PRODUCTION PLANNING TOOL

FOR

TEXTILE MANUFACTURING INDUSTRY

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Declaration

I declare that this thesis is my own work and has not been submitted in any form for another Masters, Degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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My deepest thanks to my beloved Father although he is not alive to see my achievement, I would like to mention in this from the bottom of my heart "THANK YOU VERY MUCH, MY DEAR FATHER" for directing me to the correct carrier path. And also I would like to thank my dear mother for the kind guidance and constant support given to me throughout my Msc. IT Degree program. Besides the above, I would also thank my Grandmother who constantly encouraged verbally from time to time.

Abstract

Apparel Industry is one of the most significant contributors to the Sri Lankan economy. The industry has recorded substantial growth levels over the past four decades and approximately 40 percent of the total exports hold in apparel sector.

Proper production planning and controlling is a crucial factor in Textile Manufacturing Industry. It ensures the availability of resources such as equipment, materials to meet production goals for a business. Production planning also provides a detailed plan on how a company will reach it's production goals and how long it will take to achieve it.

The proposed Production Planning Tool will help to maximize profits and make sure the customer needs are being met. Eliminating wasted time by improving process flow, reducing inventory costs, optimizing equipment usage, using employees' time to the fullest advantage and improving the delivery time of products and services will be key advantages of the proposed Planning Tool.

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Chapter 1.

1. Production Planning Tool for Textile Manufacturing Industry

1.1. Introduction

Apparel Industry is one of the most significant contributors to the Sri Lankan economy. The industry has recorded substantial growth levels over the past four decades and approximately 40 percent of the total exports hold in apparel sector.

Textile manufacturing plays the main key role in Apparel Industry. Production planning & control is one of the most important aspects of the textile manufacturing industry which has been a challenging task. Many existing problem formulations are not able to consider all major and critical constraints of the textile industry. Machine capacity planning is the most important component of textile firms. It plays an essential role for the success of the firm. Staffing and optimizing the number of workers for each shift is another important and critical constraint. Material planning and controlling also is a critical constraint. Improper planning may cause unnecessary delays on delivery and ultimately reflects on cost and the reputation of the company.

Introduction of a computer aided Production Planning Tool has become a necessity to Textile Manufacturing companies to utilize machinery, labour, and materials in an efficient manner. One of the best benefits that can have is the cost of the production. Textile manufacturers can't afford to lose time or materials in the production process. Wasting time can lead to late fees when products aren't delivered as promised. Raw material prices rise consistently, and poor planning can lead to missed opportunities and higher costs. So each production phase must be accurate as possible when planning.

Late deliveries can be harmful to the company's future, because buyers must accommodate early deliveries with additional storage capacity. Ideally, planning should allow for exact delivery when the customer demands. At the same time, company need to have sufficient labour and raw material delivery in the exact proportions to meet the deadlines without having to pay extra for overnight material deliveries and expenses incurred on labour overtime.

Another benefit is the on-time tracking. Whenever a machine breakdown happens or materials not available, the Planner can re-schedule the plan without any hazel

1.2. Background and Motivation

Production planning is an important element for performance of the manufacturing process of a company. With the constant and rapid change, production methods have been instrumental in guiding the future orientation of variables that affect short-term, medium and long-term planning. A correct guidance will increase the chances to obtain good results which will contribute to the growth of the organization(1)

Most of the companies use Excel for production planning in Textile Industry. The main drawback of using Excel is man depended. Whole productivity will depend on the Planner. Another drawback is when revising a planning board, Planner has to re-plan one by one manually. It has become hazel to them.

To solve the challenge, having a computerized Production Planning is vital. It is important to have a best suitable algorithm which can get the maximum efficiency ultimately which benefits by the company. System will provide a clear visibility of the Critical Path of the Production.

1.3. Aim

The aim of the this project is to build a computerized Production Planning Tool which can get maximum efficiency in Textile manufacturing

1.4. Objectives

Main objective is to make a smooth and easy planning tool to overcome the following key areas:

- Production Planning & Scheduling system will bring in significant efficiencies, accuracy and time saving.
- System will provide a dashboard to view the current running productions and to identify the free machine availability in order to quote a delivery date without any delay
- Backward or forward calculation algorithms for the critical path
- System will allow for complete control with optimized capacity utilization and maximum possible loading of work orders to factory.
- Facility to re-schedule the plan for unexpected machine breakdowns

1.5. Scope of the Project

The main scope of production planning includes the following:

- Identifying the list of process routes and operations, in which this will include cycle time for production completion
- Loading & scheduling machines have to be made as per the production requirements. Machine loading generates accurate information on work standard, machine-time requirements & machine capacities. Scheduling is a time-table for performing the job on the available machines so that delivery dates are maintained.
- System will provide user friendly interfaces to get a clear visibility of the production plan.

1.6. Structure of this Report

Chapter 1 Overview of the research and introduction the research problem will be discussed

Chapter 2 Discusses the literature survey done based on the topic

Chapter 3 Discussed the details of technologies used to develop the system

Chapter 4 Production planning and scheduling problem will be described. Further brief description of production environment and the complexity of production scheduling will be discussed.

Chapter 5 Process of Requirement Analysis and Designing are described in this Chapter. Techniques used to gather user requirement are explained. Diagrams are used to describe the data flow and to describe the processes.

The Process of designing with respect to both functional and Database Designing also explained. System Processes are explained using Data Flow Diagrams and Database design is explained uses ER diagrams. The Database Schema is also listed.

Chapter 6 This Chapter discusses the process of implementation. Tools and Techniques used in the development of proposed system are described in the Chapter. Also the Programming Coding used in the implementation process also listed.

Chapter 7 Project Evaluation discussed in the Chapter. The Successfulness in achieving the objectives, the results of the project, and also the deviations from the original plan are explained. Problems encountered during the project and Future work to be done is also explained.

1.7. Summary

The research of this thesis is focused on the production planning for Textile Manufacturing Industry. Increasing importance of reducing operational costs of firms in the changing environment was highlighted and was discussed that production planning and scheduling is one of the important tools in reducing the operational costs of firms.

This chapter provides the discussion of some of the background and motivation for this Study and mentions about aim and objective of this research.

Chapter 2.

2. Literature Review

There is a vast body of literature covering all aspects of industrial processes planning and management. Mostly it was related based on mathematical analysis. Advances in IT have created new approaches based on the user's direct involvement and interactions in the use of relevant decision aids in the form of software tools. Thus, in recent years, a lot of work has been done in the area of Production Planning Systems with applications in the scheduling of medium and large scale Make-To-Stock (MTS) and Make-To-Order (MTO) companies(2). Most of the research in the area has certainly been aimed at the first category. This is due to the fact that systems developed for MTS environments are usually reckoned to be also applicable to the MTO ones. Differences in the requirements between the two categories are extensively presented in(3), focusing on the application areas of production scheduling, capacity control and setting of delivery dates, and discussing the issue whether the available research can meet the needs of the MTO sector. However, the difference in (3) between the two companies above is sharp. As argued above, the situation of textile production systems is not so.

Numerous textile scheduling studies on a single-stage system have been published. A scheduling model for an apparel production system in order to allocate production capacity and schedules jobs for each production line has been proposed in (4). A computer-based system for the scheduling of dyeing textile fabrics in order to maximize the machine utilization was developed by (5). (6) Develop an expert system to aid the design of textile manufacturing process.(7) present a scheduling method, for a textile company with multiple factories, in order to distribute and schedule production jobs among the factories. Some other literature studies the scheduling on multiple-stage textile systems. Sun and Chisman (1991) develop a simulation model to assist production scheduling for a multiple-stage textile-belt manufacturing process(8). Tomastik, Luh, and Liu (1996) present a scheduling approach especially for cellular manufacturing in apparel

industry, in order to determine when to set up a cell and when to release garments into the cell(9). Min and Cheng (2006) address a textile scheduling problem, in which the due date is a decision variable; and they attempt to find an optimal due date as well as an optimal schedule in order to minimize the total cost(10). Guo, Wong, Leung, Fan, and Chan (2006) deal with a scheduling (11)

All the above researches cater only certain area to build the algorithm. In textile manufacturing real scheduling has to be considered all the factors when planning.

Chapter 3.

3. Technology

3.1. Introduction

Since this is a Production Planning tool, graphical views is an essential key factor need to be focused. The system will provide very simple, attractive and user-friendly interfaces. Proposed Production Planning tool will be a Window based application which runs on .Net framework. To achieve above goals proposed system uses SQL server, .Net Framework and Crystal report for reporting.

3.2. Database

MS SQL Server has been used as a database in order to run the system smoothly. Main reasons to take SQL server as database is,

- Large amount of records can be handled quickly and efficiently
- Using standard SQL is easier to manage the database systems without having to write substantial amount of code.
- SQL server is a well secured system to protect data.
- Data back-up and restore can be easily handled.

3.3. Visual Studio .net

Visual studio has been used as Front end development. Main reasons for selecting Visual Studio are as follows

- The structure of the Basic programming language is very simple, particularly as to the executable code.
- VS Code's built-in debugger helps accelerate edit, compile and debug loop.

- The graphical user interface of the VB-IDE provides intuitively appealing views for the management of the program structure in the large and the various types of entities (classes, modules, procedures, forms).

3.4. SAP Crystal Report

SAP Crystal Reports is a business intelligence tool that helps in generating reports from SAP as well as non-SAP data sources. Knowledge of this tool is a plus for managers and business leaders who can generate quality advanced level reports which will help them in making better strategic decisions. Key advantages are as follows

- Easy designing and coding
- Exporting to various formats

3.5. Summary

Hardware infrastructure, software used to develop the proposed system has been illustrated in this chapter. Visual Studio .NET has been used to develop the tool. Other technologies has been used to support development such as MS SQL and Crystal Report

Chapter 4.

4. Approach

4.1. Introduction

In this chapter, Production planning and scheduling problem will be described. Further brief description of production environment and the complexity of production scheduling will be discussed.

The main objective of the proposed system is to generate a valid production schedule for each order which efficiently distributes jobs among machines, which can have maximum efficiency and productivity for the company. Therefore it is necessary to have a good algorithm to build, in order to achieve the goal. Following key factors and steps were identified during the analysis of the system.

- Gather all parameters to build the algorithm
- Identify all the machines operate in production and tasks of each machine can do.
- Throughput of production
- Build an algorithm to meet the expected delivery with most efficient way.

4.2. Production Planning and Scheduling Problem

Today's business environment has become highly competitive. Manufacturing firms have started recognizing the importance of manufacturing strategy in their businesses. Firms are increasingly facing external pressures to improve customer response time, increase product offerings, manage demand variability and price competitive. In order to meet these challenges, firms often find themselves in situations with critical shortages of some products and excess inventories of other products. This raises the issue of finding the right balance between cutting costs and maintaining customer responsiveness. Firms are facing internal pressures to increase profitability through improvements in manufacturing efficiency and reductions in operational costs.

In this section, two sub sections have been categorized to illustrate the Production Planning and scheduling problem. Firstly production environment has been described and then the complexity of production planning has been illustrated

4.2.1 Production Environment

Production planning and scheduling decisions depends on complex multi-stage, multi-product, multi-machine, and batch-production environment. Large numbers of process and discrete parts manufacturing industries are characterized by increasing product variety, low product volumes, demand variability and reduced strategic planning cycle.

Unlike other production industries, Textile manufacturing industry has a process of multi-stage production environment. The concept of multi-stage in the environment considered is equivalent to the multi-level product structure, as shown below for illustration in Figure 4-1.The order of each stage of processing is called as “Process Route”

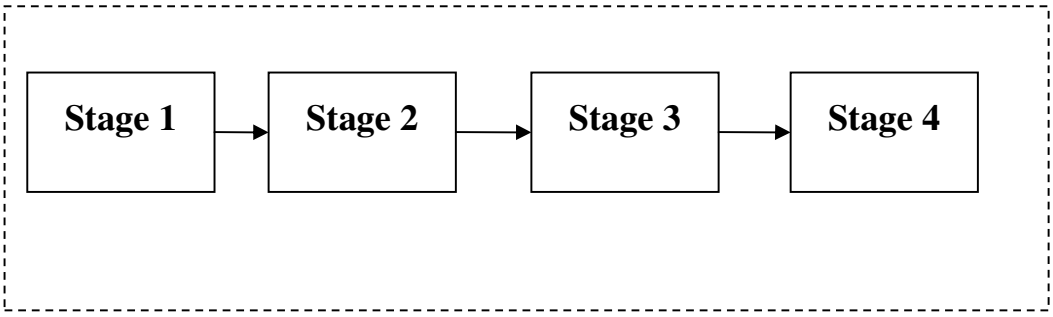

Figure 4-1Multi Level Production Stages

Each Order consists of Process Route. The challenging part of Production planning in Textile manufacturing is, it does not have exact process route. Each Order has different process route. And some machines have a capability of doing two more operations in one machine. Figure 4-2illustrates flow of three orders.

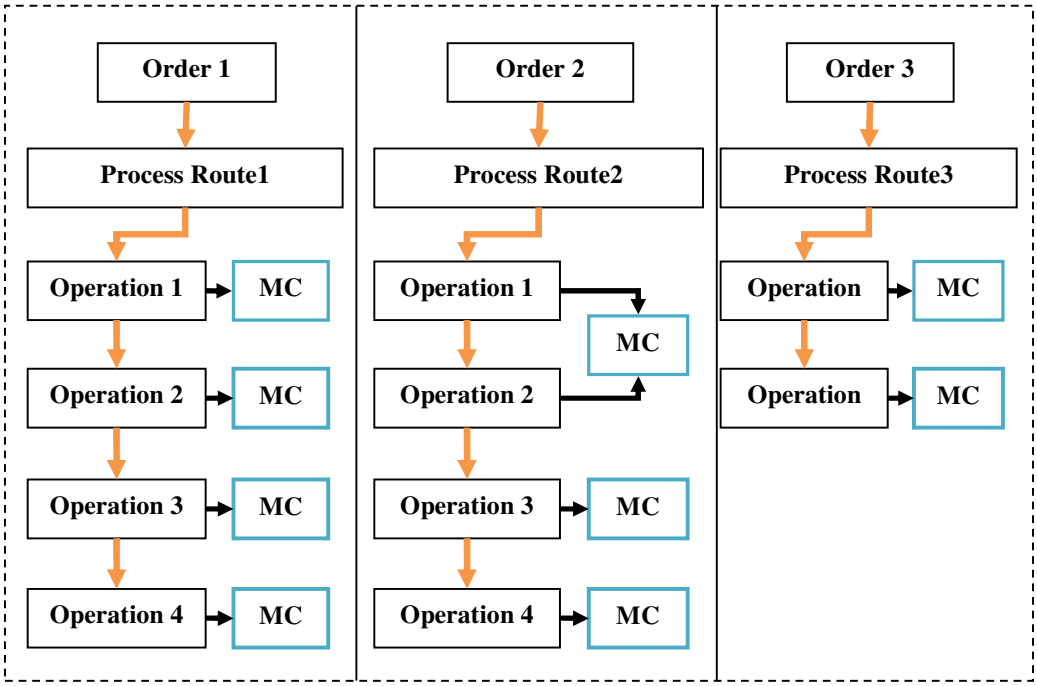

Figure 4-2 Machine, Operations and Process Routes of Different Orders

4.2.2 Complexities in Environment

In this sub-section, complexities that exist in the production environment will be discussed. The production environment discussed in previous sub-section, and the complexities in the production environment, form the basis for production planning and scheduling decisions.

To solve the production planning and scheduling problems, there are several critical concerns need to be satisfied. Following are main key concerns that have been identified during the system study.

- Deliver the finishing goods on expected delivery date without any delay
- Avoid shade variances
- High machine throughput and avoid machine idle time
- Reschedule plan for machine breakdown

Mainly Customer satisfaction needs to consider highly. Deliver the finish goods on time makes a happy customer which gives the good reputation to the company. Ultimately it will increase the profit and will reduce unnecessary charges for delayed deliveries.

In the proposed system, algorithm will give priority to expected customer delivery if not possible; system will generate a new delivery schedule based on the machine availability.

Shade variance is a big problem in fabric manufacturing process. Shade variance is the variation of shades or colour depth of fabric rolls. This variance can be happened within one roll or among different batches. When production planning, it is necessary to plan production with minimum batches to overcome this Shade variance. Complexity of production planning when considering the colour factor, the planner should schedule production with minimum batch split and deliver the order without any delay.

There are high setup times in the production process. During product changeover of a dye machine, idle time is incurred. In Dye machines, after each order dye machines have to be cleaned thoroughly which takes considerable amount of idle time. Time taking to clean machine depends on shade previously dyed and shade to be dyed next. For example, if previous shade dyed is a dark colour and currently dyeing is a light colour, cleaning time will be higher than the changing colour i.e. is light to dark colour. Higher production run of a product in a setup would result in high inventory cost, whereas more number of setups would consume significant amount of capacity in setups.

Machine breakdown is a complex attribute in production planning. The factors discussed above are static known factors for every order when planning. But machine breakdown cannot be predicted. Whenever a machine breakdown happens, proper reschedule mechanism is required to overcome the complexity of rescheduling plan. Ultimately it should minimize the planning cost and deliver the products without any delay.

4.3. Process

Merchant enters the inquiry details to the system and request delivery details from the planning team. Planner checks the machine availability and records in master plan and gives delivery schedule to the Merchant. Then the delivery schedule will be sent to customer for the confirmation. If customer does not agree with the delivery schedule, then the Planner will revise the Master Plan and send the revised schedule.

Once the customer confirms the order on agreed confirmation date, Planner will move to loading plan. If Customer confirms the order after agreed confirmation date then plan has to be revised again. Summary of the current process is illustrated in Figure 4-3.

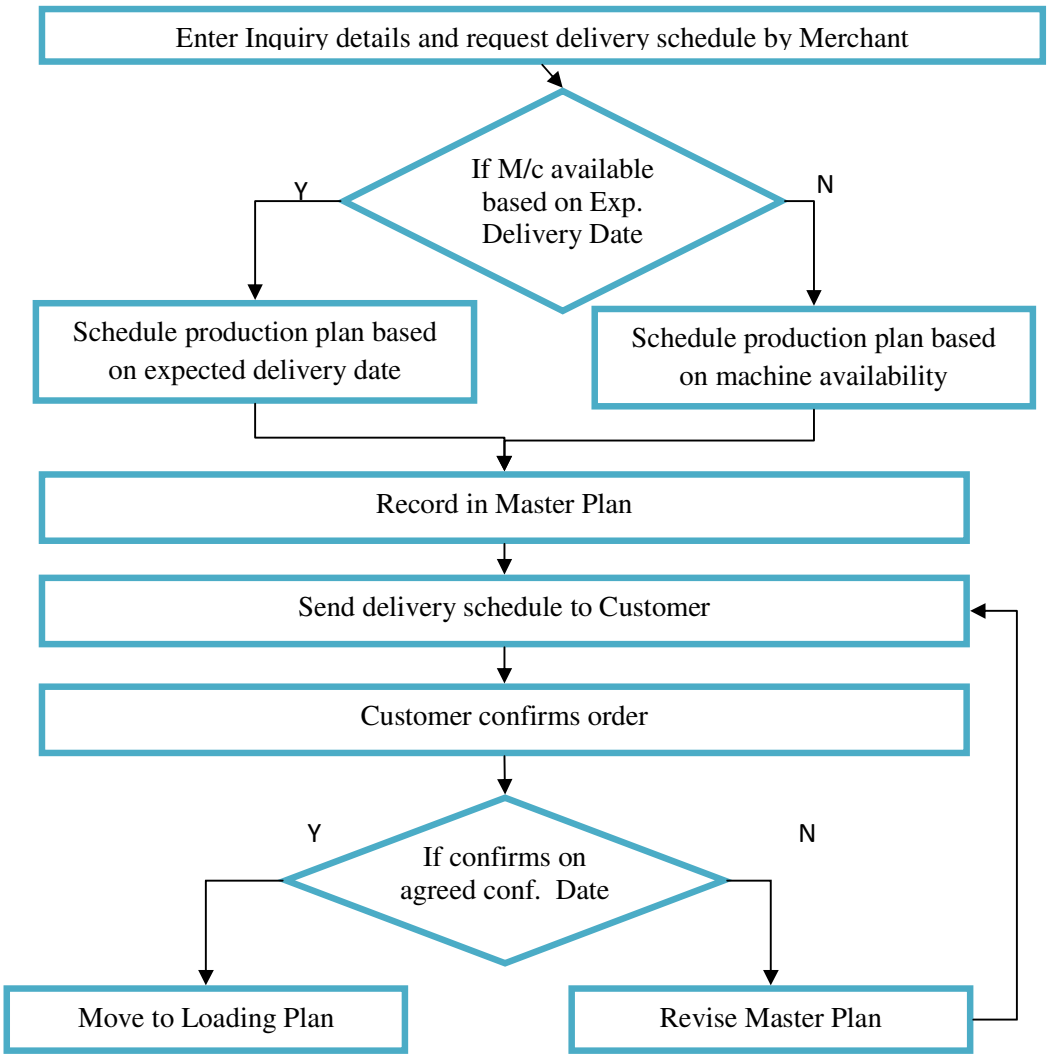

Figure 4-3 Process Flow

4.4. Main Stakeholders of the System

Following Stakeholders are available in the system

- Administrator
- Merchant
- Planner
- Operations Manager

Functions of the User roles can be categorized as follows,

Administrator:

- Secure login to the system
- User Management
- View/Generate a summary report

Merchant:

- Add Inquiry Details
- Add Order Confirmation
- View Delivery Schedule
- View summary Reports

Planner:

- Get Inquiry Details
- Get Order confirmations
- Update production schedule
- Generate Delivery Schedule
- View Delivery Schedule

Operations Manager:

- View Production Plan
- Update Machine breakdown
- View Delivery Schedule

4.5. Summary

In this chapter, the importance of having a systematic production tool and problems of production planning and scheduling was discussed. Then, we discuss the production environment in detail along with the complexities of the production environment. High level view of process flow too is discussed. Next chapter describes the analysis and design of the solution.

Chapter 5.

5. Analysis and Design

5.1. Introduction

In this chapter, detail description of the existing system and its defects will be discussed. It produces an analysis model which clearly describes how a system works now, as well as a requirement model of what the new system must do. Identifying detailed user requirements are very important. Requirement analysis must ultimately result in a specification which unambiguously describes what the system should do.

5.2. Requirement Analysis

During this research following methods were used to gather user requirements.

The initial requirements were gathered through the interviews with the management in order to identify the major components within the system and tasks. Secondly operational personnel were interviewed in order to gather the detailed information. During this discussion, the features that were not in the current system and the limitations of the existing system were identified.

And also Forming, documents and reports were analyzed in order to get a better understanding of the existing system. By analyzing these documents, the data flows, duplication of data were clearly identified.

The current system was observed in order to get a clear understanding of how the transactions are done manually by staff and their proposals were taken into consideration. To identify the basic areas of address in the proposed system were studied from similar systems through Internet. Once the requirements were clearly identified, a meeting was arranged with the management, system users in order to present the details gathered during Requirement Analysis phase.

Use Case and Data Flow Diagrams has been used to document the current system and the user requirements.

5.2.1. Functional Requirement

The main goal of this research is to implement a Production Planning & Scheduling system that will bring in significant efficiencies, accuracy and time savings. The system has to be developed taking into consideration the characteristics of the textile manufacturing industry, with its mixed manufacturing type of processes, and the variety of the type of the final product (Fabric Types). Also it is required to identify all the objects involved in production planning such as machines, products, shifts, setups, planning horizons.

5.2.2. Non Functional Requirement

In textile manufacturing industry production planning and scheduling changes rapidly. Hence the proposed system has to be user friendly and should be able to change the plan accurately and efficiently without any delay. Due to complexity of the algorithm, process time has to be optimized properly.

5.3. Overall Process

Below Figure 5-1illustrates the graphical view of the overall process

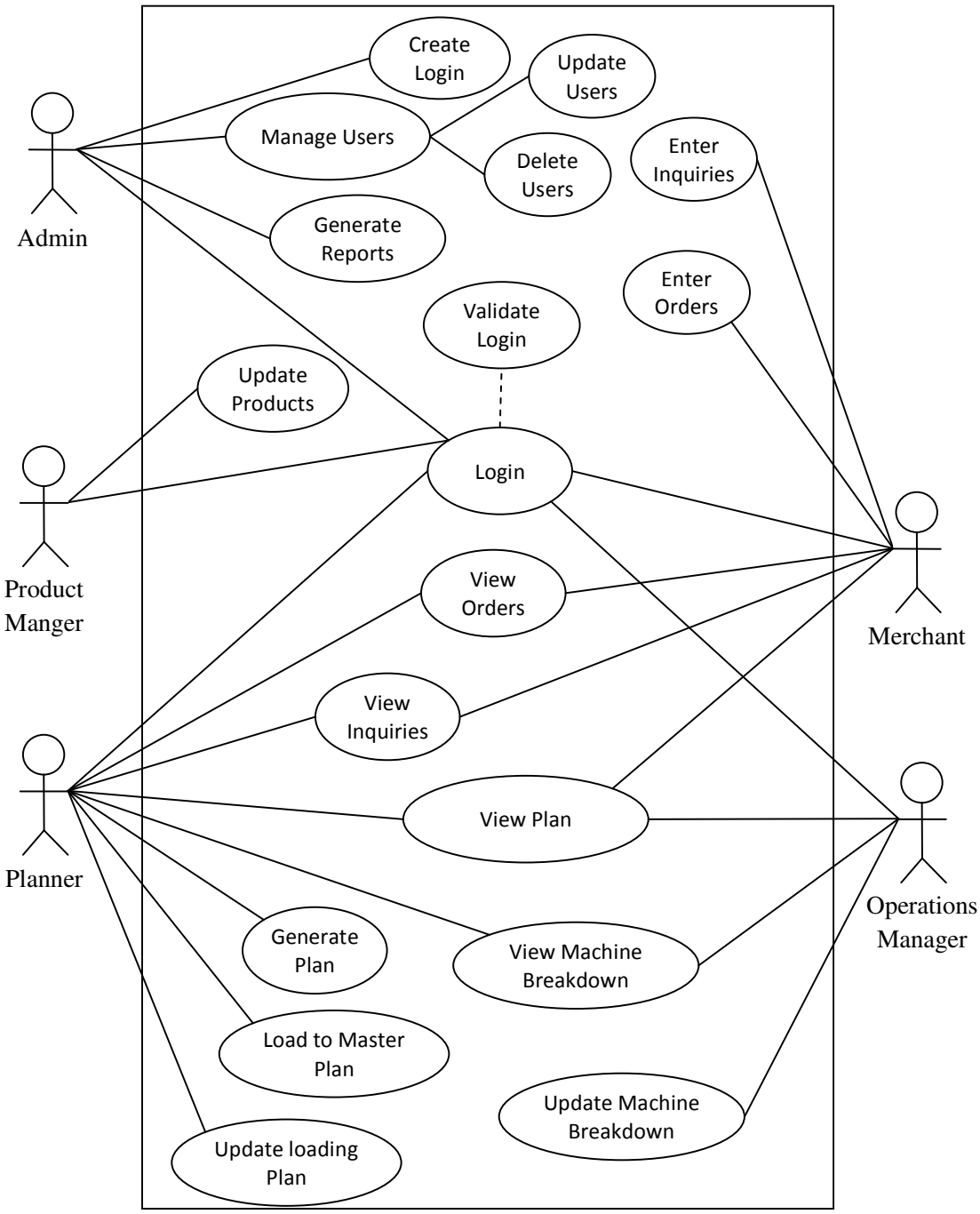

Figure 5-1 Use Case of Overall Process

Detail description of each user role are discussed in Annex A

5.4. Data Input Procedure

Inputs to the Planning tool have been categorized into two sections. First section is the Inquiry Order. Inquiry order is sent by a customer requesting for delivery days giving the product type, quantity and expected delivery days. Inquiry is not a confirmed order. The planner will input the inquiry details to the planning tool and generates a production schedule and will send the delivery schedule to the customer. All these inquiries will be loaded to Master Production Plan. Master production plan can be revised any time until customer agrees the delivery details.

The second type of input is the Confirm Orders. Once the confirm order is received, this will move to Loading plan from Master Production Plan.

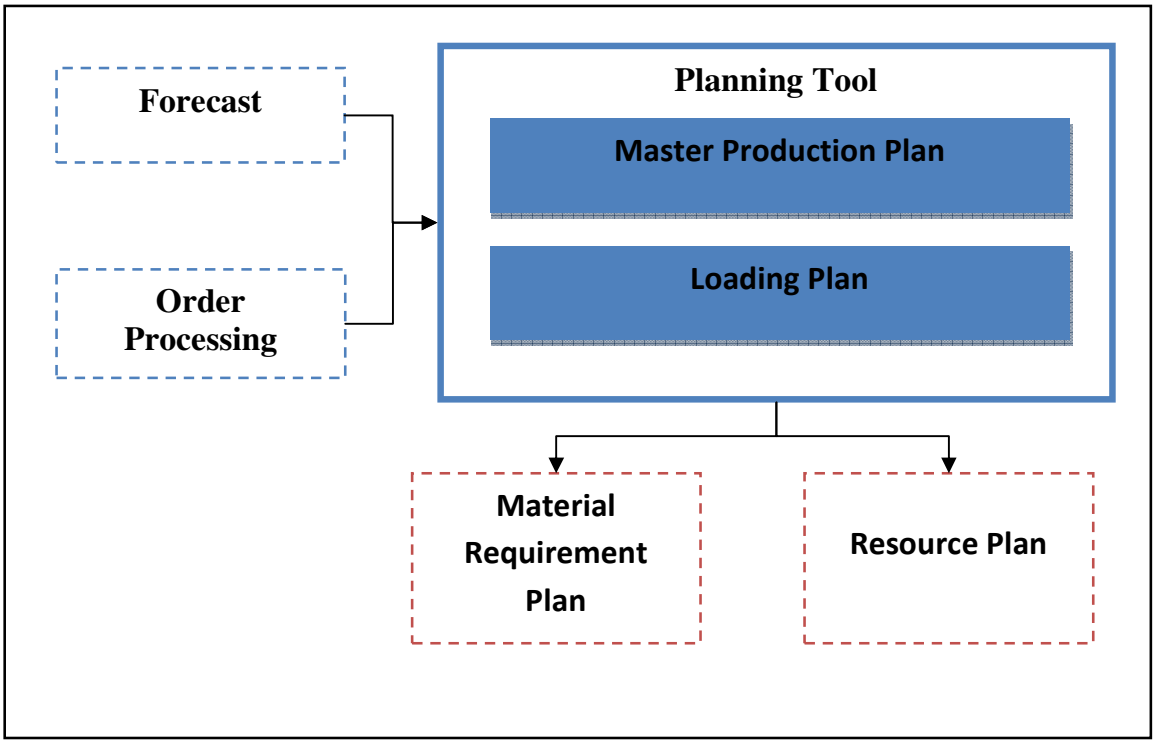

Figure 5-2: Data input procedure

- Master Production Plan
- Loading Plan

Master production planning module is the pilot plan in production. It deals with forecast which gives an output for material and resource plan. More specifically, the

managerial decisions involved in the problem concerns the specification of aggregate production rates, work force and inventory levels for each period within the above planning can be met from the master production plan.

Loading Plan is the actual plan of the confirm orders. It will freeze the machine capacity from the production plan.

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5.5. Parametric Analysis

Following key attributes were identified for the algorithm

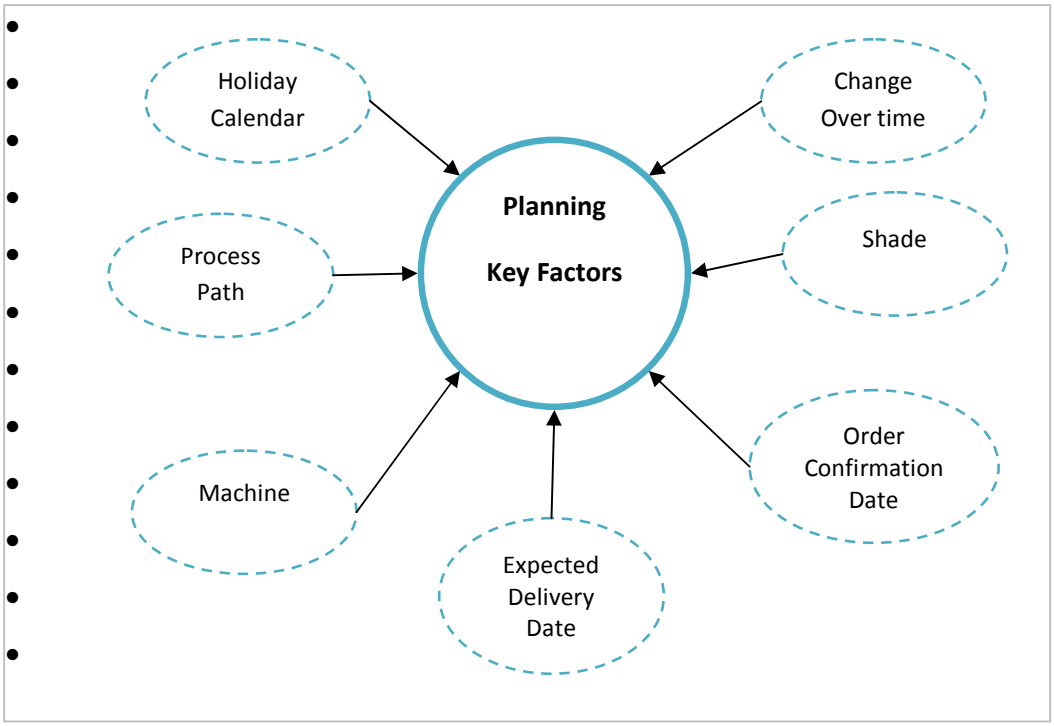


Figure 5-3: Key attributes for production planning algorithm

Detail description of the above parameters and the constraints that should be considered in the proposed system is discussed below

- **Company Holiday**

  Company holidays have to be marked in the system. A holiday can be a full day or half day. Half day should be able to mark in hours.

- **Process Path**

  Each order will have a process route. This will be decided by the Technical Department. Route need to be entered in the system. Process route includes the flow of operation and duration of each operation. Duration will be the total completion time which includes the preparation time, operation time and unloading time

- **Machine/ Machine Operations**

  All machines that operate could be identified. The most important factor is that some of the machines can do multiple operations such as heat set, bleaching, scouring. Although multiple operations are done in a single machine, some of the fabric qualities cannot be processed in the same machine.

  Dye machines are the main critical machine type which should consider when planning. Whenever there is a dye process, plan should be based on dyeing machine. To get the maximum efficiency, all dye machines should have a minimum and maximum capacity. However there will be a tolerance level to accept when there is a small quantity left to plan.

- **Shade**

  Shade is the depth of colour percentage. Shade is expressed in percentage of dye amount in unit weight of fabric. Shading or shade variation is considered as one big problem in fabric manufacturing. A lot of orders are cancelled because of the shade variation between the batches. Therefore one key point of avoiding shade variance is to reduce the number of batch split of an order.

- **Change Over time**

  Change over time is the time taking to change one batch to another of a machine. Change over time will be varied based on the shade to be dyed.

  Therefore for each machine transition time of one shade to another will be set at the initial stage. Following shade transition are identified in the process

  - ❖ Light to Dark
  - ❖ Light to Medium
  - ❖ Medium to Dark
  - ❖ Medium to Light
  - ❖ Dark to Light
  - ❖ Dark to Medium

To get the most efficiency on Change overtime number system is introduced. This will help to calculates the distance of the current shade and last shade dyed.

Shade	Value
Dark	1
Medium	2
Light	3

Table 5-1: Shade Values

- **Order confirmation date**

  Order confirmation date is the date which customer confirms the order. The importunacy of this attribute is, the production process can start only after the order confirmation date. Once the order is confirmed, Planner should be able to

freeze the plan. If the order is not confirmed as on the agreed date, then the Planner should be able to revised to plan.

- **Expected delivery date**

  Expected delivery date is the date which customer expects the delivery. In the proposed system, algorithms will prioritise to match the expected delivery date.

The above parameters can be categorized into two sections as follows.

- One time setup parameters - Static variables
- Parameters that varies to each order – Dynamic variable

Based on the above variable types, above discussed parameters have been illustrated in below table

Static Variables	Dynamic Variables
• Company Holiday	• Process Path
• Change overtime	• Machine/ Machine Operations
	• Shade
	• Order Confirm Date
	• Expected Delivery Date

Table 5-2 Variable Categories

5.6. Algorithm

Because of the large number of interacting attributes involved in this proposed tool, a standard genetic algorithm would probably require an unrealistically large amount of memory and processing time to find good solutions. As the first step of the implementation, based on the key attributes discussed on above, an algorithm has been introduced which gives a production plan with maximum efficiency.

Proposed algorithm has been categorized into several phases to reduce the complexity of the algorithm.

a. Calculate the production machine hours required for the order.

b.Allocate the machines

c. Recheck for production plan

When scheduling, Dye machine capacity is considered as the main factor. All the batch quantities depend on the Dye machine capacity. Hence job schedule of predecessors in the process path will be based on Dye Machines. In other words, a batch will be based on the Dye machine availability. As shown in Figure 5-4, proposed algorithm is divided into two algorithms.

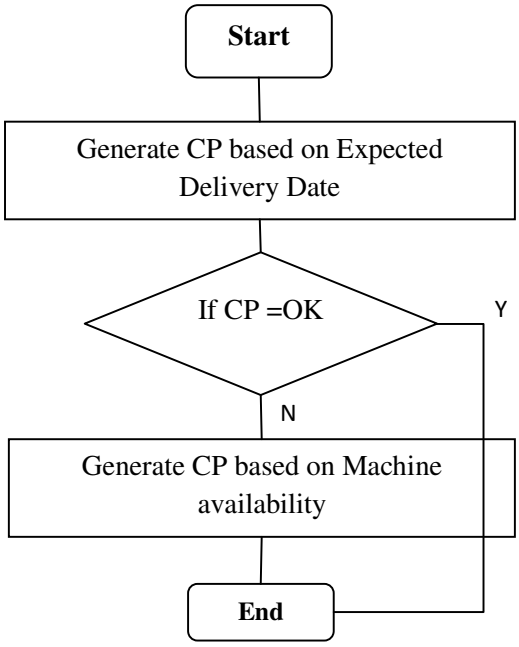


Figure 5-4: Algorithm Flow

A. Algorithm will give priority to schedule jobs based on Customer expected delivery date (Figure 5-5)

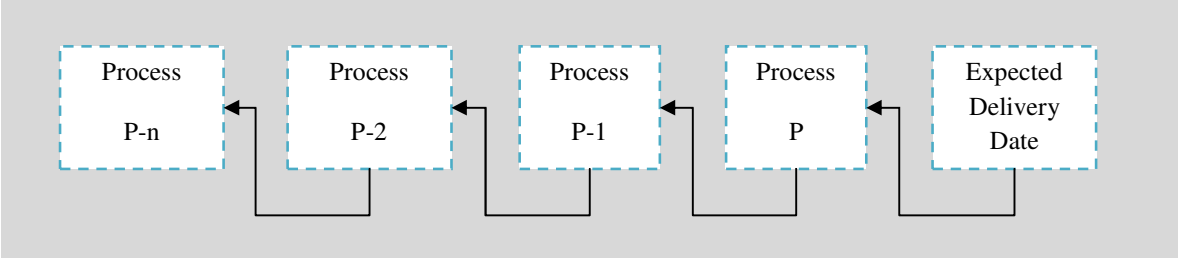


Figure 5-5: Job scheduling based on expected delivery date

B. If the production failed to do on the expected delivery date second algorithm will generate the job schedule based on the machine availability (Figure 5-6)

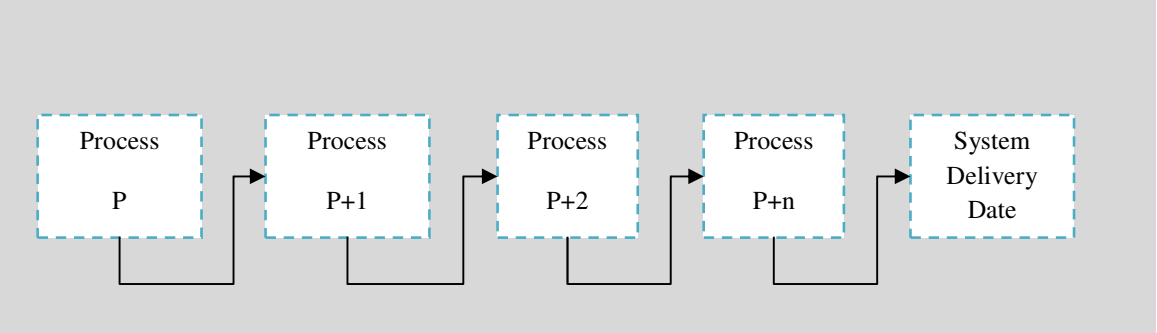


Figure 5-6: Job scheduling based on machine availability

In order to formulate the algorithm following notations will be used in the rest of this chapter

- *n* - No. of Orders
- *oq* - Order Qty
- *mc* – Machine Capacity
- *Maxmc* - Minimum Machine Capacity
- *Minmc* - Maximum Machine Capacity
- *sd* – Shade Distance
- *ed* – Expected delivery date
- *af* – Available free dates
- *cp* - Critical Path
- *aq* - Allocated Qty
- *ld* - Last possible Dye Date
- *pp* - Process Path
- *d* - Dye Machine
- *cp* - Critical Path
- *bd* - Balance to Dye

5.6.1. Algorithm 1 – Scheduling based on expected delivery

Pseudo code

Load all orders from "Inquiry Order" order by expected delivery date

Calculates the last possible date that can be dyed to meet the delivery

Check, if free dates are available before the last delivery date. If available, do planning based on expected delivery date

Otherwise move to Step 2

Step 1

//Check the availability of any free dates available that can be done in one batch before the last possible Dye Date

SELECT all Dye machines WHERE ***Max. M/C Capacity>Order Qty***
AND available ***free date*<= Last Possible Dye Date**
ORDER BY ***Shade Distance***
If exists, check the efficiency level of Dye machines and select the most efficient machine to allocate the Quantity

Note: To get the maximum efficiency Dye machines has to be filled at least 50% from the Capacity.

If not exist, move to step 2

Once dye machine is set based on the process path, it will set for other operations

Calculates the Critical Path. If CP exceeds the expected delivery date warning message will be displayed.

Step 2
Description: If Dyeing cannot be done in one batch then finds the most efficient Batch split that can be done for an order to meet the expected delivery

SELECT all Dye machines WHERE ***Max. M/C Capacity*<= *Order Qty***
AND available ***free date*<= *Last Possible Dye Date***
ORDER BY **free date,** ***Max M/C Capacity*, *Shade Distance***

Allocate Dye qty. which have the highest maximum capacity

Calculates balance to Allocate

Balance to Dye = OrderQty - Allocated Qty

Apply the balance qty. to all machines and calculate the efficiency level where balance to dye< max m/c capacity

Select the machine which has the highest efficiency where efficiency level is greater than 50% and allocate qty and balance Qty

If no records found for above condition, loop from beginning of Step 2. Here the Order Qty. will be the balance to Dye.

Once all dye machines are set based on the process path, it will set for other operations

Calculates the Critical Path. If CP exceeds the expected delivery date, warning message will be displayed.

5.6.2. Algorithm 2 – Scheduling based on Machine availability

Step 1

//Check whether there is any free dates available that can be done in one batch

SELECT all Dye machines WHERE ***Max. M/C Capacity>Order Qty***

If exists check the efficiency level of Dye machines and select the most efficient machine to allocate the Quantity

If not exist, move to step 2

Once the dye machine is set based on the process path, it will set for other operations

Calculates the Critical Path.

Step 2

Description: If Dyeing cannot be done in one batch then finds the most efficient Batch split that can be done for an order

SELECT all Dye machines WHERE ***Max. M/C Capacity<= Order Qty***

Order by **free date,** ***Max M/C Capacity*****,** ***Shade Distance***

Allocate Dye qty. which has highest maximum capacity

Calculates balance to Allocate

Balance to Dye = OrderQty - Allocated Qty

Apply the balance qty. to all machines and calculate the efficiency level where balance to dye< max m/c capacity

Select the machine which has the highest efficiency where efficiency level is greater than 50% and allocate qty balance Qty

If no records found for above condition, loop from beginning of Step 2. Here the Order Qty will be the balance to Dye.

Once all dye machines are set based on the process path, it will set for other operations

Calculates the Critical Path. If CP exceeds the expected delivery date warning message will be displayed.

In order to understand the above complex algorithm, higher level view of algorithm flow is illustrated in below Figure 5-7

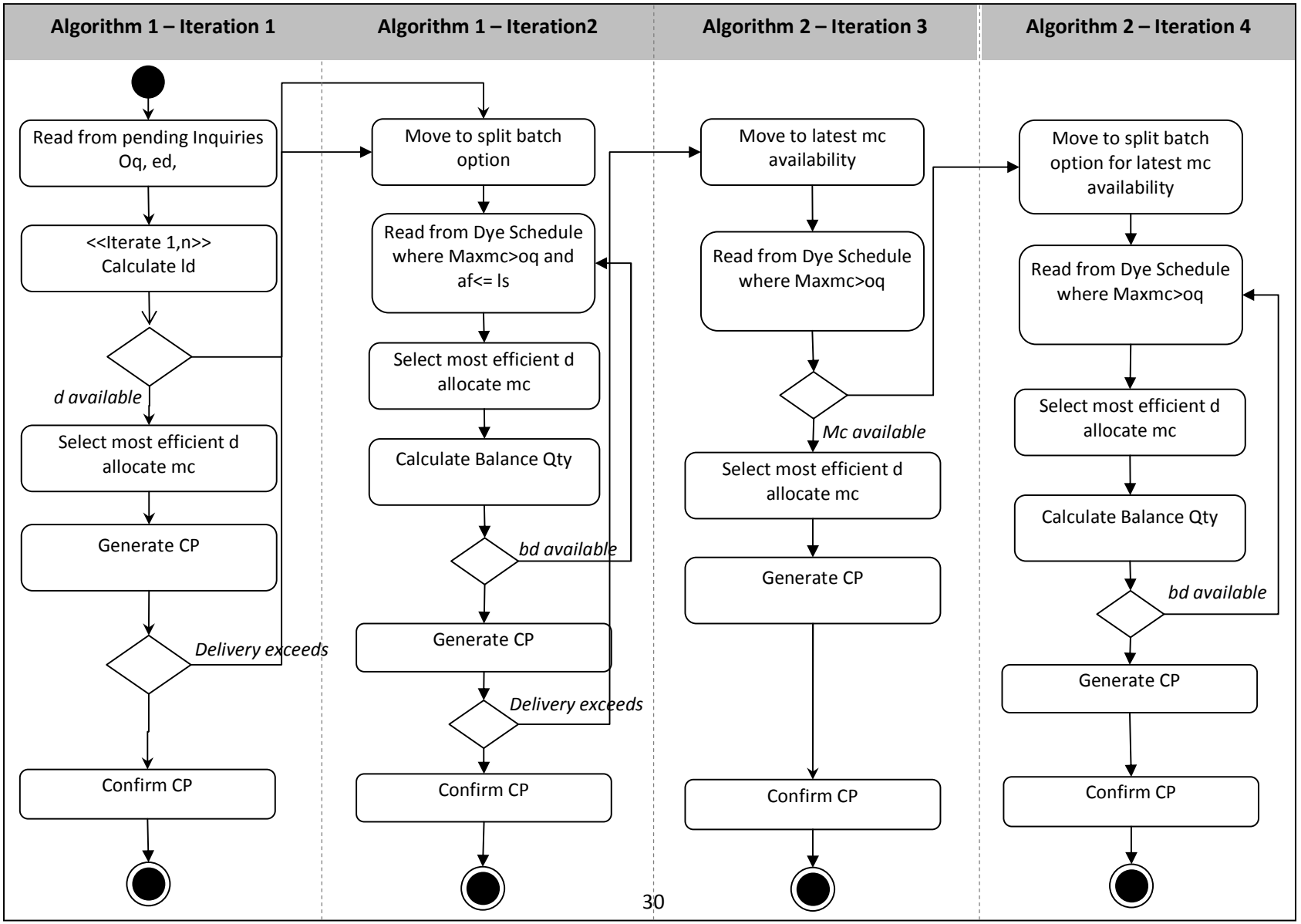


Figure 5-7 Flow of Algorithm Options

5.7. Database Schema

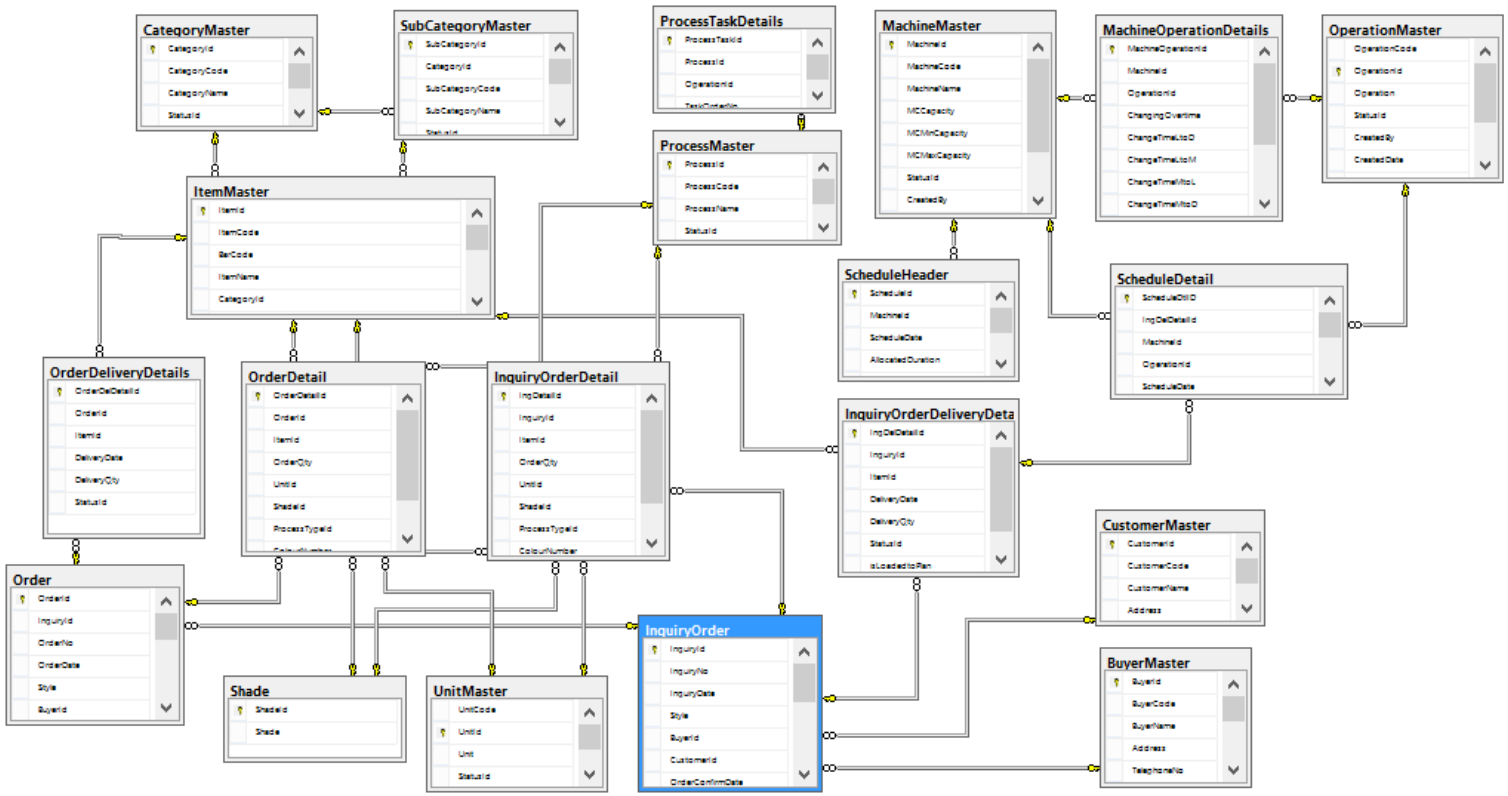


Figure 5-8- Database Schema

5.8. Summary

Requirement analysis and designing of the system was discussed in this chapter. All parameters to formulate the production scheduling and relationship between each parameter was analysed. Next chapter illustrates the implementation of the solution in detail.

Chapter 6.

6. Implementation

6.1. Introduction

The goal of the implementation phase is to implement a system correctly, efficiently, and quickly on a particular set or range of computers, using particular tools and programming languages. In the previous chapter analysis and full top level of the design discussed. This chapter describes the implementation details of each module of the solution.

6.2. Implementation of the Solution

The proposed system is developed as a client- server standalone windows application. The system is built on 3- tier which provides many benefits for production and development environments by modularizing user interface, business logic and data storage layers. Front end and business logic was developed by using Visual Studio .NET. User friendly graphical user interfaces was used to display the complex production and scheduling plan with a simple view.

For backend MS SQL Server was used as the database. As discussed in previous chapter to solve the production planning and scheduling problem, there are so many iterations repetitions have been gone through to build a proper accurate plan. Therefore to formulate the algorithm, SQL scripting has been used to speed up the processing time.

6.3. Implementing Graphical User Interfaces

6.3.1. System Login

System is loaded with the login screen (Figure 6-1). Each system user would have User Name and Password, to access the software.

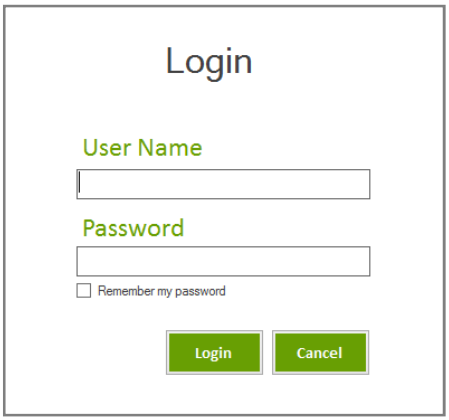


Figure 6-1: Login Screen

6.3.2. System Navigation

Figure 6-2illustrates the main menu navigation. Tile menu design was used to navigate the system

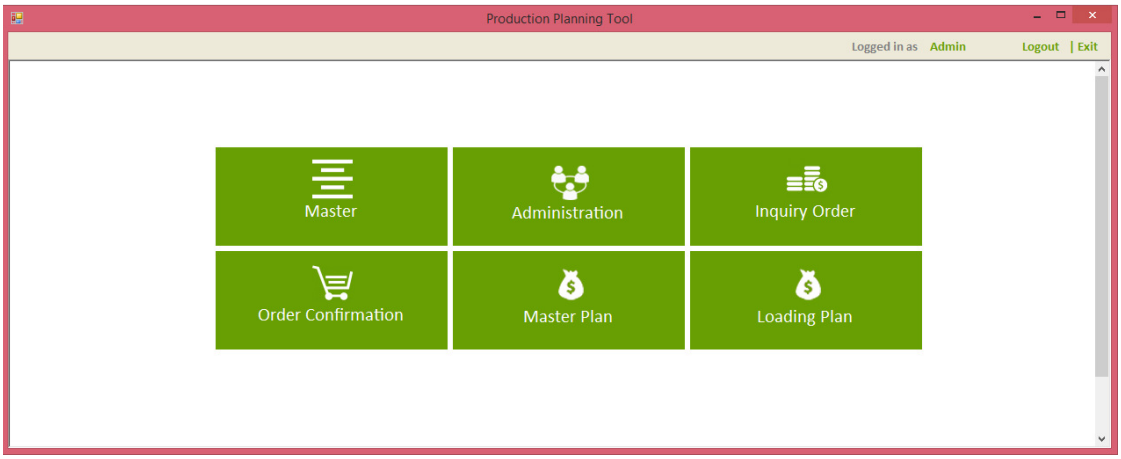


Figure 6-2: System Navigation

6.3.3. Implementation of Merchant Use Case

As illustrated in use case of merchant in Figure A-1, main functionalities of merchant are as follows.

- **Login**

  Merchant can log into the system by using the login screen in the use case

- **Enter Inquiry Details**

  All inquiries of products, and expected deliveries are entered in inquiry (Figure 6-3)

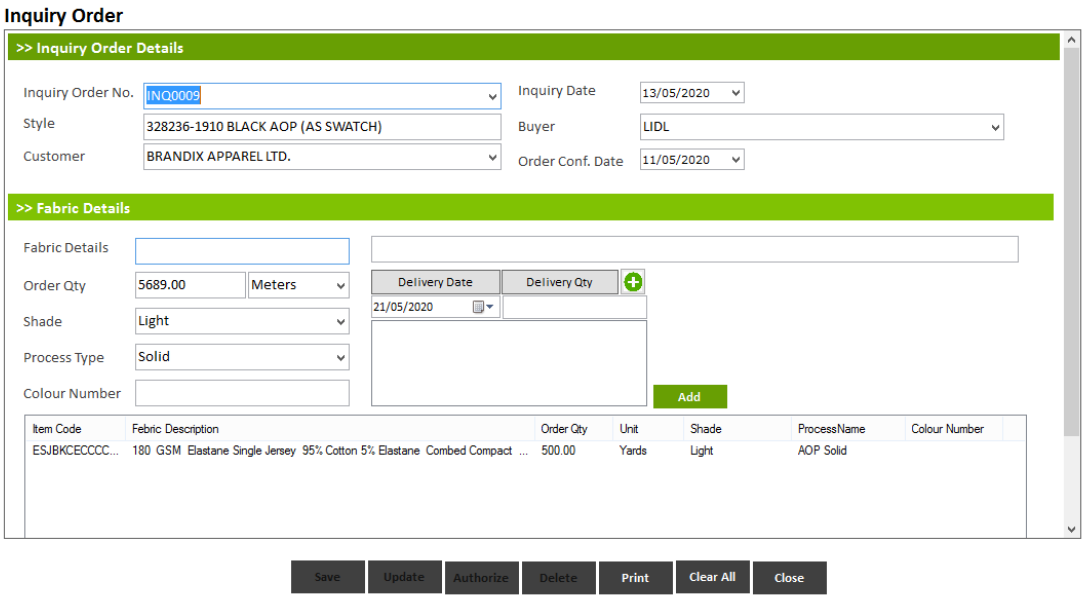


Figure 6-3 Inquiry Order Entry Screen

- **Enter Order Details**

  Once the order is confirmed by customer, merchant will enter the confirmed order details in the Order Confirmation screen (Figure 6-4) which enables the merchant to do the necessary changes the delivery days and quantities. Except delivery days and quantity, merchant cannot change any other details entered in Inquiry.

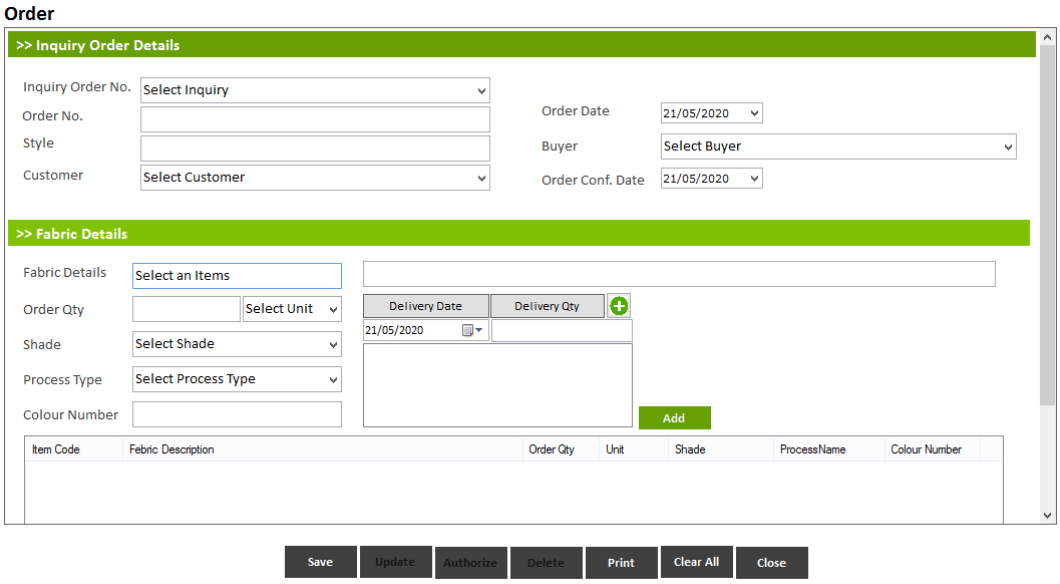


Figure 6-4: Order Confirmation Screen

6.3.4. Implementation of Planner Use Case

As illustrated in use case of merchant in Figure A-2, main functionalities of merchant are as follows.

- **Login**

  In the use case Planner can log into the system by using the login screen

- **Load to Master Plan**

  Once the inquiries entered by the merchant, Planner can view the pending inquiries which are need to load in the master plan

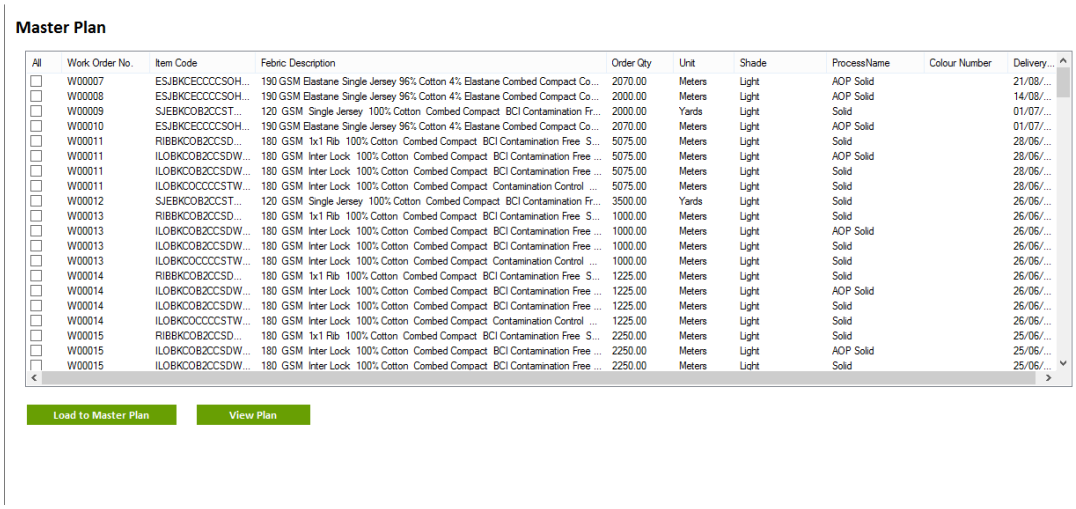
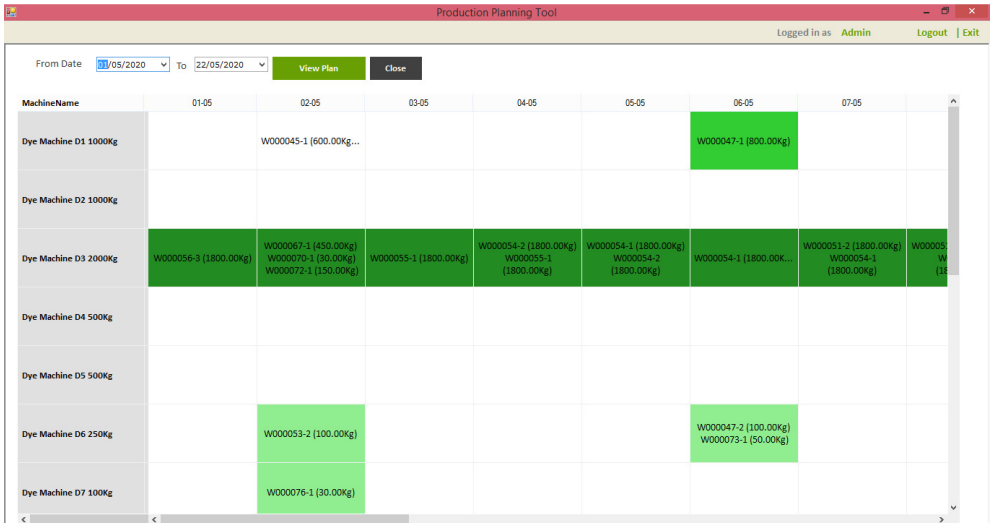


Figure 6-5: Pending Inquiry List

- **Generate Plan**

  Once inquiries loaded to the system, system will generate the Master plan of the inquiries



6.4. Summary

Functionalities of each use case and the implantation of each use case were discussed in this section. Each module has an interconnection with the system to give a better output to the user. Next chapter explains about the evaluation of the proposed solution.

Chapter 7.

7. Evaluation

7.1. Introduction

Achievements of the proposed system and main objectives are discussed in this chapter. Problems encountered and endeavours to be achieved in the future are also discussed.

7.2. Evaluation of Production Planning and Scheduling Tool

The algorithm has been applied on real data taken from the latest 100 inquiries of the company. Evaluation was done by comparing the output of the production plan from the system and manual production sheet which is currently in use. However the manual production sheet plans only by considering the available dye machine capacity, accuracy of the proposed plan to be evaluated with real production run.

In the evaluation phase, following key points were identified to check the accuracy of the system.

- Efficiency level of Dye Machine
- Rescheduling machine breakdown
- Check the production plan on a holiday

7.3. Testing of the Production Planning Tool

7.3.1. Testing Entry Screens

- User Registration and Login

Description	Test Procedure	Expected output	Result
User Registration	Enter registration details	Direct to relevant screen	Achieved
	Incomplete registration form filling	Notify all field required	Achieved
User Login	Not entered the relevant password	Notify Username or password entered is wrong	Achieved
	Not entered a relevant username	Notify Username or password entered is wrong	Achieved
	Enter incorrect username and password	Notify Username or password entered is wrong	Achieved
	Enter correct username and password	Direct to the relevant screen	Achieved

- Inquiry Order

Description	Test Procedure	Expected output	Result
Add new Inquiry	Enter all details	Display success message	Achieved
	Incomplete form filling	Remain on the same screen	Achieved
Edit Inquiry	Input relevant details	Display success message	Achieved
Authorize Inquiry	Confirm entry details	Display success message	Achieved
	Edit after authorization	Disable Save and Edit buttons	Achieved

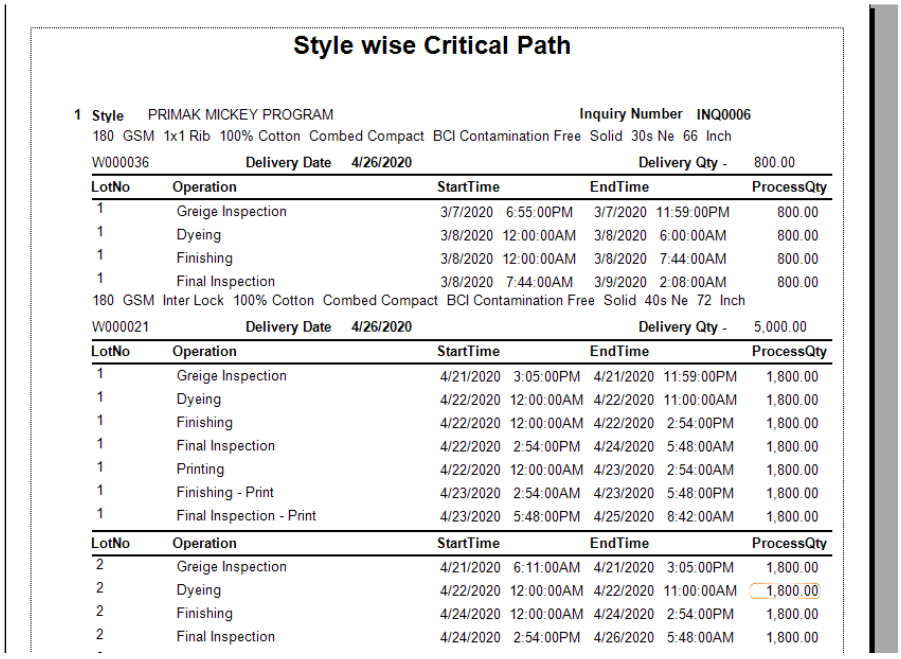
- Order Confirmation

Description	Test Procedure	Expected output	Result
Add new Inquiry	Enter all details	Display success message	Achieved
	Incomplete form filling	Remain on the same screen	Achieved
Edit Inquiry	Input relevant details	Display success message	Achieved
Authorize Inquiry	Confirm entry details	Display success message	Achieved
	Edit after authorization	Disable Save and Edit buttons	Achieved

- Moving to Master Plan

Description	Test Procedure	Expected output	Result
Save to Master Plan	Save an empty plan	Display error message	Achieved
	Select one or more inquiries and save in Master plan	Remove from pending Master plan	Achieved

7.3.2. Testing Style wise Delivery



Style wise Critical Path

1 **Style** PRIMAK MICKEY PROGRAM **Inquiry Number** **INQ0006**

180 GSM 1x1 Rib 100% Cotton Combed Compact BCI Contamination Free Solid 30s Ne 66 Inch

W000036 **Delivery Date** **4/26/2020** **Delivery Qty -** 800.00

LotNo	Operation	StartTime	EndTime	ProcessQty
1	Greige Inspection	3/7/2020 6:55:00PM	3/7/2020 11:59:00PM	800.00
1	Dyeing	3/8/2020 12:00:00AM	3/8/2020 6:00:00AM	800.00
1	Finishing	3/8/2020 12:00:00AM	3/8/2020 7:44:00AM	800.00
1	Final Inspection	3/8/2020 7:44:00AM	3/9/2020 2:08:00AM	800.00

180 GSM Inter Lock 100% Cotton Combed Compact BCI Contamination Free Solid 40s Ne 72 Inch

W000021 **Delivery Date** **4/26/2020** **Delivery Qty -** 5,000.00

LotNo	Operation	StartTime	EndTime	ProcessQty
1	Greige Inspection	4/21/2020 3:05:00PM	4/21/2020 11:59:00PM	1,800.00
1	Dyeing	4/22/2020 12:00:00AM	4/22/2020 11:00:00AM	1,800.00
1	Finishing	4/22/2020 12:00:00AM	4/22/2020 2:54:00PM	1,800.00
1	Final Inspection	4/22/2020 2:54:00PM	4/24/2020 5:48:00AM	1,800.00
1	Printing	4/22/2020 12:00:00AM	4/23/2020 2:54:00AM	1,800.00
1	Finishing - Print	4/23/2020 2:54:00AM	4/23/2020 5:48:00PM	1,800.00
1	Final Inspection - Print	4/23/2020 5:48:00PM	4/25/2020 8:42:00AM	1,800.00
LotNo	**Operation**	**StartTime**	**EndTime**	**ProcessQty**
2	Greige Inspection	4/21/2020 6:11:00AM	4/21/2020 3:05:00PM	1,800.00
2	Dyeing	4/22/2020 12:00:00AM	4/22/2020 11:00:00AM	1,800.00
2	Finishing	4/24/2020 12:00:00AM	4/24/2020 2:54:00PM	1,800.00
2	Final Inspection	4/24/2020 2:54:00PM	4/26/2020 5:48:00AM	1,800.00

Figure 7-1 Output of Style wise Delivery

7.3.3. Testing Machine wise Scheduling

Schedule - Machine wise
From 01/04/2020 to 19/06/2020

Machine Name	Dye Machine D1 1000Kg						
Capacity	1,000	Minimum Capacity	600	Maximum Capacity	950		
03-05-2020							
Operation	Start Time	End Time	Inquiry No	Work Order No	Lot No	Process Qty (Kg)	
Dyeing	03-05-2020 12:00 am	03-05-2020 4:00 am	INQ0008	W000045	1	800.00	
Dyeing	03-05-2020 6:00 am	03-05-2020 10:00 am	INQ0008	W000060	1	800.00	

Machine Name	Dye Machine D2 1000Kg						
Capacity	1,000	Minimum Capacity	600	Maximum Capacity	950		
03-05-2020							
Operation	Start Time	End Time	Inquiry No	Work Order No	Lot No	Process Qty (Kg)	
Dyeing	03-05-2020 12:00 am	03-05-2020 4:00 am	INQ0008	W000044	1	800.00	
Dyeing	03-05-2020 6:00 am	03-05-2020 10:00 am	INQ0008	W000046	1	800.00	

Machine Name	Dye Machine D3 2000Kg						
Capacity	2,000	Minimum Capacity	1,300	Maximum Capacity	1,800		
19-04-2020							
Operation	Start Time	End Time	Inquiry No	Work Order No	Lot No	Process Qty (Kg)	
Dyeing	22-04-2020 12:00 am	22-04-2020 9:00 am	INQ0006	W000021	1	1,800.00	
Dyeing	22-04-2020 11:00 am	22-04-2020 6:00 pm	INQ0006	W000021	3	1,400.00	

Figure 7-2 Machine wise Scheduling

Chapter 8.

8. Discussion

Textile manufacturing process consists of several stages such as fabric formation, finishing and dyeing which has separate manufacturing facilities due to space requirements and complexities involved in each of the stages. Due to this complexity and uncertainty it has become a challenge to process n production planning.

Most of past researches have suggested several algorithms based on certain key factors only. But in Textile manufacturing, there are several specific parameters need to be considered when processing or implementing production and planning. The proposed system has developed an algorithm that generates a production plan which gives the maximum efficiency by considering all the parameters.

Evolutionary algorithms can be successfully applied to large industrial scheduling problems through preliminary test results. Performance results were superior to those found other iterative methods. However, memory and processing time requirements would be prohibitive. without the inclusion of domain-dependent information.

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Appendix A.

Appendix A: Detail Description of Use case

A-1 Use case of Merchant

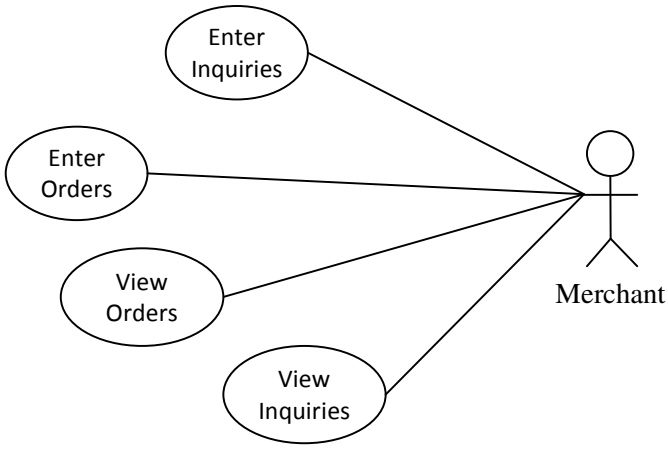

Figure A-1 Use case of Merchant

- **Use case : Enter Inquiry details**

  Brief Description

  After receiving an inquiry form the customer, Merchant enters the inquiry details such as product details, delivery details etc.

  Initial Step-By-Step Description:

  Prior to initiating this use case, Merchant has to log in to the Planning Tool

  - The merchant logsin to the system by entering user name and password
  - System will display the main navigation menu once the log in is successful.
  - Merchant selects the Inquiry Order from the menu and enter the inquiry details to the system

- **Use case : Enter Order details**

  Brief Description

  After sending delivery schedule, customer confirms the inquiry. Merchant has to enter the confirmed details to system.

  Initial Step-By-Step Description:

  Before initiating this use case, Merchant has to log in to the Planning Tool

  - The merchant login to the system by entering user name and password
  - On successful login, system will display the main navigation menu
  - Merchant selects the Order entering screen from the menu. After selecting the inquiry from the system, it updates the order details in the system.

- **Use case : View Inquiry Order Details**

  Brief Description

  After entering the inquiry details, Merchant can view the summary of the inquiry details. This summary can be viewed by the Planner

- **Use case : View Order Details**

  Brief Description

  After entering the inquiry details, Merchant can view the summary of the inquiry details. This summary can be viewed by the Planner

A-2 Use case of Planner

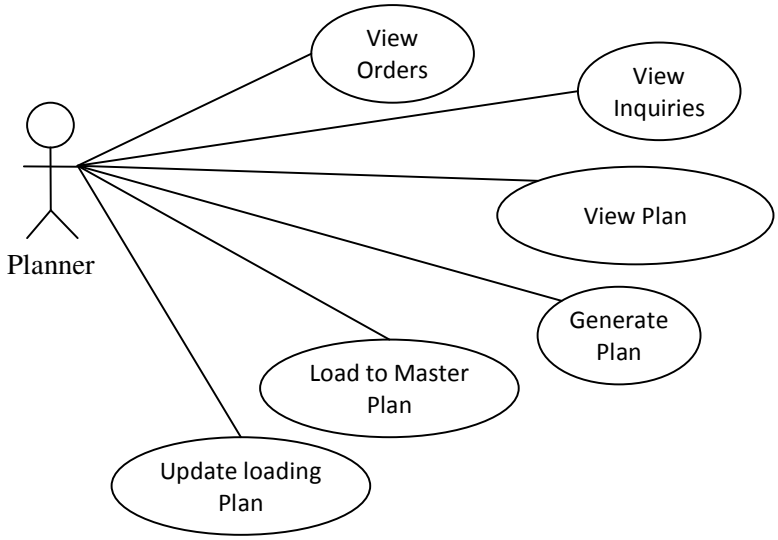

Figure A-2: Use case of Planner

- **Use case : Load to Master Plan**

  Brief Description

  After entering the inquiry details by merchant, pending inquiries will be loaded to the Master Plan. Planner can view the product code, delivery date and delivery quantity in a list.

  Initial Step-By-Step Description:

  Before initiating this use case, Planner has to login to the Planning Tool

  - The Planner logs in to the system by entering user name and password
  - On successful login, system will display the main navigation menu

- Upon selecting the Master Plan screen from the menu, the Planner can see all the pending inquiries and selects appropriate inquiries to move into the master plan.

- **Use case : Generate Plan**

  Brief Description

  Generate plan from inquiry and confirm orders. After the confirm of the order, plan will be locked. Once it is locked, schedule of the order will not be changed from the system. However planner can change order manually

- **Use case : Update Plan**

  Brief Description

  Planner can update or remove machines; holiday plan and re run the plan

- **Use case : View Plan**

  Brief Description

  Planner can view the plan after scheduling the plan. This plan can also be viewed by Merchant and Operations manger