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DESIGN & IMPLEMENTATION OF A BESPOKE MRPII SYSTEM FOR A SMALL AND MEDIUM ENTERPRISE (SME) MANUFACTURING COMPANY

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ABSTRACT

Due to significant challenges and increase in competition within the global environment, manufacturing companies need to focus on Manufacturing Planning and Control (MPC) systems in order to gain a competitive edge. This research paper describes a contribution towards the design and implementation of a bespoke MRP II system for a SME company dealing in tool reclamation. The paper covers the investigation of currently available MRP II systems and also investigates the present MPC system of the concerned SME company. On the basis of these investigations, a new/bespoke design has been proposed and developed for an MRP II system that is tailor-made for the aforementioned company. The newly designed MRP II system has been developed (using MS Access and Visual Basic for Application i.e. VBA) as a database planning tool of MPC system and contains the critical modules Demand Management (DM), Rough Cut Capacity Planning (RCCP), Master Production Scheduling (MPS), Material Requirements Planning (MRP), and Capacity Requirements Planning (CRP). The bespoke MRP II system has been tested within the real manufacturing environment existing in the SME company with positive results. The key outcome of the research has shown that even small SME's can design and implement their own MRPII system, which is particular and relevant to their own special manufacturing environment, using a minimal of time, software and financial resources.

Key Words: *Manufacturing Planning & Control (MPC) System, Manufacturing Resource Planning (MRP II), Small & Medium Enterprise (SME), Tool Reclamation.*

INTRODUCTION

In today's production world, an effective manufacturing company (whether small, medium or large) depends upon the accurate and precise planning of manufacturing resources such as materials, machines, tools, processes, labour, and capacity (Andijani and Selim, 1996). In the past, different companies have adopted different MPC systems according to their organizational activities and resources (Chan and Burns, 2002). Recent research has shown that Small and Medium Enterprises (SMEs) are far behind the Large Enterprises (LEs) in certain planning and manufacturing environment especially in developing countries due to limited resources and economy (Uddin and Saeed, 2010). In today's manufacturing environment, a company can rarely survive without implementing any one of the MPC systems (Wacker and Hanson, 1997).

According to Humphreys et al (2001), "Improving and increasing the competitiveness is now essential for small and large businesses alike". MPC approaches can be placed into two categories, namely the quantitative approach and the systems approach. The quantitative approach contains Statistical Inventory Control (SIC), Aggregate Production Planning (APP) and Reorder Point (ROP), whilst on the other hand the systems approach includes Period Batch Control (PBC), MRP, MRP II, Enterprise Resource Planning (ERP), Just-In-Time (JIT) production, Optimized Production Technology (OPT), Hierarchical Production Planning (HPP), Constant Work-In-Process (CONWIP) and the Hybrid MPC system (Chan and Burns, 2002).

In the late 1960's, an effective MPC system approach known as MRP originated and played vital role to form an effective inventory strategy in an environment of known demand (He et al, 2005). This MRP system was initially implemented in the air line and mobile industries (Moustakis, 2000). After a decade, the production world realized that the MRP system required some essential changes in terms of looking at additional manufacturing resources other than materials planning (Porter et al, 1999). Therefore, in the late 1980's, major changes were made which led to the evolution of new system approach known as MRP II (Wong and Kleiner, 2001).

An MRP II system plans, monitors, and integrates all the resources of a company and is based on several modules which look at manufacturing

routings, production schedule, and work centre capacities (Kumar and Meade, 2002). According to Ip and Yam (1998), MRP II can be defined as "A methodology for the effective planning of all resources of a manufacturing company". Hence, the MRP II is a database planning tool and has the characteristic of MRP closed-loop feedback and therefore it has also been referred to as "Closed Loop MRP" (Wong and Kleiner, 2001). MRP II has extended its approach by linking several business functions or modules such as business planning, capacity planning, shop-floor control, human resource planning, production planning, purchasing, marketing, finance and accounting (He et al, 2005). Sometimes MRP II is also referred to as a management system which is "based on scheduling network, aims to help people to run their business effectively, towards high productivity levels and satisfactory customers, services, and simultaneously minimizing inventory and product/service cost" (Hokoma, 2006).

Since, an MRP II system is based on number of modules which are linked to one another with feedback response mechanism (Salaheldin and Francis, 1998), therefore an MRP II system indicates three main strategies in terms of planning and controlling the system of a company; these are described as strategic planning, tactical planning and execution (Rondeau and Litteral, 2001).

The strategic planning (sometimes also known as top management planning) covers defining and setting the organisation's primary aims or objectives and ultimately adopting certain actions to achieve those aims, whilst the tactical planning (also known as operation management planning) provides guidance to implement the activities specified at the level of the strategic plan (Boone and Kurtz, 2005). The execution planning (or operation management execution) involves the purchasing and manufacturing plan and also includes the actual demand production, shipping and delivery activities (Voss, 2006). The MRP II system's modules can also be categorized on the basis of long, medium and short range planning activities (Enarson, 2006: Xiong et al, 2001). All the modules of MRP II system are interlinked in such a way that the data information flows smoothly from higher to lower levels (Yung et al, 1998).

Selected SME Manufacturing Environment for Research Study

Author selected a real SME manufacturing environment for research study. This research paper presents a bespoke MRP II system developed for a particular SME company dealing in manufacturing operations only for tool reclamation. This SME company has around 45 employees and an average turnover of £1.5 million per year. It consists of three major production lines producing a number of various products and with two weeks turnaround period. Each production line has sub processes such as welding, milling, grinding, fitting, and inspection. The high volume key products are short-hole drills, tool holders, boring bars, drills, end mills, and milling cutters, as shown in Figure 1. Moreover, a company is using Equinox and Opera softwares with three operating workers to manage its production lines, key products, customer demands, and accounts details respectively. The overall manufacturing environment of SME is shown in Figure 2.

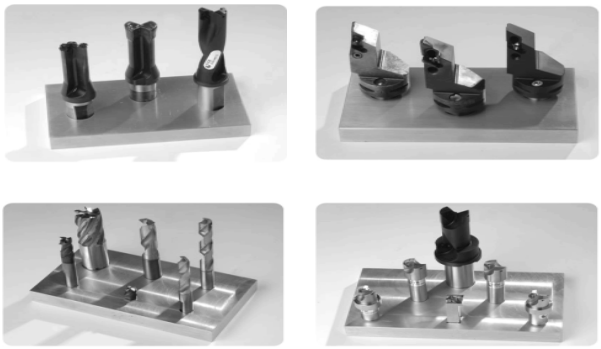

Figure 1: Key Products of the SME manufacturing company (NTR, 2008)

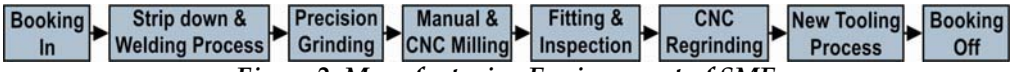

Figure 2: Manufacturing Environment of SME

RESEARCH METHODOLOGY

To design and implement a bespoke MRP II system, author has taken three steps procedure as a research methodology. First step of this research paper covers the conceptual design of MRP II system for the selected SME whilst the second step covers the development of MRP II database in MS Access software for the proposed MRP II framework. The final step involves the implementation of bespoke MRP II system and the

accomplishment of results in an SME.

A conceptual design of a bespoke MRP II system is proposed by the author after investigating the top management requirements and manufacturing environment of a SME company through private communications and visits. It is then compared with the standard MRP II system which helps in the derivation of a tailor made (bespoke) MRP II system for the aforementioned SME company.

To transform the theoretical knowledge and proposed bespoke MRP II system into reality, author uses MS Access software to develop the database. A database is a collection of descriptions of particular data, relating data in a logical manner and designed in such a way that fulfils the desired needs of a company or an organization (Connolly, 2005). MS Access is friendly usage software (Erwa, 1998). MS Access is based on number of features such as tables, forms, queries, reports and other application objects like macros, visual basic for applications (VBA), and structured query language (SQL) (Haag et al, 2003). These features are used for developing the database or relational database management system (RDBMS) in an organized manner (Korol, 2005). It was proven by Erwa in 1998, which developed a standard MRP II database in MS Access for assembly operations. This paper develops a bespoke MRP II database system for a tool reclamation company with the help of MS Access instead of using any other softwares because of its flexibility in terms of easy access, quick availability, and low purchasing cost.

The developed MRP II database is then compared with existing softwares and tested by the author in the real working environment of an SME company with positive results. Each step of research approach is now discussed one by one.

Step One: Conceptual Design of MRP II System

Since some companies deal with manufacturing and fabrication operations rather than assembly operations few modifications are possible in actual existing MRP II system (Chan, 2005). By keeping in mind the manufacturing environment of a SME company, author proposes a conceptual design framework of a bespoke MRP II system covering five major modules and then compares with the standard existing MRP II system. These are as follows,

1) DM (Demand Management Customer Related Files)

To keep the records of customer's batch orders several files are required such as the customer's company name, delivery address, contact details, batch order date, shipping date and batch quantity. There are three files that author feels necessary in order to link customer related information such as customers, orders, and order detail files.

2) RCCP (Rough Cut Capacity Planning File)

In order to know about the capacities of the company the parameters associated with these such as processing time, time per shift, shift per day, utilisation, action and efficiency data associated with production machinery need to be stored in a RCCP file. The SME company has many automated and manual machines (like CNC and manual milling), therefore by creating this file a company gains a sufficient idea about their manufacturing environment and production performance.

3) MPS (Master Production Schedule File)

The product master file is required to keep the records of products such as product code, description, unit cost, and product mix. With this file, author wants to assure the company to become familiar with what products can be produced or are available, and therefore can keep the information of its key products such as end mill, and tool holder. There is no component file designed because the components are considered to be sub-tools used in final tool/product manufacturing which is not required here.

4) CRP (Capacity Requirements Planning Routing File)

This file indicates the processes that result in the completion of the final product. This file also shows the setup and the time of each process for every key product, the routing file also includes all the operator's information.

5) SFC (Shop Floor Control)

This module contains the information in the form of three key reports that give production control, inventory records, and purchasing details. Each report is generated when the information flows smoothly from demand management module to capacity requirement planning.

Integrating Modules

In this section, paper presents the integration of all designed modules which generate three key reports thus giving rise to a newly bespoke MRP II system for a SME company as shown in Figure 3. This section also discusses the comparison and difference between the existing standard MRP II system and newly bespoke MRP II system.

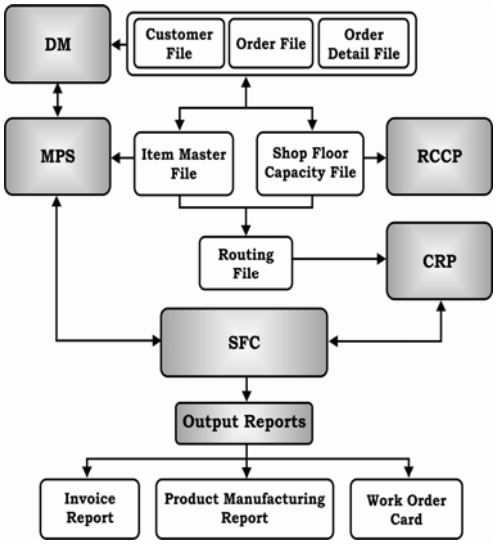

Figure 3: Bespoke MRP II System (Uddin, 2008)

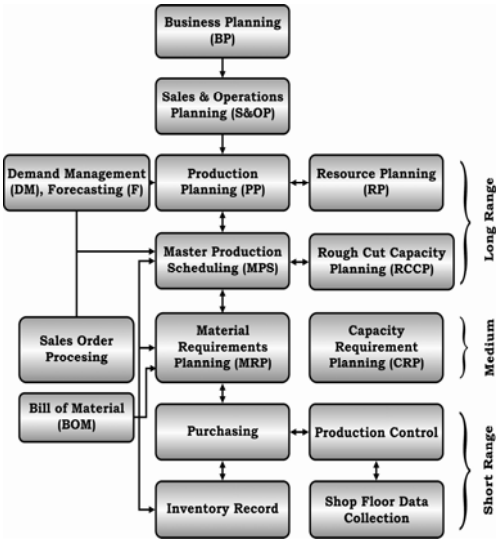

Figure 4: Standard MRP II System

When the newly designed MRP II system (Figure 3) is compared with standard MRP II system (Figure 4), it can be observed that there are a number key modules are absent as shown in Table 1. The reason for this is that for the considered SME, it was deemed that a ***lean*** MRPII system was the key requirement. As an example, the BOM (bill of materials) is in essence, the manufacturing process which describes how assembling processes lead to the final product creation and also lists the sequence of processes along with sub-tools used to make the final product. Here, SME

is not dealing with the assembling processes and hence there is no need to create it and such information is created in the routing file of bespoke MRPII system.

On the other hand, the implementation of the MRP (material requirements planning) file is complicated because the SME does not deal with the individual lead time and quantity of the components like sub-tools such as the filler rod, shims and also inserts acting as manufacturing tools all of which are used in the final product. A single filler rod can be used for a number of products and a product can also take three to six filler rods, therefore no gross or net requirement calculations for the components are possible to calculate. The system calculates the gross future predicted demand, using historic demand data and future forecasting of product demand. Table 1 shows the comparison between the features of designed and standard available MRP II system along with differences w.r.t LEs and SMEs which justify the design of bespoke MRP II system.

Table 1: Comparison between Designed Bespoke MRP II and Standard available MRP II

Modules	**Designed Bespoke MRP II**	**Standard Available MRP II**	**Differences of MRP II w.r.t. LE & SME**
Business Planning (BP)	x	✓	No need of BP in SME
Sales & Operations Planning (S&OP)	x	✓	No need of S&OP in SME
Demand Management (DM)	✓	✓	Both SME and LE require
Production Planning (PP)	✓	✓	Both SME and LE require
Resources Planning (RP)	✓	✓	Both SME and LE require
Master Production Scheduling (MPS)	✓	✓	Both SME and LE require
Rough Cut Capacity Planning (RCCP)	✓	✓	Both SME and LE require
Sales Order Processing	✓	✓	Both SME and LE require
Material Requirements Planning (MRP)	x	✓	No need in SME particularly dealing with tool reclamation

Modules	Designed Bespoke MRP II	Standard Available MRP II	Differences of MRP II w.r.t. LE & SME
Capacity Requirement Planning (CRP)	✓	✓	Both SME and LE require
Bill of Materials (BOM)	x	✓	No need in SME particularly dealing with tool reclamation
Inventory Records (IR)	✓	✓	Both SME and LE require
Shop Floor Control (SFC)	✓	✓	Both SME and LE require

Step Two: Developed Bespoke MRP II Database

An important stage of this research study was to use software that should result in cost minimization, minimal operating complexity and easy access. Currently, the considered SME is using Equinox software for the production side that operates by three workers and Opera software for the account details that operates by two operators. This research study preferred MS Access technology over another softwares available in markets for the development of bespoke MRP II system database, which led to remarkable cost minimization along with the reduction in labour as discussed in Table 2 and Table 3.

Table 2: Effect of Present Softwares used by SME

Software	Average Purchasing Cost (License + Update charges)	Number of Operators required	Advantage
Equinox	3500 £	Three	Production Control
Pegasus Opera	400 £	Two	Finance & Accounts
Total	**3900** £	**Five**	

Table 3: Effect of Developed MRP II database for SME

Software	Average Purchasing Cost (License + Update charges)	Number of Operators required	Advantage
MS Access 2007	100 £	One	Production Control + Finance & Accounts
Total	**100** £	**One**	

The overall MRP II database structure in general is now discussed in this section. The developed database consists of ten major files, which are all related to one another through the one-to-many (1:∞) referential integrity rule of RDBMS. These databases with their names and brief functions are summarized in Table 4. MS Access ensures proper data maintenance and prevents duplication or the wrong entry of data. After defining the tables, the forms and reports were made possible to develop a human interface database system with the help of VBA, SQL and Macros applications. Figure 5 illustrates that how the design of bespoke MRP II system was transformed into MRP II database in MS Access.

Table 4: Structure of MRP II Database Tables

File Name	Number of Tables Built	File Purpose
Shop Floor Capacity	1	Information regarding available resources
Route File	1	Information regarding product completion
Products or Item Master File	1	Information related to all repaired products
Order Details	1	Customer ID and Product quantity details
Payments	1	Payment related information
Payment Method	1	Payment Procedure
Orders	1	Shows work order ID of Customer and Order due date
Shipment Methods	1	Method of Shipping an order
Customers	1	Customer related information
Employees	1	Employees name who serves an order

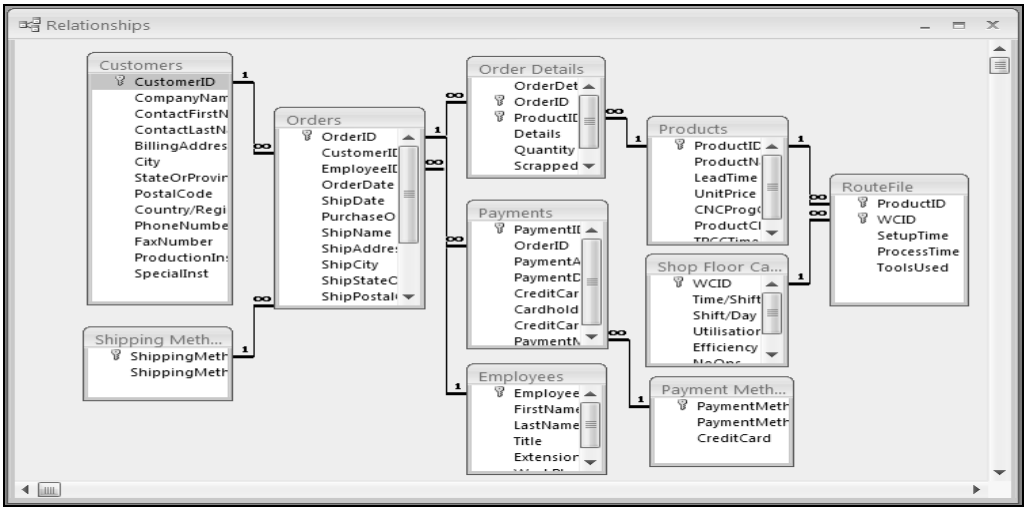

Figure 5: Relationships between MRP II Database Tables in MS Access

Step Three: Implementation and Results of the Bespoke MRP II Database System

The developed MRP II system was implemented within the existing manufacturing environment of SME. This database implementation resulted in time, labour reduction, and cost saving. Its implementation replaces five operators with a single operator who manages both production and accounting sides with efficacy and ease. Furthermore, two softwares Eqinox and Opera are replaced by single MS Access software. This research study also noticed that developed database was implemented successfully because it was operated very effectively by many users with minimal qualification, time, and training in comparison to Equinox and Opera softwares where operator requires special training. These were the major differences between softwares available in markets and newly developed MRP II. It is self-explanatory to the user. As an example, a first screen that appears is the Switchboard as shown in Figure 6 and Figure 7. Once the operator starts MRP II database, the user finds four friendly command buttons on the main Switchboard Form which guide the user.

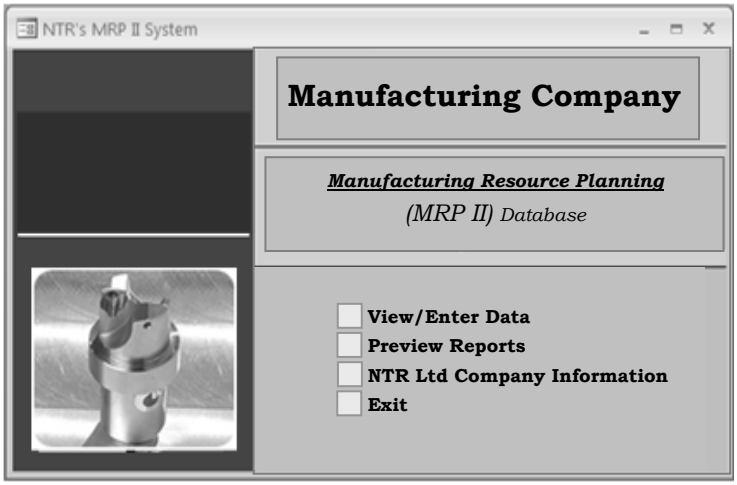

Figure 6: The "Switchboard" Form

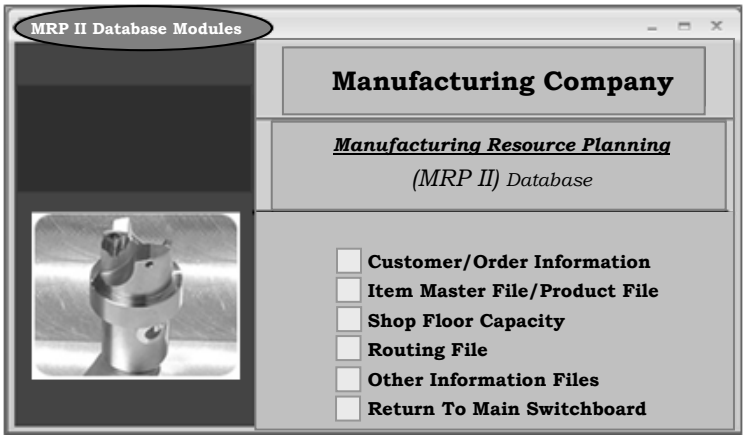

Figure 7: The "MRP II's Database Modules" Form

During implementation of MRP II database, it was also judged how much information can be obtained through the reports. This research study also makes sure that maximum information should be available to top management through key reports which was not possible in existing databases of SME Company. As an example, CNC program codes, overall batch production time, and special instructions information were not available to workers and managers in the reports of Equinox except lead time. For this purpose, total six reports are made as shown in Table 5 and two of which major are shown in Figures 8 and 9.

Table 5: Summary of Six key Reports of MRP II Systems

Report Name	Purpose	Type of Report
Customers	To show customers information	Data View
Invoice	To generate invoice for customer	Calculations
Products	Product manufacturing information	Calculations
Shop Floor Capacity	To show information of shop floor resources	Data View
Total Customer's Sale	To show the gross sale of customer and grand total sale	Calculations
Work Order Card	To show batch completion time with product repair information	Calculations

Database Reports

PRODUCT MANUFACTURING INFORMATION

Product ID 1.12 — *TPCC Time* 37.49
Product Name 3232-22MM OU TIL DE TORNAGE — *Unit Price* £31.35
Class S

WCID	Setup Time	Process Time	Tools Used
A9b-Booking off SPL	0	4	
A9a-Final Inspection SPL	0	3	Torque screws, etcher, hardness tester, pre-setter, gauge, shadow graphs, taps
A8-Gblast Spray SPL	0	3.5	Shot blast machine and shot blast material: Calcium Carbonate
A7-Fitting 1 SPL	0	6.3	Grinding machine, taps, files, Presetter, fixtures, vice, Vertical Milling machine
A6-Milling 2 SPL	0	0	
A6-Milling 1 SPL	2.13	7.03	Manual machine, cutting tool, Spares (insert, shims, boot, clamps, pin)
A5-TIG Welding SPL	0.2	6	TIG Weld, filler rod (SD 3: High Carbon rod), wire brush, fixtures, electrode.
A4-Strip Down SPL	0	3.33	Grinding machine, Angle Grinder, Burrs, Punch, Shot blast machine.
A3-Booking In SPL	0	2	
A2-Pre Inspection SPL	0	0	
A1-Goods In SPL	0	0	
Sum	2.33	35.16	
Total PCC Time	37.49		

Figure 8: The "Products" Manufacturing Report

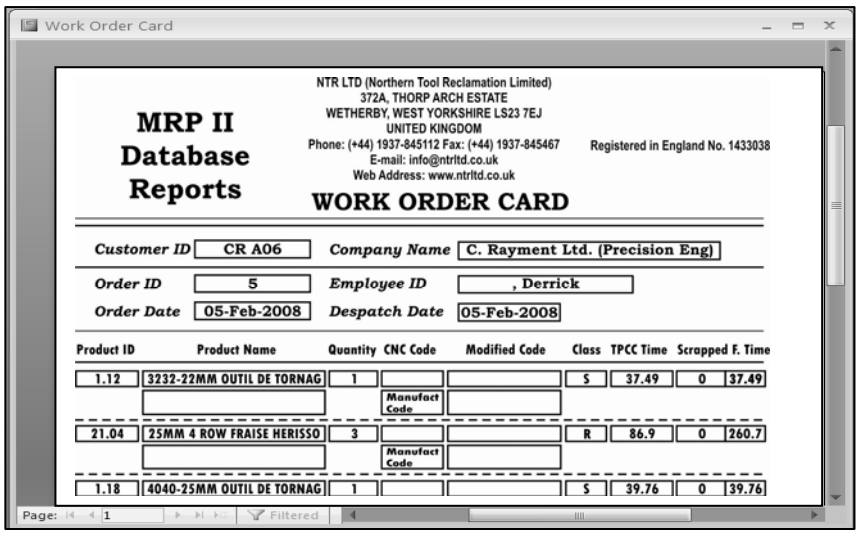

Figure 9: The "Work Order Card"

The developed MRP II database was tested for two months in working environment and effective positive results were obtained after performing pugh's evaluation analysis for the developed MRP II database with the existing softwares of SME. Pugh's evaluation is shown in Tables 6 and 7.

Table 6: Rating evaluation for successful implementation

Performance Rating in Database	Rating Symbol
Satisfactory (Reference)	S
Better than satisfactory	+
Worse than satisfactory	-

Table 7: Pugh's evaluation for the developed MRP II database

Successful Database Implementation Criteria	Equinox Database	Opera Database	Bespoke MRP II Database
Production lines status reports	+	S	+
Product completion time reports	S	-	S
Accumulative batch production	+	+	-
Maximum information through reports	S	-	+
Customer order reports	+	S	+
Customer previous accounts reports	-	+	-
Company account details report	-	S	+
Minimum operators	S	S	+
Minimum software purchasing cost	-	S	+
Access flexibility	-	-	+
Easy maintenance	S	+	S
User friendly	+	S	+
Minimal training	S	+	+
Easy to operate	S	-	+
Easy to install	+	S	+
Easy to learn	-	-	+
Overall performance	+	S	+
Compact	S	S	S
Reliable	+	+	+
$\sum +$	7	5	14
$\sum -$	5	5	2
$\sum S$	7	9	3
Total $\{(\sum +) - (\sum -)\}$	**3**	**0**	**12**
Rank	**2nd**	**3rd**	**1st**

CONCLUSIONS

A number of conclusions are drawn by looking at the development of one of MPC systems with MS Access. The modifications in MRP II system are possible by working on the key modules such as DM, RCCP, MPS, BOM, MRP, CRP, and SFC. According to many researchers, though an advance systems such as ERP, OPT, and JIT are available with more benefits than MRP II but this system is possible to implement with the help of MS Access in small or large companies within acceptable range of resources and in terms of cost effectiveness. The current work is also a solid contribution towards a modified form of MRP II system.

In recent years, many SMEs have realized the importance of MPC systems, like the MRP II, as a way forward to achieve success and gain a competitive advantage. However many SME's are inhibited from implementing these due to factors like the myriads of MRPII systems existing in the market place, the high purchase costs and the final implementation. The importance of this research study is that it has shown how a ***lean and bespoke*** MRPII system, focusing on the manufacturing environment existing within the SME, can be designed in-house, at a very low cost. The development statistics show that the lean MRPII System was designed, developed and implemented by one employee over a period of two months, using standard software openly available. The present manufacturing environment of the SME company can be handled effectively by the current lean MRP II system, which is controlled through a single operator.

Due to limited resources and time, the current study was unable to fulfil the task of accumulative scheduling. The accumulative scheduling system should be introduced in the MRP II system database due to which the company would be able to know how many batches are possible in a day for processing and which batches to schedule for next day. Therefore, it is strongly recommended that the current study should be continued in designing and on development side for upcoming years due to which an advance, reliable, and flexible MRP II system without any hindrances will be possible.

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Nomenclature

Terms	*Abbreviations*
Bill of Material	BOM
Business Planning	BP
Capacity Requirements Planning	CRP
Computer Numerical Control	CNC
Database Management System	DBMS
Demand Management	DM
Inventory Records	IR
Large Enterprises	LEs
Manufacturing Planning & Control	MPC
Manufacturing Resource Planning	MRP II
Master Production Scheduling	MPS
Material Requirements Planning	MRP
Microsoft	MS
Production Planning	PP
Resource Planning	RP
Relational Database Language	RDL
Rough Cut Capacity Planning	RCCP
Sales & Operation Planning	S&OP
Shop Floor Control	SFC
Small & Medium Enterprises	SMEs
Structured Query Language	SQL
Visual Basic for Application	VBA