship matrix.

	C_Tool	Jig	Fixture	Holder	Die	Gauge	Issue	Returns	Template
C_Tool	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Jig	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Fixture	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Holder	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Die	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Gauge	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Template	–	–	–	–	–	–	1–1 issues	1–1 issues	–
Issue	1–1 issues	1–1 issues	1–1 issues	1–1 issues	1–1 issues	1–1 issues	–	–	1–1 issues
Returns	1–1 issues	1–1 issues	1–1 issues	1–1 issues	1–1 issues	1–1 issues	–	–	1–1 issues

Table 3. C_Tool Data Created in ORACLE V7.1.

Tool number	Char (14)
Name	Varchar2 (30)
Type	Varchar2 (30)
Supplier	Varchar2 (15)
Material	Varchar2 (15)
Tool_Desc	Varchar2 (230)
Tool_Crib_No	Number (3)
Storage_No	Number (10,2)
Rack_No	Number (10,2)
Status	Varchar2 (20)
Condition	Varchar2 (20)
Speed_max	Number (10,5)
Feed_max	Number (10,5)
Speed_min	Number (10,5)
Feed_min	Number (10,5)
Depth_of_cut	Number (10,5)
Total_life	Number (10,5)
Worked_hrs	Number (10,5)
Rem_life	Number (10,5)
Cost	Number (10,5)

Individual forms for each tool group, i.e. tool data entry form, tool issue form, tool receiving form, tool life details form, tool assignment form, tool storage form, accessories and help form.

4.2 Tool Life Status Form

This form gives the life status of each tool that is available in the tool room. The user can have a graphic display of life status in the form of pie chart with the help of a graphic button. A VBX control which will move according to the worked-hours, indicates the worked-hours of that tool.

5. Conclusions

An exhaustive database has been designed and developed in an ORACLE V 7.1 RDBMS package to control, store and retrieve associated data. A form-based interface has been created to access the database. A menu interface has been developed that can call items like submenu, forms, etc., to carry out the data processing requirements.

The major useful data that can be derived from the tool management system are:

Status of tool, such as available tools, issued tools, or out of use tools.

Life status of tools – both numerical information and graphical output.

Tool storage information details.

Status of tool transactions on a day-wise graphical output.

With the implementation of the above tool-management system, it is expected that 30% of the product manufacturing cycle time pertaining to the tooling problem can be significantly reduced, based on a trial conducted. Thus, a computerised database management system helps to eliminate the tooling problem and thereby enhances the productivity and system requirements. The above module can also be integrated with other available modules in the shop floor for future modification.

Acknowledgements

The authors duly acknowledge the assistance of P. Sivakumar, P. Mohanasundaram, and V. Mohanram in this project.

References

1. K. Shanker and B. V. Gopinath, “Design and development of a database for tool planning and control”, Emerging Trends in Manufacturing: Proceedings of the 12th All India Machine Tool Design and Research Conference, Delhi, India, pp. 166–169, Tata McGraw-Hill, New Delhi, India, 10–12 December 1986.
2. S. Garapati, S. and H. P. Wang, “Decision support system for tool management in FMS”, 1988 International Conference on Computer Integrated Manufacturing, Troy, NY, USA, pp. 53–61, 23–25 May 1988.
3. P. G. Ranky, “Comparative analysis of tool management system, architectures designed for flexible machining and assembly (FMS/FAS) systems in CIM environment”, 1988 International Conference on Computer Integrated Manufacturing, Troy, NY, USA, pp. 36–43, 23–25 May 1988.
4. P. G. Ranky, “Generic tool management system architecture for flexible manufacturing systems (FMS)”, Robotica, 6(3), pp. 221–234, July–August 1988.
5. D. Veeramani, D. Upton and M. Barash, “Cutting tool management in computer integrated manufacturing”, The International Journal of FMS, 3(4), pp. 237–265, 1992.
6. S. Mitsui, F. Tanaka and T. Kishinami, “Design method of tool database for tool use planning”, Precision Engineering, 61(6), pp. 799–803, 1995.
7. H. A. ElMaraghy, “Automated tool management in flexible manufacturing”, Journal of Manufacturing Systems, 4(1), pp. 1–13, 1985.