AN INTEGRATION OF MANUFACTURING RESOURCE PLANNING AND JOB SHOP SCHEDULING

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Abstract

Many manufacturing industries are specialized in various operations in making varieties of components. It has various batches for production of different component based on the size, material and shape. This paper proposes a framework model for integration of manufacturing resource planning with job shop scheduling. To achieve truly computer integrated manufacturing systems, the integration of employee time tabling and job shop scheduling is essential. Generally Manufacturing resource planning and job shop scheduling are to be considered as too hard and complex production areas. This integrated system consists of two modules. First module provides all the required details of different rolls in integration of manufacturing resource planning and Job shop scheduling to tackle the variability in job durations and machines. Then the second model provides a feasible production schedule for job-shop scheduling problem. Heuristics algorithm is used to find an optimum schedule with minimizing the resource cost as well as refine the makespan results. In the job shop scheduling problem n jobs have to be processed on m different machines. Each job consists of a several sequence of tasks that have to be processed during an uninterrupted time period of a fixed length on a given machine. This integrated system is menu driven and very user friendly. This system is designed for companies with multiple warehouse locations who need quick and easy access to important production information such as available stock levels for production and sales. This system is also designed to make the production process more efficient, improve the customer service and satisfactions. Generally the entire system will be used to find the test service reports quickly. It allows a large amount of data to be securely backed up with makespan and cost effective to make the process easily. The application aims to realize an integrated system that has rapid response to changing customer requirements and capability to integrate heterogeneous manufacturing facilities. This proposed system developed in scholastic search way to bring optimized results in stipulated time with respect to optimum schedule and also tested in two different Manufacturing Industries using Visual Basic .NET as the front end and MYSQL as the back end tool. The system been tested with various sets of input data and has been found working properly.

Key words: Job Shop Scheduling. Manufacturing Resource planning, Integration, Heuristics algorithm, Shuffled Frog Leaping Algorithm

I. INTRODUCTION

To develop a window based application which helps the manufacturing industry to attain best procurement practices and supports the operation of procurement activity at the optimum total cost in the correct quality at the correct time and location for express gain by signing a contract. Contract means formal legal agreement for the supply of goods and services including the request for proposal, formal quotation, proposal evaluation, acceptance of a tender. The system has been designed to store the data needed for the above mentioned scheme and meets all the required computations. Specifically this covers the assembly of spare parts and replacements, quality control of purchasing and ordering such parts and the standards involved in ordering and warehousing the said parts. The level of uncertainty and risk is relatively high during initial phases of the production initiation and planning. It starts falling significantly while executing as the picture becomes clearer due to progressive planning elaboration. And also based on the amount of stock, if measured in terms of resources deployed and the financial commitment is relatively low during initial phases but it rises rapidly during execution.

New manufacturing technologies are emerging every day, pushing the bounds of possible and redefining the world around us. This is especially true in the world of computing where much work goes into the design and development of new planning systems, tools, and software packages. This led to the development of various process analysis and manufacturing software packages. Because of that many of the complicated engineering problems can be solved in a much easier way. Many of these packages use the heuristic method for solving the problems. So in the recent days, it is very simple to carry out the study of various complex problems subjected to more complicated constrained loads. Optimization techniques have found its own place in these packages due to the automatic formulation technique adopted in it. It needs only the geometric, Production process planning, cost and material properties from the user for solving the problems. Now, computer packages are used for the purpose of design using the optimization technique. Optimization is a design technique in which the best design solution for a problem is seeded using multiple execution and comparison of analysis results. Optimization is carried out for one or more responses acted upon by various constraints.

In this paper we propose a model of integrated manufacturing resource planning and job shop scheduling that takes account of resources with no notable remarks or interruption of the processed task, an employee may perform several tasks simultaneously during a shift, at each shift a set of activities has to be performed and each activity requires a specific number of manufacturing resources. To develop a window based application which helps the organization to attain best procurement practices and supports the operation of procurement activity at the optimum total cost in the correct quality at the correct time and location for express gain by signing a contract. In manufacturing systems, the decisions related to resources availability and the decisions related to scheduling jobs on the machines are often made in a sequential process. The objective of job scheduling is to find the optimum schedule to minimize the costs whereas the objective of manufacturing resource planning is to maximize customer's satisfaction and to minimize the risk factor. In many manufacturing industries resource planning is first developed and then the scheduling of jobs must take based on the resources and employee availability or first the scheduling of jobs is done then the resource planning will be established based on the machine availability and loads. An integrated system is used to improve the production costs, minimizing labor costs, maximizing completion time and increase the customer's satisfaction. However, the resulting of the problem has generally been considered as too complex to be used in practical situations.

The integration frame work of manufacturing resource with process planning model considered three dimensions of planning, The Benefit of the system include correction with geometric model, reduced search space and alternate plan generation [1].

We propose to integrate the two problems by associating each job on machine and a set of activities performed by the employees based on the manufacturing resource availability. The system has been designed to store the data needed for the above mentioned scheme and meets all the required computations. The application developed in this paper aims to realize an integrated system which has rapid response to changing customers requirements and capability to integrate heterogeneous manufacturing facilities [2]. Generally, The Employee time tabling philosophy is still employed by the majority of manufacturing enterprises for Job Shop Scheduling, process shift planning and production planning [3]. If infeasibility occurs, production management must produce a new master resource planning and production schedule to generate another plan or find alternative sources of production capacity. Finite scheduling is an optimization technique that tries to generate a sequence of operations over a given set of machines with the sole purpose of minimizing some type of shop performance measure like makespan, mean flow time, etc.

The Existing system in Manufacturing and Resource Planning is VISUAL BASIC with MS ACCESS. It is not user friendly. Every time it requires series of commands for performing specific operations. It is time consuming system. Updating of data globally is difficult. File maintenance creates confusion for large purchase requisition. The main drawbacks of the existing system are It did not provide to the need of the management fully, Not user friendly, Programming is too complex, comparatively very slow and Proper coding is not used.

The proposed system solves the drawback of the existing system and works satisfactorily. It has been proposed to computerize the existing system with VB.NET and MYSQL Server. This system gives user friendliness towards performing certain operations. Updating of data and file maintenance is very efficient. The proposed system has both facilities used the old systems, as well as some additional features are added which are user-friendly and more reports are generated. Some of the main features are the system is user – friendly, Processing time is less, Quick response, Accurate calculation, Retrieval of information is easy, Flexible and Security is maintained.

Job shop scheduler is used to generate sequences randomly and allocate the tasks to time intervals on the machines and the aim is to find a schedule that minimizes the overall completion time, which is called the makespan. In the job shop scheduling problem n jobs have to be processed on m different machines. Each job consists of a sequence of tasks that have to be processed during an uninterrupted time period of a fixed length on a given machine. So the maximum of completion times needed for processing all jobs, subject to the constraints that each job has a specified processing order through the machines and that each machine can process at most one job at a time. Gantt chart is used to find the initial sequence and makespan in job shop simulator.

Solving Job Shop scheduling problems with due date constraint to find an optimum sequence is rarely considered. The production planning procedures used in material requirement planning (MRP), manufacturing Resource planning (MRP II) ignored detailed scheduling constraints which are no guarantee that a feasible schedule for existing production plan [4]. Flexible Resources are playing a important role in today's competitive environment [5]. The Improvements in best way can achieved by integrating optimal scheduling with flexible resources. In earlier stage an integrated approach for Production Planning and Scheduling model for Multi-Stage Manufacturing System was proposed. To optimize the flow velocity and potential flow a feasible optimal production plan based on the material flow and inventory flow management was also developed [6].

Bruker [7] and Garey show that the Job shop scheduling is an NP-hard [8] problem. Because of the NP-hard characteristics of job-shop scheduling, it is usually very hard to find its optimal solution, and an optimal solution in the mathematical sense is not always necessary in practices [9]. Researchers turned to search its near-optimal solutions with all kind of heuristic algorithms [10]. Fortunately, the searched near optimal solutions usually meet requirements of practical problems very well. In this work an integrated system is developed and SFL algorithm is also implemented. In earlier research, the job-shop scheduling problem has been extensively studied with the objective of minimizing some functions of the completion times of jobs. Several techniques have been proposed and different heuristics have been designed and developed for solving the minimum makespan problem, the minimum total tardiness problem and so on. SFHM algorithm was used for minimizing mean tardiness and mean flow time multi objective criteria [11].

An effective SFLA was used for minimizing maximum completion time (i.e., makespan) [12]. In this work SFLA and SFHM algorithm are used for solving the scheduling problem to meet due dates in a simple job shop. It is developed to approximately minimize the makespan (maximum completion time) and maximize the customer's satisfactions.

This work focuses on two stages. First stage an integrated system is developed for Manufacturing Resource Planning and Job shop simulator. Second stage is refining the results of makespan with Shuffled frog leaping algorithm. The paper describes how to integrate Resource Planning and job shop scheduling and also this algorithm uses to refine makespan. First, presents the architecture of overall system and second job shop simulator with representation of sequences. Third describes the integration of Employee timetabling with Job Shop Simulator and At Last implementation of Shuffled frog leaping algorithm.

Generally, a feasibility study precedes technical development and project implementation .It evaluates and analysis the potential impact of a proposed project. It also determines the possibility of either improving the existing or develop totally new system. The objective of the feasibility study is not only to solve the problem but also acquire a sense of its scope. During the study the problem the definition is crystallized and aspect of the problem to be included in the system is determined, consequently cost and benefits are essential with greater accuracy at this stage.

Economical feasibility deals about the economical impact faced by the organization to implement a new system, not only hardware and software is considered but also the benefits in the form of reduced costs. This system will certainly be beneficially since there will be a reduction in manual work, and increase in the speed of work and does not need any high cost equipment. The amount of found that the company can pass in the research and development of the system is limited. This can be quantified in terms of volumes of data, trends, frequency of updating, etc. in order to estimate whether the new system will perform adequately or not. As per the request both these software, hardware the proposed system is technically feasible. How they are allocating vehicles in online. Their study carried out to check the technical feasibility. That is the technical requirement of the system.

II. PROBLEM DESCRIPTION

Client uses series of commands for performing specific operations because of complex programming. It did not cater to the need of the management fully. File maintenance creates confusion for large purchase requisition. Updating of data globally is difficult and Contains excessive fields which are not required. Hence errors occur frequently. In the existing system suppliers are predetermined manually by the procuring company but in the developed system it has to be done by the system that is suppliers are ranked by the system based on payment details.

Thermal Energy Systems is a company, which has specialized operations in making finned tubes and heat exchangers. These products are made out of different materials and used in various applications. The tube is designed to be universal. All tubes are designed around specific requirements to ensure that multiple tube sections will fit together. The ends of the tube can either be smooth or grooved (similar to a screw). Additionally, there are several different tube sizes ranging from very small (one-fourth inch) to very large (10 feet). The system is menu driven and very user friendly. The system been tested with various sets of input data and has been found working properly.

Normally, Integration of Manufacturing Resources planning based on the following knowledge areas such as human Resource, cost, Scope, Risk, Time, Quality, Material Purchasing, Supplier, Procurement and Communications [13].

A. Constraints for framing manufacturing Resources

The traditional value of resource constraints in the manufacturing production unit includes scope baseline, Schedule baseline and cost baseline. In all industries the quality of product is inherent part of the resource scope baseline. But meeting the above three resource constraints are managing in risk environment for opportunities with optimum utilization of resources. The process of developing a new planning system that formally authorizes a planning or module phase and documenting initial resource requirements with competencies that satisfy the customer's needs and expectations.

B. Integrated System Implementation

Integration of all the manufacturing resource areas throughout entire production with the help of various appropriate applicable processes groups are shown in figure. The main system is a group of related manufacturing resources in a coordinated way to obtain benefits and control, not available from managing them individually. Integrated system is a collection of all production and manufacturing that are grouped together to facilitate effective planning of that work to meet strategic manufacturing objectives. The integration of manufacturing resource planning with Job shop scheduling implements their objectives based on specific goals. Maximize the valve of profit by examining processes or methods for inclusion and timely exclusion if not meeting the process objectives.

Implementation of integrated system is the important stage where theoretical design is turned to a working system. Two major factors for the implementation are testing the system and training the user. Since the existing system involves manual operations the new system is implemented in parallel with the existing. This was done to build users confidence about the system, but also to check the efficiency of the developed system.

The traditional term of constraints in the context of integrated system includes scope, nature of the work, schedule baseline and cost baseline. Here the quality of the resource planning is inherent part of scope baseline. But the extended constraints discusses one step further and states meeting these baselines with constraint is managing in risk environment for opportunities with optimum utilization of manufacturing resources as shown in Fig. 1.

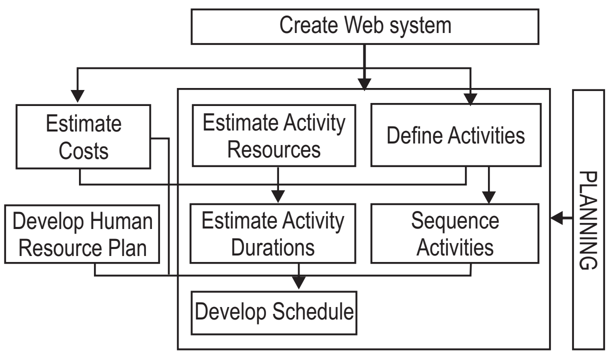

Fig. 1. Integrated Manufacturing Resource System Model

There are several methods for handling the implementation and the consequent from the old to new computerization system. The most secure method for conversation from the old to new system into run the old and new system in parallel. In this approach, a person may operate in the manual older processing system as well as start operating the new computerization system. This method offers high security, because even if there is a flaw in the computerization system, we can depend upon the manual system. However, the cost for maintaining two systems in parallel is very high. This out weights its benefits.

Another commonly method is a direct cutover from the existing manual system to the computerization system. The change may be within a week or within a day. There are no parallel activities. However, there is no remedy in case of a problem. This strategy requires careful planning. In any case, every system must have the ability of overcoming every possible threat. The security that is to be provided will have to decide by the system analyst. The system has a user level security. Every user will be member of a specific group. This group will be granted specific rights.

C. Structure Influence

Structure influence on manufacturing resource planning based on the resources availability. The entire resource objectives are as shown in the following Table 1

Table 1. Resources Availability

Characteristics	Resource Availability
Functional	Minimum or none
Weak unit	Limited
Balanced unit	Low to moderate
Strong unit	Moderate to High
Projected	High

D. Integrated System Development Process

Integrated system is to be developed by the process of identifying the specific actions performed to produce the product deliverables. First stage is developing the manufacturing resource flow process and second stage is preparation of master scheduling plan as shown in fig. 2

The resource planning is a form of progressive elaboration planning where the production work to be accomplished in the near module is planned in detailed way that the low level of the integrated system, while far in the future plan and components that are needed are relatively very high-level. When insufficient information n of the resources are available, while decomposing the branch of integrated system and also new high level master production schedule for the same component may be developed. The master schedule activities are sequenced with logic relationship between the scheduling networks.

An identification and description of the all resources and quantities of resources required for each schedule activity based on the production due dates and also the amount of detail and the level of specificity of the resource requirement descriptions can vary by different application areas. The resource requirement documentation for each schedule activity can include the basis estimation for each resource, constraint assumptions made in determining which types of resources are applied, their availability and quantity.

III. OVERALL SYSTEM ARCHITECTURE

The operational feasibility is a measure of how well a proposed system solves the problems, and takes advantage of the opportunities identified during scope definition and how be involved in the planning, Executing, Initiating, Monitoring, Controlling and development of the system as shown in Fig. 3. This system will certainly by support since it produce good result it satisfies the requirements identified in the requirements analysis phase of system development.

User should and reduces the manual work. The level of acceptance by the user socially depends on the methods that are employed to educate the user about the system and to make him families with it. This project will certainly be beneficially since there will be a reduction in manual work, and increase in the speed of work and does not need any high cost equipment. In the existing system suppliers are predetermined manually by the procuring company but in the developed system it has to be done by the system that is suppliers are ranked by the system based on payment details.

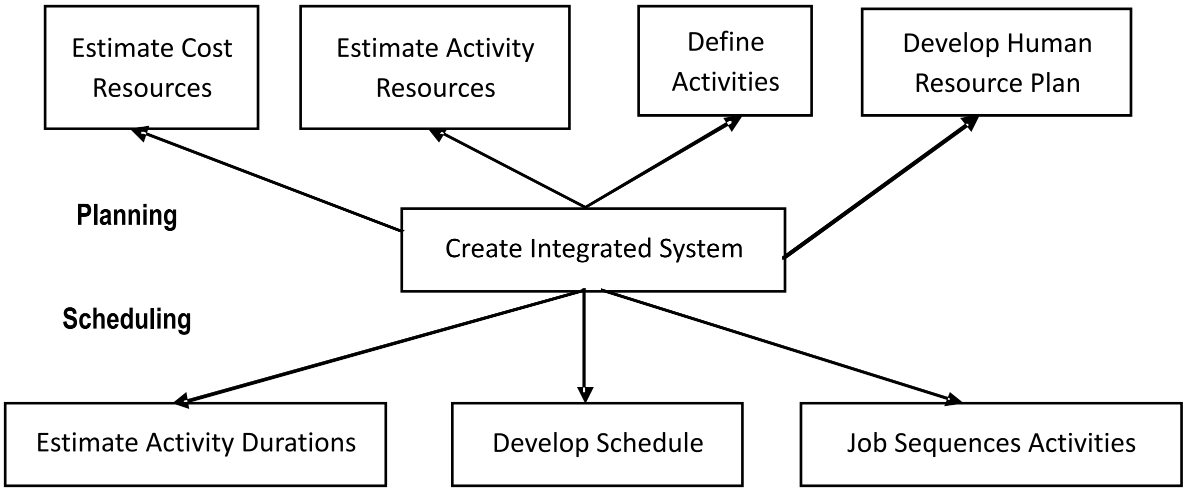

Fig. 2. Manufacturing Resources based on master Production Areas

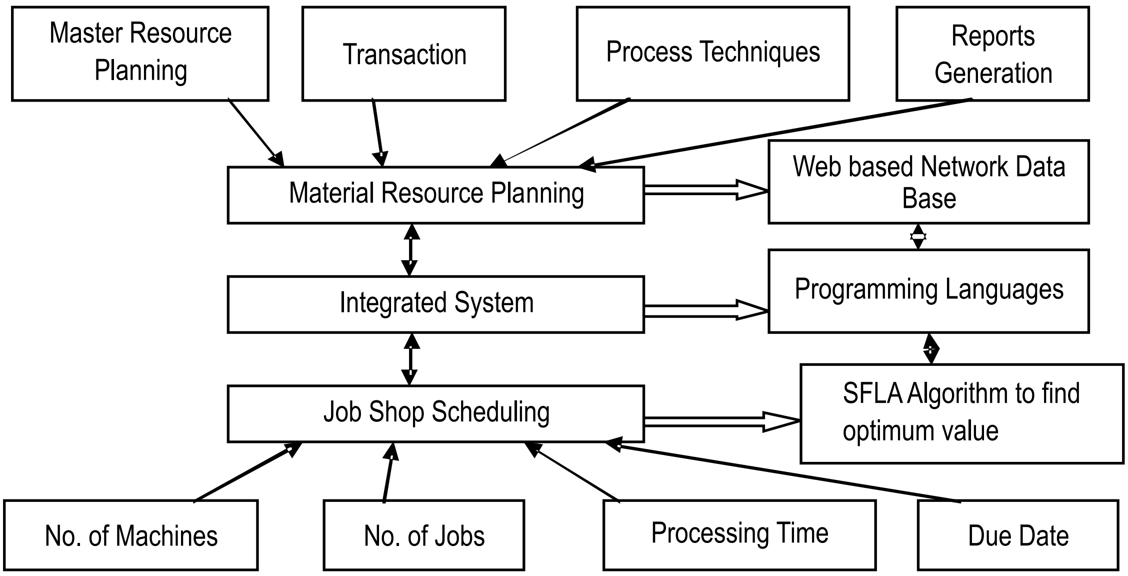

Fig. 3. Controlling and development of the Integrated system

Table 2. Levels of the Planned Work and Resource Input and Output

Levels	Planned Work	Input	Output
LEVEL 1	Manufacturing Resource Planning	Admin	Admin
		Supplier	Supplier
		Unit	Unit
		Stock	Stock
LEVEL 2	Manufacturing Resource Planning Process	Material Receipt Details	Receipt Reports
		Material Requirement Details	Requirement Reports
		Standard Mix Details	Standard Mix Reports
		Batch Details	Batch Reports

A. Input Data Design For Manufacturing Resource Planning

The collection of Input data is the most expensive part of the system, in terms of both the equipment used and the point of contact for the users with the system. It is prone to error, if the data is going into the system is incorrect, and then the processing and output will magnify these errors. So, the objectives of input design are to produce cost effective method of input, to achieve good accuracy, to ensure that input is acceptable and understood by the user. In this project, data collected from user at different levels are stored in the database. Tender Invitation Process facilitates to collect the data regarding the tender details and which are stored and retrieved in the Quotation proposal for further analysis. Compare Quotation will analyze the input data received in the previous stages and will produce the result.

Accuracy of input data will fetch the result in successful and erroneous status. Based on the given input management decision on the specific quotation shall be analyzed and reviewed as and when required. Input design play a vital role in the whole system and it should be flexible and user friendly. All the levels of planned work and their input and output details are shown in Table 2 and Fig. 4

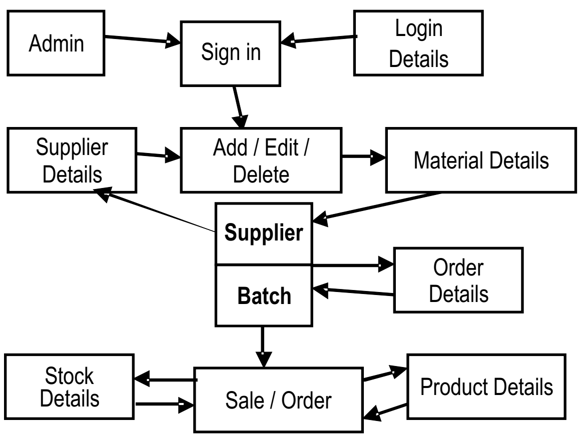

Fig. 4. Final Level of the Planned Work

B. Process Design Analysis

A quality output is one, which meets the requirements of the end user and presents the information clearly. In the system results of processing are communicated to the users and others through outputs. In the output design it is determined how the information is to be displayed for immediate need and also the hard copy output.

It is most important and direct source information to the user. Efficient and intelligent output design improves the system's relationship and the helps the user in decision making.

The application output design is customized based on users input, which will generate the data depending on the users requirements. The accessibility of the output design is secured in the system with user authentication and rights. Reports can be generated in various formats such as PDF, EXCEL, MS WORD etc. these form of soft copy reports facilitates the fastest communication by sending through mail which reduces the time and transportation charges.

C. Manufacturing Resource Planning Analysis

Testing is a valid to the success of the system. This phase the follows the coding phase. Testing takes logical assumption in a consideration. If all parts of the system are properly working the goals will be automatically achieved. Software testing is important element of software quality assurance and represents the ultimate review of specification design and coding. In this testing is providing the good application to the software product to improve the quality. Testing is a process of executing a program with the intent of finding an error. Unit testing comprises the set of tests performed by an individual programmer.

In this project the data was separately prepared and tested for all sub modules of the system under all relevant conditions. This process helps in finding bugs if any in the software there by rectification in modules each time and error is observed. The validation testing is performed for all the data in the system. The data are completely validated according to the company's request and requirement. The validation testing is performed for material code where code should contain twelve digits and it is being checked whether it meets the criteria of twelve digits entry. Supplier code should be four digits where first two digits should represent the city name and next should be serial number. Email address should be case sensitive. Purchase officer code should be single character, where no two purchase officers should contain same character. Live data was loaded and all the transaction and output of the system were checked and verified. Manufacturing Resource Planning processes are shown in Fig. 5.

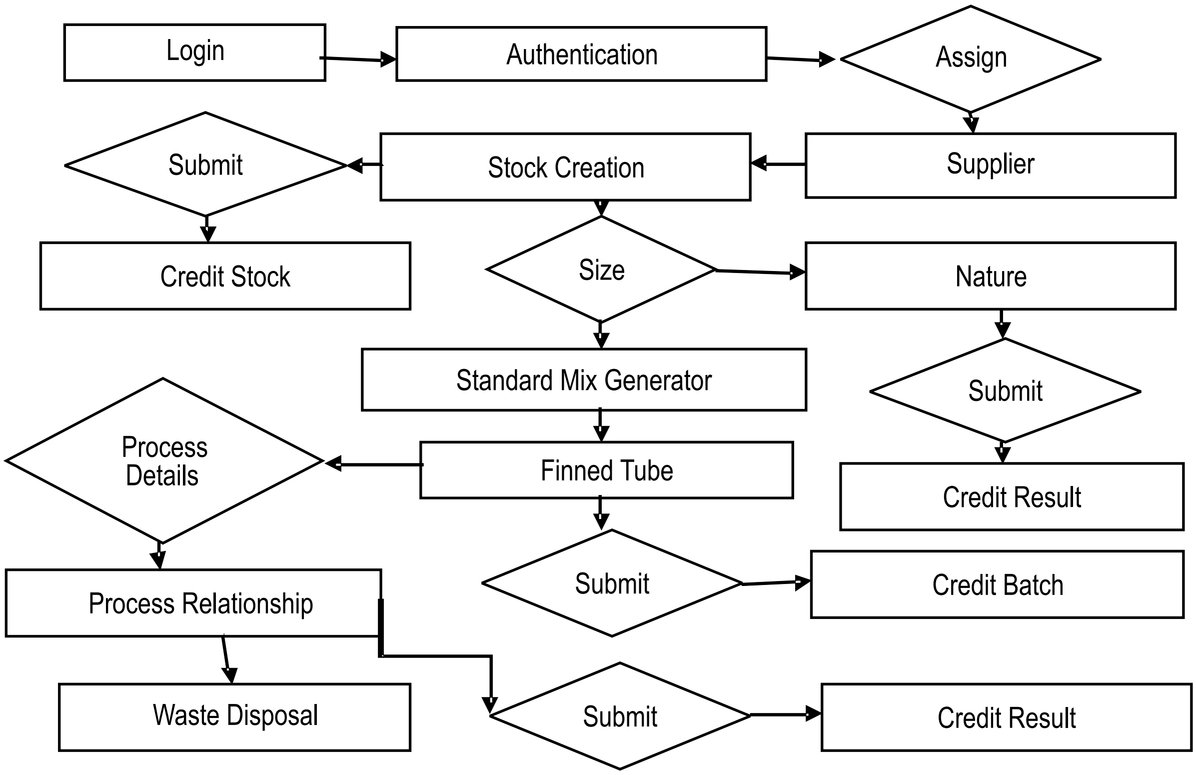

Fig. 5. Resource Planning Processes

D. Integrated System Analysis

The system testing is actually series of different tests whose primary purpose is to fully exercise the computer base system. It is divided into recovery testing and security testing. The recovery testing is a system testing that forces the software to fail in a variety of ways and verifies that the recovery is properly performed. While running this software, if there is no proper connection to the backend, error message will be fired and on debugging this error could be detected and rectified. The security testing is done to verify the protection mechanisms built in, to avoid improper penetration. Database security is ensured by means of restricting the update or delete and insert options and giving only read rights to the users. The database is secured through the "User id" and "Password". Access rights are given to the users. Integration testing is a systematic technique for constructing the program structure while at the same time conducting tests to uncover errors associated with interfacing. The objective is to take unit - tested modules and build a program structure that has been dictated by design. A set of conditions or variables are raised under whether an application or software system is working correctly or not.

Feasibility Modules

This Forward pass is starting at the beginning of integrated system develop early start and early finish dates for each task, processing to end of the network. Early start date is earliest possible point in time an activity can start based on the integrated network logic and any schedule constraints. Early finish date is earliest possible time the activity can finish. The precedent Activities based on resource activities are listed in Table 3.

Table 3. Composition of Precedent Activities

Activity	Duration (Days)	Precedent Activities (finish start)
A	4	-
B	3	A,B
C	9	C with 2 days LEAD,
D	8	C
E	5	D & 2 days LAG with E
F	7	F
G	2	–

E. Software Description

The Existing system in Manufacturing and Resource Planning is VISUAL BASIC with MS ACCESS. It is not user friendly. Every time it requires series of commands for performing specific operations. It is time consuming system. Updating of data globally is difficult. File maintenance creates confusion for large purchase requisition. The main drawbacks of the existing system are It did not provide to the need of the management fully, Not user friendly, Programming is too complex, comparatively very slow and Proper coding is not used.

This Integrated Framework is a managed, type-safe environment for developing and executing applications. Framework manages all aspects of program execution, like, allocation of memory for the storage of data and instructions, granting and denying permissions to the application, managing execution of the application and reallocation of memory for resources that are not needed. Some reasons for building applications using in this Framework are Improved Reliability, Increased Performance, Developer Productivity, Powerful Security, Integration with existing Systems, Ease of Deployment, Mobility Support, XML Web service Support, Support for over 20 Programming Languages and Flexible data access.

IV. GENERATION OF JOB SHOP SCHEDULING MODULE

The job shop simulator is developed using the object-oriented paradigm to model the job shop. Its various components such as Place, Transition and Tokens are developed as generic objects in the simulator and they serve as the building blocks for the job shop model. In addition, each of them are further categorized into different types and having different functions. This model tries to finish five jobs in as short a time as possible. Each job has five operations, and each operation must run on all five machines with a certain time period. Job Shop simulator uses the order solving method to shuffle the values in the matrix tree which contains number of machines and processing times to come up with the maximum completion time (makepan).

A. Representation of solution Seed (Sequences) in Job Shop Simulator

Consider the five-job five-machine problem as shown in Fig.6 and Fig.7. Suppose a seed sequence is given as [5, 4, 3, 2, 1], where 1 stands for job j1, 2 for job j2, 3 for job j3, 4 for job j4 and 5 for job j5. This sequence has to be operated five times in the same order because each job has three operations. So that the initial seed as the following format [5 4 3 2 1 5 4 3 2 1 5 4 3 2 1 5 4 3 2 1 5 4 3 2 1].

Processing Time (Sec)					
MACHINE					
JOB	**1**	**2**	**3**	**4**	**5**
J1	64	7	74	54	80
J2	66	69	70	45	45
J3	31	68	60	98	10
J4	85	14	1	76	15
J5	44	18	90	13	91

Fig. 6. Processing Time Sequence

MACHINE SEQUENCE					
JOB	**1**	**2**	**3**	**4**	**5**
J1	m1	m2	m3	m4	m5
J2	m1	m3	m4	m5	m1
J3	m3	m4	m5	m1	m2
J4	m2	m5	m1	m4	m3
J5	m5	m1	m2	m3	m1

Fig. 7. Machine Sequence

There are three 2s in the seed, which stands for the three operations of job j2. The first 2 corresponds to the first operation of job j2 which will be processed on machine 1, the second 2 corresponds to the second operation of job j2 which will be processed on machine 3, and the third 2 corresponds to the third operation of job j2 which will be processed on machine 2. We can see that all operations for job j2 are given the same symbol 2 and then interpreted according to their orders of occurrence in the sequence of this seed. This concept is used to find the makespan for the sequences of the problems where the generated seed (job sequence) is operated equal to the number of machines represented in the particular problem.

V. COMMUNICATION BETWEEN MANUFACTURING RESOURCE PLANNING ANDS OF JOB SHOP SCHEDULING

Based on above analysis and design, a complete system has been successfully developed and tested.

The Excel solver is used as platform of the application. The job shop simulator is used to find the sequence and Gantt chart is used to calculate the makespan. The experiment shows that the integrated system can rapidly respond to Customers order. On the other hand, the Manufacturing resource planning system can effectively collaborate with the Job Shop scheduling simulator to meet requirement of production tasks.

After establishing Manufacturing Resource Planning, the system needs to send the daily planned order to the job shop Scheduler to simulate the optimum result with makespan. In addition, because customers may add, modify orders with web server at any time; the computing results of integrated system should be updated to reflect the changes of customer orders. Once the customers add or modify orders, this monitoring system will invoke the manufacturing resource planning to update the resource available data automatically. Then Resource planning system initiates a client object that communicates with server object residing in the job shop system to send jobs for processing. When order is completed, the client residing in the job shop will communicate with server residing in resource system to return finished jobs to system database develop module. Then the server residing in integrated system sends relevant data to database or other objects.

A. Solution Methodologies

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VI. HEURISTIC ALGORITHM

The heuristic algorithms were employed for various engineering application problems due to their robustness and convergence to global optima. Heuristic method of learning involves discovery and problem solving using reasoning and past experience. An approach without formal guarantee of performance can be considered a “heuristic”. These heuristic approaches are used in practical situation when no better methods are available. The following section deals with the various heuristic approaches like Artificial Intelligence, Bottleneck based heuristics, Local search approaches, Meta Heuristics and Hybrid Approaches in earlier research work [14].

A. Shuffled Frog Leaping Algorithm

Eusuff et al. proposed a new meta-heuristic algorithm called Shuffled Frog Leaping Algorithm for solving scheduling problems with discrete decision variables. SFLA is a population-based cooperative search metaphor combining the benefits of the genetic-based memetic algorithm and the social behavior based particle swarm optimization Inspired by natural memetics [15], Muzaffar Eusuff and Lansey described the algorithm through observing, imitating, and modeling the behavior of frogs searching for food placed on separate stones haphazardly positioned in a pond [12].

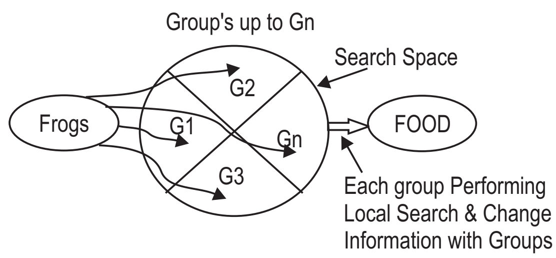

Fig. 8 Global Exchange Flow of SFLA

SFLA has been tested on a large number of combinatorial problems and found to be efficient in finding global solutions [16]. The SFLA is a population-based cooperative search metaphor inspired by natural memetics and consists of a frog leaping rule for local search and a memetic shuffling rule for global information exchange as shown in Fig. 8.

The SFLA comprises a set of interacting virtual population of frogs partitioned into different groups (memeplex), referred to as memeplex, searching for food. The algorithm functions simultaneously as an independent local search in each memeplex. Furthermore, the SFLA compares favorably with the Genetic Algorithm, the Ant Colony Optimization, and the Particle Swarm Optimization in terms of time processing [17].

VII. IMPLEMENTATION OF SHUFFLED FROG LEAPING ALGORITHM

SFLA for solving the JSS problem with minimizing total holding cost and makespan criterion are proposed by population initialization, partitioning scheme, memetic evolution process, shuffling process, and a local search. SFLA was combination of memetic Algorithm and Particle Swarm Optimization. It has been performed from memetic evolution of a group of frogs when seeking for food. The initial population of frogs was partitioned into groups or subsets called “memeplex” and the number of frogs in each subset was equal.

The SFLA was follows two search techniques (a) local search and (b) global information exchange. Based on local search to reach the makespan, the frogs in each subset improve their positions to have more foods. After local search, obtained information based on Global information exchange between each subset was compared to other to produce best sequence way of schedule. Each operation is decided by meeting pre-specified due dates and minimizing objective function. Initial population of sequence generated randomly by increasing order and selected sequence divided into number of meme lexes.

A. Local Search Procedure

The division is done with the high level frog (column sequence) arranged in first memeplex, second one arranged in second memeplex, the last frog to the last memeplex and repeated frog back to the next order memeplex. Fitness function evaluated within the limits that the memeplex are infeasible.

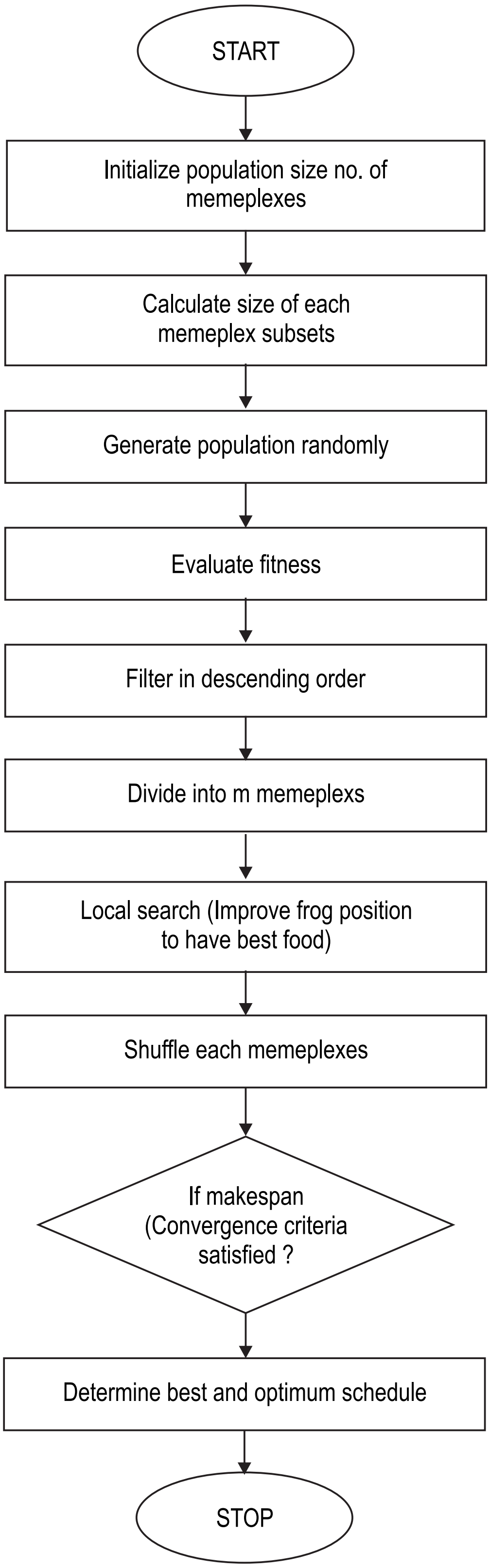

Fig. 9. Shuffled Frog Leaping Algorithm

B. Global Information Exchange Procedure

Table 4. Manufacturing Resource Planning Modules and Phases

Phases	Manufacturing Resource Planning		
I	Master Resource Planning	Material Issued	Note
II	Transation	Materal Receipt Note and Material	Requirement Alarm
III	Process Techniques	Batch Creation	Standard Mix Generator, Process Relationship, Output Control Record: Finished Goods and Waste Disposal
IV	Reports Generation	List of Suppliers	List of Stock, List of Material receipt, List of Requirement, Standard Mix Summary, Batch Summary, Process Relationship Summary, Process Efficiency Summary and Waste Summary

The best frog memeplex values were identified each subset was compared to each other to produce best sequence way of schedule. For each iteration the frogs with the best fitness and worst fitness were identified and also the frog with the makespan schedule was identified. Finally, if the convergence criteria are not satisfied the position of the worst frog for the memeplex is adjusted and new subsets of memeplex will be created for the next iteration. Implementation of the Shuffled Frog Leaping Algorithm is shown in Fig.9

VIII. INDUSTRIAL EXAMPLE PROBLEM SOLUTION

Orders received from the customer as per production plan then those manufacturing resources are identified in workstations for completing production tasks. Job shop scheduler will generate optimal schedule.

A. Manufacturing Resource Planning Generator

The Manufacturing Resource planning module contains the following module Phases are shown in Table 4.

a. Material Issued Note

It is a module which store the information about the raw materials issued to production. This form will have a control over the raw material movement.

b. Production Planning

It is pre budgeted production planning for matching the demand with supply. In this module, we can analysis the demanded sales quantity and required production units for sales and required raw material for production units.

c. Material Requirement Alarm

It is material requirement note which will give a notification when raw material reach its re order level. i.e raw material needs to be ordered for production process.

d. Batch Creation

It is a set of production process. Every batch has different material mix and consumption, this module create a batch for every production process.

e. Standard Mix Generator

Every batch of production requires some standard mix which is predetermined by the experts in concern department. This module facilitates to generate exact mix for given or proposed output quantities. At the time of production, site engineer may use this mix standard to produce effective output from the process.

f. Process Relationships

It is a production technique which combines all the steps in the manufacturing. In this module, all the process related to manufacture of pipes have been updated and consolidated. This module consist all the information about the particular range of pipes such as dimension, mix, size, perception, thickness measurement and quality standards.

g. Output Control Record and Finished Goods

It is a note which records finished goods movement. All the produced (finished goods) quantities have to be transmitted from factory to warehouse, for which we need some degree of control over movement. This module stores all the information in this regard such as no of quantity, lot size, warehouse, and inspection details.

h. Waste Disposals

Waste, can be generated from the production process. Every factory or company should dispose their wastes with environmental care. This module helps the factory/company to have better control on waste disposal portion, records all the information regarding the disposal.

i. Architecture Reports

This module will give all Management required reports as well as miscellaneous reports. The login information contains many modules like, Admin, Transactions, Techniques and Overhead reports are shown in Fig. 10. Stock Creation and unit of measure based on the resource variables are shown in Fig.11. Resource processes and Process efficiency analysis are shown in Fig.12. Finally Material Requirement Alarm and Material Receipt Note with field names and control codes are shown in Fig. 13.

Login Form				
User Name				
Password				
Branch				
Main Screen				
Admin	**Transaction**	**Techniques**	**Overhead**	**Reports**
Admin Reg	Material Receipt Note	Standard Mix Generator	Waste Disposal	
Supplier Reg	Material Requirement Alarm	Batch Creation		
Stock creation		Process Relationship		
Unit of measure		Process Efficiency Analysis		

Fig. 10. Base Login Module

Stock Creation, Unit of Measure

Field Name	Control	Variable name	Field Type	Size	Description
Stock code	txt	F - Tube			
Stock name	txt	Finned Tube			
nature	cmb				raw material, finished goods, waste
Length(mts)	txt			6 mts	in case of Finished goods
Diameter(inches)	txt			12 inches	in case of Finished goods
Thickness(mm)	txt			15 mm	in case of Finished goods
under category	txt	Finned Tube			
under sub category	txt		Rigid/Flexible		
Description	txt				about the stock
measurement unit	cmb				
Grade	cmb		AA, BB, AA+, BB+		
Branch					
created_date					
created_by					
IsDeleted					

Fig. 11. Stock Creation and unit of measure

Process Relationship

Field Name	Control	Variable name	Field Type	Size	Description
Process_id	txt				
Product Id	cmb				
Product Name	txt				
Process Details - Grid					
Date of Start					
Date of finish					
Process Name					
Input Kg's /Litre					
Output Qty					
Rejection Qty					
Length(mts)					
Diameter(inches)					
Thickness(mm)					
Inspected By					
Date of Inspection					
IsDeleted					yes or no

Process Efficiency Analysis

Field Name	Control	Variable name	d Type	Size	Description
Process_ef_id	txt				
Product Id	cmb				
Product Name	txt				
batch no	cmb				
Process Details					
Process Name					
Input Qty					
Loading Time					
Unload Time					
Process Time					
Total Time					
Output Qty					
Process Efficiency (%)					
Inspected By					
Date of Inspection					
IsDeleted					yes or no

Fig. 12. Resource processes and Process efficiency Analysis

Material Requirement Alarm and Material Receipt Note

Field Name	Control	Field Type	Size	Description	Stock code	stock name	measurement	Available Qty	Used Qty	Description	Grade
Material Used Control	txt										
Date of Issue	date										
Production batch ref.	cmb			from batch creation							
Product Name	txt			from batch creation							
Length(mts)	txt			from batch creation							
Diameter(inches)	txt			from batch creation							
Thickness(mm)	txt			from batch creation							
grid											
Stock code											
stock name											
measurement											
Available Qty				from Material Receipt note							
IsDeleted				yes or no							

Fig. 13. Material Requirement Alarm and Material Receipt Note

This MRP II system is also designed to make the production process more efficient, improve the customer service and satisfactions. It allows a large amount of data to be securely backed up with makespan and cost effective to make the process easily. This proposed system developed in scholastic search way to bring optimized results in stipulated time with respect to optimum schedule and also tested in two different Manufacturing Industries using Visual Basic .NET as the front end and MYSQL as the back end tool.. The system been tested with various sets of input data and has been found working properly.

B. Job Shop Module Generator

Job shop scheduler needs operational sequence and processing time for processing jobs. Randomly generated data are used as input along with Master Production Schedule as shown in Fig. 14.

Processing Times (Mins)										
Jobs	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
J1	3	4	2	2	1	3	3	4	5	1
J2	3	2	3	1	3	2	2	4	1	4
J3	4	4	3	5	4	3	2	4	2	1
J4	2	1	2	3	2	4	3	5	5	2
J5	2	3	4	1	3	2	3	1	3	2
J6	1	2	3	4	3	3	3	4	2	2
J7	3	2	2	3	4	4	2	4	1	3
J8	3	4	4	5	5	2	3	3	2	4
J9	4	1	2	5	1	2	1	5	3	1
J10	5	4	1	2	4	2	2	4	1	4

Fig. 14. Processing time sequence

Operational sequence									
Jobs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
J1	7	9	2	4	1	6	5	2	3
J2	9	10	7	5	8	4	1	10	6
J3	9	1	5	7	3	10	8	2	6
J4	2	3	7	9	8	10	1	5	4
J5	1	4	3	7	9	5	8	10	6
J6	6	10	5	1	9	7	4	2	3
J7	9	2	5	3	1	6	8	10	7
J8	3	6	8	4	2	9	10	7	5
J9	7	8	6	9	4	10	5	1	3
J10	3	2	7	9	8	1	10	5	6

Fig. 15. Operational sequence

C. Implementation of Shuffled Frog Leaping Algorithm

Initial population of sequence generated randomly by increasing order and selected sequence divided into number of memeplexes. Local Search the division is done with the high level frog (column sequence) arranged in first memeplex, second one arranged in second memeplex, the last frog to the last memeplex and repeated frog back to the next order memeplex. Fitness function evaluated within the limits that the memeplex are infeasible but in Global information Exchange the best frog memeplex values were identified each subset was compared to each other to produce best sequence way of schedule with smart intelligence make makespan and worst fitness frogs were identified. Finally, if the convergence criteria are not satisfied new subsets of memeplex will be created for the next iteration. This procedure is repeated for desired number of iterations to reach optimal results. Gantt chart is used to calculate maximum completion time i.e. makespan.

Initialization

Initial population (job sequence) is selected randomly

2	4	1	5	3
4	2	4	3	4
5	5	1	2	1
4	3	3	1	5
3	2	2	5	1

Makespan = 536 sec, Total Idle Time = 1244 sec

3	3	2	2	1
4	1	2	5	5
3	5	4	2	1
1	2	3	3	4
4	4	5	5	1

Makespan = 506 sec, Total Idle Time = 1145 sec

Last Iteration – Machine sequence

5	4	4	1	4
3	2	2	5	1
1	2	3	3	5
4	2	1	5	4
2	3	5	3	1

Makespan = 493 sec, Total Idle Time = 892 sec

Job Sequence

2	3	5	2	2
4	3	5	1	3
5	2	5	3	4
1	4	4	5	4
1	1	3	2	1

Makespan = 416 sec, Total Idle Time = 570 sec

2	4	5	1	1
3	3	2	4	1
5	5	5	4	3
2	1	3	5	2
2	3	4	4	1

Makespan = 407 sec, Total Idle Time = 532 sec

If the customer changes the requirements/orders manufacturing resource planning system will automatically update the input required resources as it send purchase order to the supplier and process the randomized schedule order. In turn the supplier will send the material in time and scheduler will generate the schedule using Shuffled frog Leaping algorithm.

D. Implementation based on completion of Integrated System Execution of Shuffled Frog Leaping Algorithm

Table 5. Integrated Frame work

Integrated System	Processes	Description
Manufacturing Resource Planning	Identifying	Change in resource needs, Influencing the factors
	Reviewing	Approving and managing the approved changes
	Maintaining	Integrity of baselines by releasing approved changes
	Controlling	Effects of changes in all resources (Cost, Schedule etc)
	Documenting	Complete resource planning execution
Job Shop Scheduling	Identifying	Change in production schedule and processes
	Reviewing	Approving and managing the approved changes
	Maintaining	Configuration and Planning Documentations
	Controlling	Product quality to standards and validating defect repair
	Documenting	Complete Master production Schedule with all changes

The database of the integrated manufacturing process includes main change in developing objectives and change control in all resource activities in differing levels of detailed production scheduling. The main benefit of the integrated frame work as shown in the Table. 5

This integrated process involves the modification of existing products or the creation of new items in a related category. These products are marked to current customers through established channels. These integrated system ha s two main objectives. One is to increase the production activity, product Quality and product life cycle of existing products. Second is to utilize the favorable reputation and product name of the firm. The main assumption of this work was satisfied the customer of the company would be interested in new products of the same company. Further enhancements can be made to the application, so that the functions are very attractive and useful manner than the present one.

XI. CONCLUSION

In this paper, an enterprise application is developed to integrate Manufacturing Resource Planning system with job shop simulator by using web technology. This integrated approach mainly used for satisfying the customer of the company would be interested in new products of the same company and also once the customers add or modify orders, data automatically updated in manufacturing resource planning system as per the changes of customer requirements rapidly. This work deals with the computerization of the production in making finned tubes of Thermal energy Systems. This Project helps to have a better management of finned tubes like extruded type, Supplier of the tube, Material of the tube, Action of the tube, Diameter of the tube, length value, Thickness of the combined tube, Current quantity of the tube and Remarks. The impact of the manufacturing Resource Planning module is totally helpful for others to find out the details without difficulty. According to the testing results of the application, it shows that the proposed system has good performance in terms of response to customer. Job simulator is used to find sequence and initial makespan. Shuffled frog leaping algorithm also used to refine the results and a schedule which gives optimal makespan. Finally Manufacturing resource Planning (MRP II) effectively collaborates with Job Shop to meet the requirement of production. In future, the retrieve supplier's complete information for the particular material requirement planning to be integrated with the Job shop Scheduling. The project has covered almost all the requirements. Further requirements and improvements can easily be done since the coding is mainly structured or modular in nature. Changing the existing modules or adding new modules can append improvements.

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