DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

CAPACITY PLANNING IN A TEXTILE COMPANY

by
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July,2008
İZMİR

CAPACITY PLANNING
IN A TEXTILE COMPANY

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"CAPACITY PLANNING IN A TEXTILE COMPANY"** completed by **EZGİ CERYAN** under supervision of **PROF.DR.SEMRA TUNALI** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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This thesis is dedicated to my beloved son Arel.

Ezgi CERYAN

CAPACITY PLANNING IN A TEXTILE COMPANY

ABSTRACT

This thesis provides the opportunity of launching the capacity planning system in a company in the textile sector. The objective of this project is handling the demand fluctuations by utilizing regular time working capacity and subcontractor capacity for each product group in a predetermined planning period and giving the customer realistic due dates. To fulfill this target, it is essential to keep the company's and subcontractor's production costs at the minimum while meeting the due dates at optimum.

In order to achieve these goals a hybrid approach involving a two phased solution methodology is carried out. First an allocation problem is solved using mathematical programming following the assignment of jobs to the facilities under given capacity constraints. Afterwards, a detailed simulation model of the production floor is run to determine in which order the jobs will be processed on these facilities. The output of the mathematical programming model is used as an input for the simulation model. The use of analytical modeling and simulation together as a hybrid approach leads to a mathematically optimal and a realistically feasible solution.

Keywords: Linear Programming, Capacity Planning , Job-Shop Scheduling, Simulation

BİR TEKSTİL FİRMASINDA KAPASİTE PLANLAMASI

ÖZ

Bu tez, konfeksiyon sektöründe faaliyet gösteren bir firmada kapasite planlaması imkanını sunmaktadır. Bu projenin amacı; her ürün grubu için belli bir planlama dönemindeki normal mesai çalışma kapasiteleri ile fason üretim kapasitelerinden optimum düzeyde faydalanarak, karşılanamayan ya da geciken siparişlerin miktarını minimum düzeyde tutmak ve talep dalgalanmalarını karşılamaktır. Bu amaçları gerçekleştirirken , işletmenin normal mesai ve fason üretim işçilik maliyetlerinin minimum düzeyde tutulması esas alınmıştır.

Bu amaçlara ulaşabilmek için hybrid bir yaklaşım önerilmiştir.Bu yaklaşım 2 aşamadan oluşmaktadır. Öncelikle matematiksel programlama yöntemi ile bir atama algoritması yazılarak kapasitelere uygun atamalar yapılmış daha sonra ikinci aşamada simulasyon ile çizelgeleme algoritması oluşturulmuş ve termin süreleri mümkün olan en optimum sürelere yaklaştırılmıştır. Burada planlama metodu olarak matematiksel programlama metodu kullanılmıştır. Bu aşamada amaç fonksiyonunu etkileyebilecek kısıtlar belirlenmiştir. Matematiksel modelin çıktısı olan atama verileri simulasyon çalışmasının girdisi olarak kullanılmış ve müşterilere gerçekçi termin süreleri verilmesi amaçlanmıştır.

Anahtar Sözcükler: Matematiksel programlama, Kapasite planlaması, Atölye tipi üretim çizelgeleme, Simulasyon

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CHAPTER ONE

INTRODUCTION

1.1 Purpose of the Research

The dynamics and flexibility of manufacturing systems are of increasing importance for companies in the global market. Two main strategies to gain competitive advantages are cost efficiency and superior value adding to customer (Christopher, 1992). The operational control of the manufacturing system is the most important aspect of this process .Typical activities in that process are short-term capacity and resource planning, scheduling and sequencing of the customer orders. The production plan provides key communication links from top management to manufacturing. It determines the basis to focus on the production resources in detail to achieve the firm's strategic objectives.

Moreover, the production plan provides a direct and consistent dialogue between manufacturing and top management, as well as between manufacturing and the other functions. Many key linkages of production planning are outside the manufacturing planning and control system (MPC). These key linkages are shown in Figure 1.1.

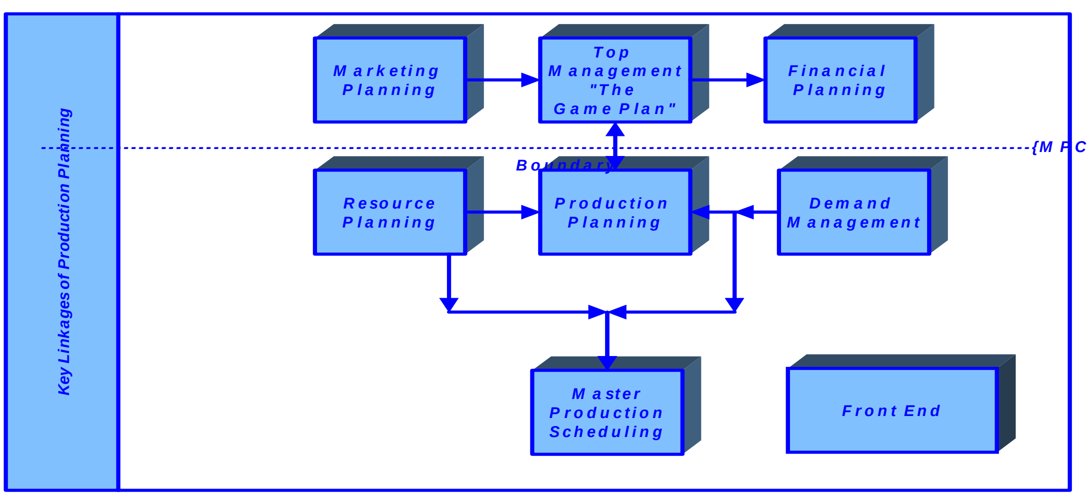

Figure 1.1 Key Linkages of Production Planing (Vollmann,1992,p:365)

The purpose of this study was to determine which items should be produced locally and which should be outsourced to external subcontractors in a textile company operating in Izmir so that the cost of production can be minimized and realistic due dates can be given to the customers.

Traditionally, mathematical programming is used as a framework for developing such an approach. Much of the research in mathematical programming is directed towards the formulation and generation of optimal solution to problems, by using insights into the structure of these problems and rigorously analyzing special cases and simplified models. The solutions to these models may need to be modified manually or through an intelligent decision aid to accommodate features not captured in the model.

To overcome the difficulty in mathematical modeling, and also to realistically model a real industrial problem, in this study a hybrid procedure integrating analytic approaches and simulation modeling is proposed. In doing so, the advantages of mathematical programming and simulation are brought together while eliminating their disadvantages.

1.2 Research Methodology

The production plan states the mission, which manufacturing company must accomplish to meet the overall objectives of the firm. How to accomplish the production plan in terms of detailed manufacturing and procurement decisions is a problem for manufacturing management. In this thesis we will deal with the capacity planning and scheduling problem by employing both analytical approaches and simulation modeling. This hybrid methodology brings together the advantages of both approaches while eliminating their disadvantages.

1.3 Outline of the Thesis

The capacity planning and production scheduling problem is explained in the following chapter. Chapter three presents the survey of current relevant literature and introduces the mathematical programming and simulation approaches to deal with the production planning and scheduling problem. Chapter four illustrates the implementation of the proposed hybrid approach using an industrial case study from a textile company operating in Izmir. Finally, concluding remarks are presented in chapter five.

CHAPTER TWO

CAPACITY PLANNING AND PRODUCTION SCHEDULING

2.1 Production Planning

Manufacturing planning and control entails the acquisition and allocation of limited resources to production activities so as to satisfy customer demand over a specified time horizon. As such, planning and control problems are inherently optimization problems, where the objective is to develop a plan that meets demand at minimum cost or that fills the demand that maximizes profit.

Typical management activities supported by production planning systems include:

- Plan requirements and availability to marketplace needs,
- Plan for materials to arrive on time in the right quantities needed for product production,
- Ensure utilization of capital equipment and other facilities is appropriate,
- Maintain appropriate inventories of raw materials ,work in process and finished goods – in the correct locations,
- Schedule production activities so people and equipment are worked on the correct things,
- Track material, people, customers' orders, equipment and other resources in the factory,
- Communicate with customers and suppliers on specific issues and long-term relationships,
- Meet customer requirements in a dynamic environment that may be difficult to anticipate,
- Respond when things go wrong and unexpected problems arise.

2.2 Production Planning for Operations and Capacity

A large portion of management activity involves working with and through other people to develop plans that appears best for the organization's success and to see that plans are executed.

Planning is an important management activity. There is a natural tendency to think that the greatest accomplishment , people must stay busy at all times. But perfect execution, with 100 percent efficiency of a poor plan will not lead to the most desirable result. It is important that the efforts of people in organization be guided by plans that are most likely to achieve the best goals for the organization.

Adequate time must be spent evaluating conditions and planning how the organization's efforts can best be applied while there is sufficient time to successfully carry out the plan. Planning involves establishing suitable goals, anticipating what actions must be initiated. So there will be sufficient lead time for the activities to be accomplished smoothly and efficiently.

2.3 Overview of the Operations Planning Activities

The firm must plan its operation planning activities at a variety of levels and operate these as a system. The Major Planning Activities in an organization are presented in Figure 2.3.

Long Range Planning is generally done focusing on a horizon greater than one year. Intermediate range planning usually covers a period from 6 to 18 months, with time increments that are monthly or sometimes quarterly. Short Range Planning covers a period from one day or less to six months, with the time increment usually weekly. Process planning deals with determining the specific technologies and procedures required to produce a product or service. size and scope of the production system.

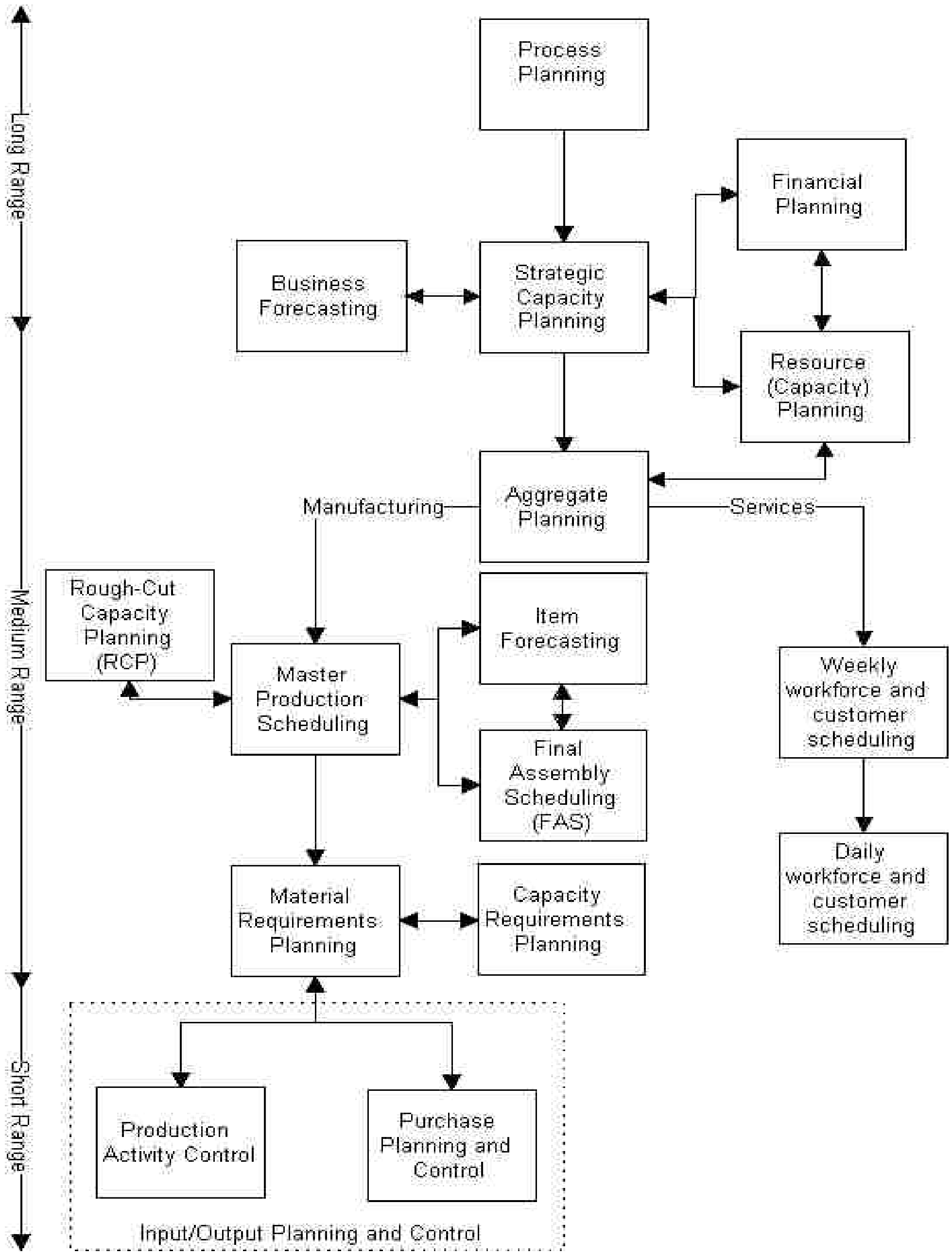

Figure 2.3 Major Planning Activities (Chase,1998,p.402)

The aggregate planning process is essentially the same for services and manufacturing, the major exception being manufacturing's use of inventory builds up and cutbacks to smooth production. After the aggregate production planning stage, manufacturing and service planning activities are generally quite different.

In manufacturing, the planning process can be summarized as follows: The production Control group inputs existing or forecast orders into a master production schedule(MPS). The MPS generates the amounts and the dates of specific items required for each order. The MPC is usually fixed over the short run (six to eight weeks). Beyond six to eight weeks, various changes can be made, with essentially complete revisions possible after six months.

Rough-cut capacity planning is then used to verify that production and warehouse facilities, equipment and labor are available ant that key vendors have allocated sufficient capacity to provide materials when needed. Materials Requirement Planning(MRP) takes the end product requirements from the MPS and breaks them down into their parts and their subassemblies to create materials plan. This plan specifies when production and purchase orders must be placed for each part and subassembly to complete the products on schedule. Capacity Requirements Planning (CRP) should really be referred to as capacity requirements scheduling, since it provides a detailed schedule of when each operation is to be run on each work center and how long it will take to process. The information it uses comes from planned and open orders from the materials plan.

Final Assembly Scheduling provides the operations required to put the product in its final form. It is here that customized or final features of the product are scheduled. Input/Output planning and control refers to a variety of reports and procedures focusing on schedule demands and capacity constraints deriving from the materials plan.

Production Activity Control is a relatively new term used to describe scheduling and shop-floor control activities. The planning activity is daily or weekly order scheduling of jobs to spesific machines, production lines, or work centers.

Purchase Planning and Control deals with the acqusition and control of purchased items, again as specified by the materials plan. Input/Output planning and control are necessary to make sure that purchasing not only is obtaining materials in time to meet the schedule, but is aware of those orders that, for various reasons, call for rescheduling purchases. In services, once the aggregate staffing level is determined, the focus is on workforce and customer scheduling during the week or even hour by hour during the day.

Workforce schedules are a function of the hours the service is available to a customer. The particular skills needed at particular times over the relevant time period, and so on. Many service jobs have unique time and legal restrictions affecting scheduling that typical manufacturing work lacks.

Customer scheduling deals with setting appointments and reservations for customers to use the service, and assigning priorities when they arrive at the service facility. These obviously range from formal reservation systems to simple sign-up sheets. In summary, all the planning approaches attempt to balance the capacity required with the available capacity , and then schedule and control production according to the changes in the capacity balance. In Figure 2.3 the major planning activities are shown.

2.3.1 Hierarchical Production Planning

One approach to aggregate capacity analysis that is based upon disaggregation concepts and can accommodate multiple facilities is hierarchical production planning. The approach incorporates a philosophy of matching product aggregations to decision-making levels in the organization. Thus, the approach is not a single mathematical model but utilizes a series of models where they can be formulated. Since the disaggregation follows organization lines, managerial input is possible at each stage. A schema of the approach is shown in Figure 2.4 Hierarchical Planning Schema.

The development of hierarchical production planning (HPP) has been the effort of a group of researchers (Bitran, Haas, Hax, Meal, and others) over several years. Some of the work has involved mathematical contributions, while others increase the depth or breadth of application (incorporating distribution centers or levels of detail in a factory). All, however, are based on some fundamental principles.

One principle has been mentioned already: the disaggregation should follow organizational lines. Another principle is that it is only necessary to provide information at the aggregation level appropriate to the decision. Thus, it is not necessary to use detailed part information for the plant assignment decisions. Finally, it is necessary to schedule only for the lead time needed to change decisions. That means that detailed plans can be made for periods as short as the manufacturing lead times.

The process of planning follows the schema of Figure 2.4 Hierarchical Planning Schema first involves the specification of which products to produce in which factories. The products are combined in logical family groupings to facilitate the aggregation, assignment to factories, and modeling processes. The assignment to factories is based on the minimization of capital investment cost, manufacturing cost, and transportation cost.

Once the assignment to factories has been done and managerial inputs incorporated, an aggregate production plan is made for each plant. The procedure for the determination of the aggregate production plan could be any of those discussed previously. The aggregate plan specifies production levels, inventory levels, overtime, and so on, for the plant. This plan is constrained by the specific products and volumes assigned to the plant.

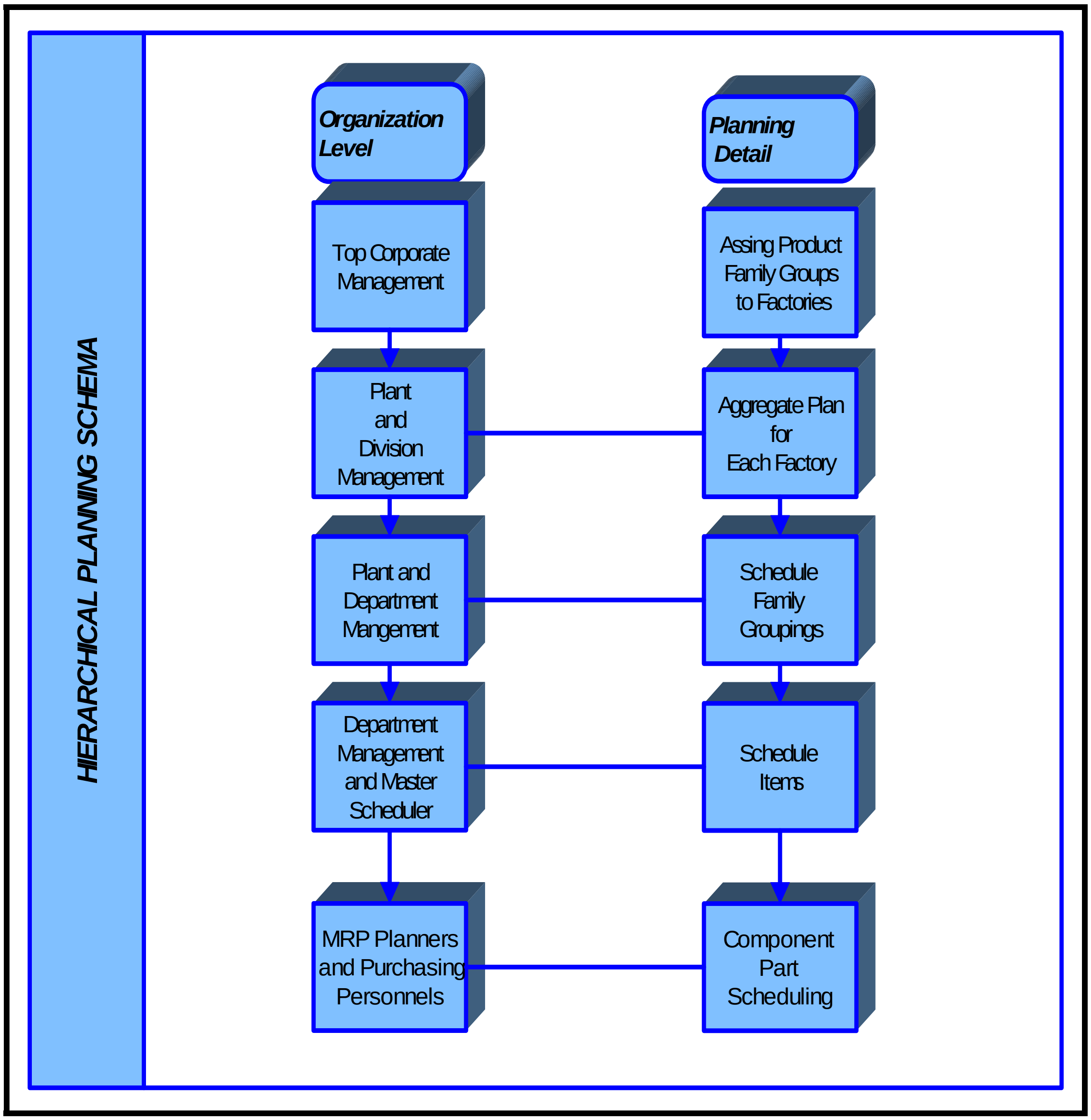

Figure 2.4 Hierarchical Planning Schema

The next step in the disaggregation calls for scheduling the family groupings within the factory. The schedule is constrained by the aggregate production plan and takes into account any inventories that may exist for the group. The intention at this stage is to realize the economies of producing a family grouping together. The production lots for the groups are determined and sequenced. If no major economies are achieved by scheduling the group as a unit, the procedure can move directly to the scheduling of individual items, the next stage shown in Figure 2.4 Hierarchical Planning Schema.

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The determination of the individual item schedule is analogous to making a master production schedule (MPS). In the HPP schema, the MPS is constrained by the previously scheduled family groupings and may cover a shorter planning horizon. In some instances, mathematical models can be used to establish the schedules. In all cases, the items are scheduled within the capacity allocated for the family group to which it belongs. The detailed part and component scheduling can be done with MRP logic, order launching and inventory systems, or even mathematical modeling.

A recent extension to the basic HPP model is to use variable planning periods rather than the fixed planning period of 20 days used in the Bitran, Hass, and Hax approach. Oden develops a recursive algorithm to predict length of the planning period which minimizes the annual sum of setup and inventory holding costs. Oden's model produces consistently lower production costs (overtime, setup, inventory holding) than those of the fixed period approach.

2.3.2 Aggregate Planning

The aggregate plan is a preliminary, approximate schedule of an organization's overall operations that will satisfy the demand forecast at minimum cost. Planning horizons, the period over which changes and demands are taken into consideration, are often one year or more and broken into monthly or quarterly periods. This is because one of the purposes of aggregate planning is to minimize the short-sighted effects of day to day scheduling where small amounts of material may be ordered from a supplier and workers laid of one week. By taking a longer term perspective of resource use, short- term changes in requirements can be minimized with a considerable cost savings.

The basic approach in minimizing short-term variations is to work only with aggregate (grouped or bunched together) units. Aggregate resources are used, such as total number of workers, hours of machine time, and tons of raw materials, as well as aggregate units of output-gallons of product, hours of service delivered, number of patients seen , and so on- totally ignoring the fact that some are blue and others are red, some soft and some hard, and so forth. That is, neither resources nor outputs are broken down into more specific categories; that occurs at a later stage.

On occasion, the units of aggregation are somewhat difficult to determine, especially if the variation in output is extreme (such as when a manufacturer produces dishwashers, clothes washers and dryers). In such cases, equivalent units are usually determined based on value , cost , worker hours input, or some similar basic measure.

The resulting aggregate planning problem is to minimize the long-run costs of meeting forecasted demand. The relevant costs include those of hiring and laying off workers, storing finished goods (if a product is involved), wages and overtime charges, shortage and backordering costs and subcontracting costs. As it turns out , the use of inventory to buffer production against variations in demand is an extremely important managerial option. In service organizations this option is usually not available since services, such as plane trips, can not be inventoried. The result is an increase of cost to produce the service with a result of increase in the price of the service.

2.3.3 The Production Plan

The result of managerial iteration and changes to the aggregate plan is the organization's formal production plan for the planning horizon, used by the organization. Sometimes this plan is broken down (i.e disaggregated) one level into major output groups - for example, by models but not by colors. In either case, the production plan shows the resource requirements and output changes over the future: hiring requirements, capacity limitations, the relative increases and decreases in materials inventories, the output rate of goods or services.

2.3.4 The Master Schedule

The driving force behind the scheduling process is the master schedule, also known in industry as the master production schedule (MPS). There are two reasons the MPS is the driving force. It is this point that actual orders are incorporated into the scheduling system. This is also the stage where aggregate planned outputs are broken down into individual scheduled items(called level zero items). These items are then checked against lead time (time to produce or ship the items) and operations capacity (if there is enough equipment, labor etc.) for feasibility.

The actual scheduling itself is usually an iterative process, with a preliminary schedule being drawn up, checked for problems, and then revised. After a schedule has been determined, the following problems are checked:

- Does the schedule meet the production plan?
- Does the schedule meet the end item demand forecast?

- Are there priority or capacity conflicts in the schedule?
- Does the schedule violate any other constraints regarding equipment, lead times, supplies, facilities, and so forth?
- Does the schedule conform to organizational policy?
- Does the schedule violate any legal regulations or organization ,union rules?
- Does the schedule provide for flexibility and back-ups?

Any one of these problems may force a revision of the schedule and a repeat of the iterative process. The result is that the master schedule then specifies what end items are to be produced in what periods to minimize costs and gives some measure of assurance that such a plan is feasible. Clearly, such a document is of major importance to any organization it is, in a sense, a blueprint for future operations.

2.3.5 Rough-Cut Capacity Planning

As a part of checking the feasibility of the master schedule, a simple type of rough-cut capacity planning is conducted. Historical ratios of workloads per unit of each type of product are used to determine the loads placed on the work centers by all the products being made in any one period. Then the loads are assumed to fall on the work centers in the same period as the demands; that is, the lead times are not used to offset the loads. If the work center's capacities are not overloaded (under-loads are also checked). It is assumed that sufficient capacity exists to handle the master schedule and it is accepted for production.

2.3.6 Capacity Planning

The inventory control system and master schedule drive the capacity requirements planning (CRP) system. This system projects the job orders and demands for materials into equipment, workforce, and facility requirements and finds the total required capacity of each over the planning horizon.

This may or may not exceed available capacity. If it is within capacity limits, then the master schedule is finalized, work orders are released according to schedule, material's orders are released by the priority planning system, and load reports are sent to work centers listing the work based on the CRP system. Note that external lead times (usually longer than internal lead times) from suppliers have already been checked in the priority planning stage, so the master schedule can indeed now be finalized. If the capacity limits are exceeded, however, something must be changed. Either some jobs must be delayed, a less demanding schedule devised, or extra capacity obtained elsewhere (e.g., by hiring more workers or using overtime). It is the role of production planning and control to solve this problem.

2.3.7 Allocation of Jobs

Although the capacity planning system determines the sufficient gross capacity exists to meet the master schedule, no actual assignment of jobs to work centers is made. Some equipment will generally be superior for certain jobs, and some equipment will be less heavily loaded than other equipment. Thus, there is often a "best" (fastest or least costly) assignment of jobs to work centers.

2.3.8 Sequencing

Even after jobs have been assigned to work centers, the order in which to perform the job (sequencing) must still be decided. Unfortunately, even this seemingly small final step can have major repercussions on the organization's workload capacity and the timeliness of job completions.

2.3.9 Detailed (Short-Term) Scheduling

Once all the foregoing has been specified, detailed schedules itemizing specific jobs, times, materials, and workers can be drawn up. This is usually done for only a few days in advance, however, since changes always occur and detailed schedules become outdated quickly. It is production planning and control's responsibility to ensure that when the job is ready to be worked on, all the items, equipment, facilities, and information are available as scheduled.

2.4 Scheduling

Scheduling in general deals with assignment of activities to limited recourses where a set of constraints has to be regarded. These constraints can be e.g. restrictions on the ordering of operations, due dates etc. Despite of many different scheduling definitions, all include similar constraints and objectives.

"Scheduling is a study that concerns the allocation of limited resources to the tasks, which can be in several forms, from service industry to manufacturing systems, or information processes" (Pinedo, 1995).

"Scheduling specifies the resources that each task needs at particular times. Any process that defines a subset of What - When - Where can be said to "do scheduling " (Parunak, 1990).

The ultimate objective of the scheduling task is to select a schedule that optimizes some pre-stated goal. In this context a schedule is formally defined as a set of start and completion times for a group of jobs on a group of machines that satisfy all problem constraints. According to Baker (1974), the three types of decision-making goals that are prevalent in scheduling are:

- Efficient utilization of resources.

- Rapid response to demands.
- Close conformance to prescribed deadlines.

A planner constitutes a scheduling function which covers the entire jobs or the group of tasks defined for the group of the jobs in the company. Scheduling function should have integration with several other important functions in the organization.

Initially, it is affected by the production planning process, which handles medium and long-term planning for the entire organization. At this level, scheduling process should consider many components such as inventory levels, forecasts and resource requirements to optimize at a higher level, the product mix and resource allocation for long term period, then it focuses on unexpected events in the shop floor such as machine breakdowns, or random processing times.

As known planning is a whole system in which scheduling is only one of the stages. The main difference between scheduling and planning under time/resource constraints is that, in scheduling we know the set of activities in advance, while in planning we have to generate the activities. This difference also explains the major interaction between traditional planning and scheduling: first plan/generate the set of activities and then schedule/allocate these activities to resources. The diagram in Figure 2.5 depicts the information flow and the place of scheduling activity in a manufacturing system.

The scheduling function uses mathematical techniques or heuristic methods to allocate those limited resources to the processing of tasks. A proper allocation of resources enables the company to optimize its objectives and achieve its goals. Resources may be machines in a workshop, runways at an airport, crews at a construction site, or processing units in a computing environment. Tasks may be operations in a workshop, takeoffs and landings at an airport or stages in a construction project. Each task may have a priority level, an earliest possible starting time, and a due date. The objectives may also take many forms, such as minimizing the time to complete all tasks or minimizing the number of tasks completed after their due dates. (Pinedo& Chao, 1999, p.2)

Although to define a scheduling problem in words is often easy, unfortunately, scheduling can be difficult to perform and implement. Since the time function goes into the scheme, solution branches grow up to a huge amount, at once. Then, implementation difficulties arise related to the modeling of the real world scheduling problems whereas technical difficulties come across the solution methodology and procedures. Resolving these difficulties takes skill and experience but is often financially and operationally well worth the effort. (Pinedo& Chao, 1999, p.5)

2.5 Principles of Scheduling

Scheduling is comprised of a series of sequential steps or a routing. General plans or schedules have the following inputs related with the sequential steps:

- The sequence of operations
- Necessary sequential constraints
- The time estimates for each operation
- Required resource capacities for each operation

In addition scheduling activity serves for finding the answers to the questions such as when an end item will be completed, and what jobs are to be completed during a specified time. Figure 2.5 shows the flow of information in a manufacturing system.

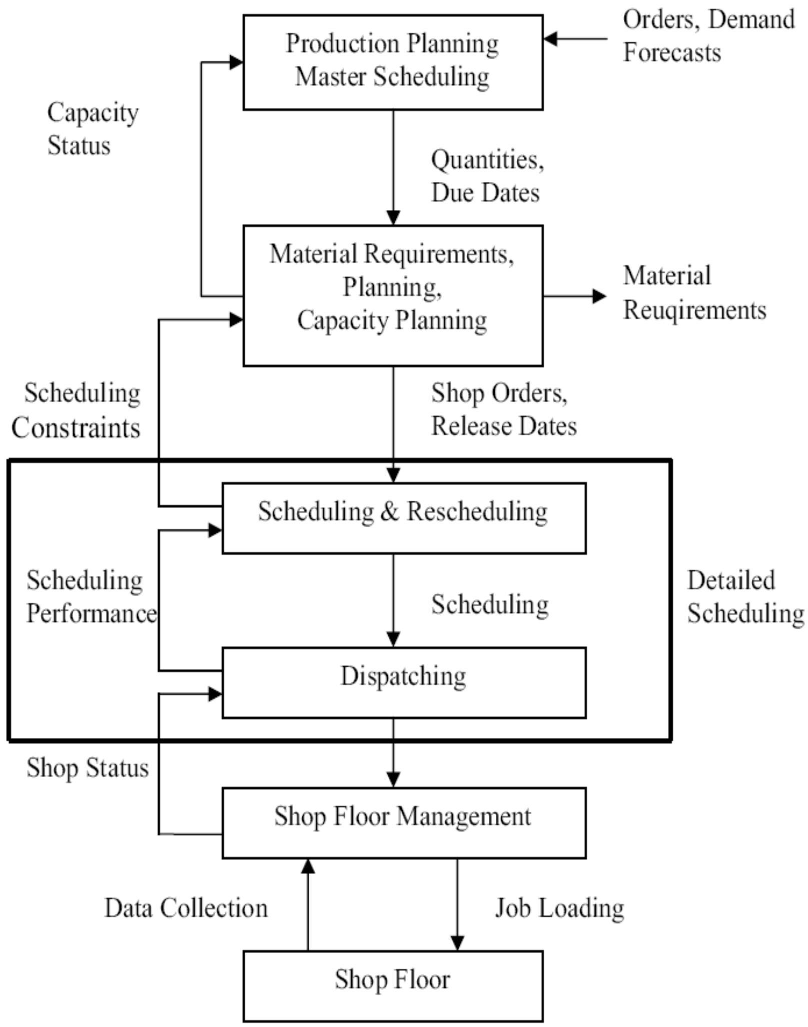

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Figure 2.5 Information Flow Diagram in a manufacturing system (Pinedo&Chao,1999)

2.5.1 Scheduling Objectives

Different types of objectives may be under consideration in solving scheduling problems. The classical objective functions which are either of the ‘min-sum’ or the ‘min-max’ type are built by considering the following elementary functions (Brandimarte, Villa, 1995, p110):

$$Flow\,time : F_i = C_i - r_i$$
$$Tardiness : T_i = \max\{C_i - d_i, 0\}$$
$$Earliness : E_i = \max\{d_i - C_i, 0\}$$
$$Lateness : L = C_i - d_i$$

The most significant min-sum objective functions are:

$$\sum_{i=1}^{n} C_i = Total\ completion\ time \qquad \sum_{i=1}^{n} w_i C_i = Total\ weighted\ completion\ time$$

$$\sum_{i=1}^{n} T_i = Total\ tardiness \qquad \sum_{i=1}^{n} w_i T_i = Total\ weighted\ tardiness$$

$$\sum_{i=1}^{n} U_i = Number\ of\ tardy\ jobs \qquad \sum_{i=1}^{n} w_i U_i = Weighted\ number\ of\ tardy\ jobs$$

The most significant minmax objective functions are:

$$L_{max} = \max L_i = maximum\ lateness$$

$$T_{max} = \max T_i = maximum\ tardiness$$

$$C_{max} = \max C_i = makespan$$

$$r_i = Release\ date \quad d_i = Due\ date \quad w_i = Weight\ of\ a\ job \quad C_i = Completion\ time\ of\ a\ job$$

The shop structure is also a part of a scheduling framework. For example, in a flow shop the jobs go through a fixed sequence of the same routing steps whereas in job shops have customized products with unique routing steps. Additionally shop structure is about its capacity. A solution may not be appropriate for each different problem sizes although the problem remains same.

The critical issues about product structures, which affect the scheduling environment, are:

- Existence of single part or assembly routings
- Type of processing time distribution
- Alternate routings
- Operation overlapping
- Lot sizes

Flexibility of the production system is an important criterion for work center capability. The extent to which capacity for a particular work center can be increased or decreased and the time delay to change the capacity both affects scheduling performance. Another issue in work center capacity is to focus on the bottlenecks. If the capacity of the bottleneck can be well utilized, then the overall scheduling performance would be improved too.

2.6 General Assumptions in Machine Scheduling

To simplify the complexity of manufacturing and service environments, most of the scheduling problems are solved under assumptions associated with job characteristics and objective functions. The following list gives a set of these assumptions and points out when some of them are inadequate to represent a realistic scheduling problem (Brandimarte & Villa, 1995, pg.104-106):

Single parts and batches of parts are always treated as a single job.

Although this assumption may be appropriate in many situations, in case of large lots, it may produce poor quality schedules. The classical machine scheduling formulation does not allow starting processing on a latter machine until all the parts in the lot are processed on the first one. However, a better schedule may be obtained by transferring a sub-batch of a part to the preceding machine before the completion of the whole batch; such sub-batches are called transfer batches.

Job cancellation is not allowed.

All the jobs are to be processed eventually. This is not always true; for instance, it may be useful to draw a distinction between high-priority and low-priority jobs; low priority jobs may be scheduled only if the execution of the high-priority ones leaves enough idle time on the machines.

Preemption is not allowed.

Preemption occurs when an operation is stopped and resumed at a later time. This is clearly unacceptable from the technological point of view in most manufacturing environments. However, this is not the case, when scheduling tasks on computer systems.

Each job visits all machines exactly once.

In practical problems, some machines may not be required for a certain job. In other cases, a machine may be visited more than once by the same job, e.g., reworking of defective parts.

Machines are always available.

In practice, machines may not be available because of controllable events (e.g., preventive maintenance) and uncontrollable events (e.g., failures).

Jobs are all known in advance.

This is the characteristic that distinguishes static and dynamic scheduling problems. In a dynamic scheduling environment, new jobs arrive at unpredictable times.

The problem is purely deterministic.

In practice, scheduling problems are stochastic in nature. Machine failures, unpredictable processing times, (e.g., in the case of manual operations) causes this uncertainty.

Processing times are independent of the schedule.

Essentially, this assumption implies that setup times are sequence-independent and can be included in the processing time. This is not the case when sequence dependent setup times are to be dealt with. A classical case occurs in paint production, where sequencing a lot of white paint after the production of black paint is a very bad idea, due to the large setup time needed to clean the machine.

Machines are the only resources modeled.

In practice, it may be necessary to model additional resources such as transportation devices (e.g., automated guided vehicles), tools, or skilled labor.

Work-in process is allowed.

Jobs may wait in a queue until next machine required for processing is idle. In some metallurgical processes, this situation is not possible.

Machines are able to process one job at a time.

This is a correct assumption for many mechanical operations. Batch processors such as thermal treatment machine, PCB processors, etc violates the assumption.

Precedence constraints can be occurred.

2.7 Classification of Scheduling Systems

Scheduling models and systems are classified into different categories hierarchically and these categories are summarized in Figure 2.6. Scheduling problems are first divided into two categories as static and dynamic. In the static scheduling problem, a fixed set of jobs which are defined at the beginning of the scheduling process are to be planned. The typical assumptions are that, the entire set of jobs arriving at the same time and all the work centers being available at that time.

Static scheduling problems are investigated by using either deterministic or stochastic processing times. Methods based on the deterministic times can be divided into subtypes of those producing optimum results and those utilizing heuristic scheduling procedures. As the computational difficulty increases exponentially with the problem size, optimization methods are used mostly for small problems. For more complex problems, heuristic procedures such as dispatching or sequencing rules are used.

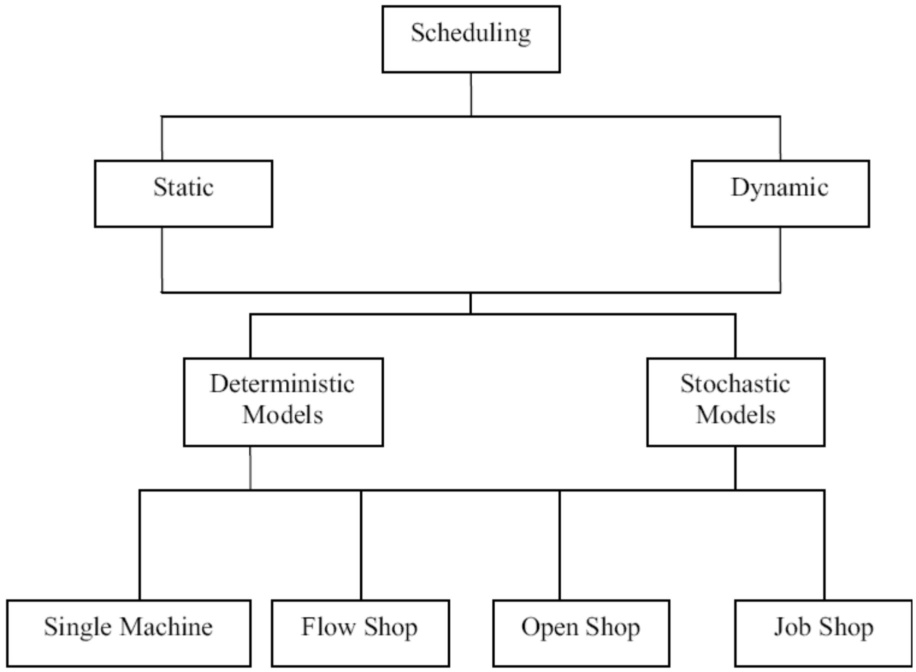

Figure 2.6 Classification of scheduling

Dynamic scheduling additionally considers the new jobs that are added during the production. Dynamic scheduling is based on the prioritization between jobs. The rules that are used in dynamic scheduling differ from the rules used in static scheduling in terms of the properties which are considered for scheduling process. Whereas in static scheduling the unchanged properties such as processing time or due dates are considered, in dynamic scheduling the properties which change during the scheduling process such as reaming process time are considered.

Simulation is most commonly used for large scale dynamic scheduling cases. The main difference between stochastic and deterministic models is the randomness of events and times. In stochastic models, machine breakdowns, unexpected orders, random process times and preemption are considered whereas in deterministic models not.

In this study , simulation is used in conjunction with analytical modeling to deal with a dynamic scheduling problem in a textile company. The further details about these two methodologies employed are given in the following section.

CHAPTER THREE

LITERATURE REVIEW

The job shop scheduling problem (JSP) is one of the hardest discrete optimization problems. It consists of sequencing a set of jobs on a set of machines in order to minimize an objective function. Each machine processes at most one job at a time and each operation is processed on one machine given.

The flexible job shop scheduling problem (FJSSP) is NP-hard since it is an extension of the job shop scheduling problem. The NP-hardness of an optimization problem suggests that it is not always possible to find an optimal solution quickly. Especially, by the increase of problem size, an enormous computational effort is needed for an optimal solution. So there should be made a trade off between solution quality and time

For scheduling a high variety of different techniques are used. Generally they can be classified into two main groups :

1. Optimum solution seeking methodologies
2. Approximate solution seeking methodologies

The methods which seek for optimization are the most complicated ones so they require enormous computation time to reach the optimal solution. The bigger problem size is considered, more difficult to reach the optimality so they are not always applicable to all problems in real life. The approximation methods which don't look for optimal solutions have greater application areas since they require less computation time.

3.1 Optimization Using Mathematical Techniques

3.1.1 Linear Programming

Linear programming is an optimization technique used to solve optimization problems which are formulated or programmed as a series of linear expressions. These expressions are statements of constraints that bound the problem solution and the objective function. Some scheduling problems can be formulated as linear programming problems with the objective defined in terms of the problem variables. However, as is the case with most scheduling problems of practical dimension, the computational demands can be extreme.

3.1.2 Branch and Bound Techniques

Branch and bound algorithms are straightforward and useful techniques for solving combinatorial problems. Two basic operations, branching and bounding are used in order to prevent complete enumeration of the solution space, and hence reduce the computational complexity of the problem. The branching procedure partitions the overall problem into a series of sub problems in a tree-like structure. The bounding procedure is used to estimate the lower bound of each "active" sub problem in an attempt to establish the likelihood that a particular sub problem will contain the optimum solution.

In this manner a decision tree is dynamically created level by level. Applying branch and bound strategies at each of these levels determines the possible set of nodes on that level of the tree from which the search can continue. As the complete problem is divided at each level, estimation of lower bounds for each sub problem allows large branches of the solution space to be removed from the investigation as the search is guided towards the base of the tree and hence find the optimal solution to the problem. The objective of branching and bounding strategies is to do this with the least possible computational effort and hence in the quickest possible time. In terms of scheduling problems, the number of levels in the decision tree represents the number of operations in the problem.

A schedule is any arrangement of these operations that satisfies all problem constraints. Each sub problem is identical to the problem at the preceding level with the exception of a single operation that has been fixed in the last available position in the emerging partial schedule. Repeating this process down through the decision tree and across its full width would constitute complete enumeration of the problem.

Obviously, calculation of all possible permutations would uncover the optimal schedule but would take too long when faced with any problem of practical dimension (i.e. the fundamental problem). Branch and bound strategies seek to remove large groups of schedules that have been proven to lead to sub optimal results.

As the search advances through each level of the tree the most likely candidates for optimality begin to emerge. The optimum schedule is pieced together level-by level until all jobs have been given appropriate positions in that schedule.

Work with enumerative techniques such as branch and bound algorithms have progressed over the years. Unfortunately however, even with tight bounding techniques these methods require excessive computational time when faced with the large dimensionality of complex practical problems. Even though success has been somewhat limited to problems of small to medium dimension, many of their strategies have been embedded in modern approximation techniques.

In this study , to deal with a real-world scheduling problem , we used Lingo version 8 which employs Branch and Bound technique as a search method.

3.1.3 Approximation Methods

Even when augmented by sophisticated rules and procedures, the most promising enumerative technique, branch and bound algorithms may fail to produce satisfactory results when faced with practical problems that, by their nature tend to be of large dimension. The realization that an enumerative technique was unlikely to ever offer a satisfactory solution to combinatorial problems brought about a paradigm shift. That's why; attention was concentrated on solving the General Scheduling Problem using approximation techniques. Unlike optimization techniques, approximation methods do not guarantee that the solution generated will optimize whatever criterion is under scrutiny. In many instances an optimum solution to a problem is not required and a sub optimal solution is satisfactory, provided that it is within a few percent of the optimum. Approximation methods do just that.

Aggressive elimination strategies can very quickly arrive at a solution that is adequately close to the optimum. As the search technique closes in on the optimum the costs explode as gains are diminished in correspondence with the law of diminishing returns. Therefore, the cost of settling for a sub optimal solution compared with the optimum solution is much less than the cost of computing the optimum compared with the cost of computing a solution close to that optimum. This is the fundamental basis for accepting approximation algorithms as promising approaches to solving this age-old problem.

The emphasis is now placed by many researchers on developing the most efficient approximation algorithm. (i.e. the algorithm that gets closest to the optimum in the shortest possible time). A more in-depth explanation of these and other techniques follows.

3.1.4 Dispatching Rules

Dispatching rules are the simplest form of approximation technique. Dispatching rules are a set of heuristics commonly used in scheduling. Most dispatching rules are: “simple single pass priority dispatching rules….once a decision is arrived at by the operation of a rule, it is implemented without reconsideration of alternative courses of action.” (King and Spachis 1980).

The choice of rule is system dependent and often determined by the objective criteria.

Job Slack (S) Give priority to the jobs with least ‘job slack’, i.e. the amount of contingency or free time, over and above the expected processing time, available before the job is completed at a pre-determined date.

Job Slack Ratio The ratio of the total time remaining to the remaining slack time. This rule tends to minimize due date related objectives

Scheduled Start Date The date on which operations must be started so that a job will meet a required completion date.

Earliest Due Date Process the job with the earliest due date first. This rule tends to minimize the maximum lateness among the jobs waiting for processing.

Subsequent Processing Times Process the job with the most remaining processing time first.

Service in Random Order (SIRO) Rule The next job is selected at random from those waiting for processing. No attempt is made to optimize any objective.

Earliest Release Date First (ERD) Rule This rule is equivalent to the well-known first-come-first served rule. This rule in a sense minimizes the variation in the waiting time of the jobs at a machine.

Shortest Processing Time First (SPT) Rule This rule orders the jobs in non-decreasing order of their processing times. This rule tends to minimize the sum of completion time.

Longest Processing Time First (LPT) Rule This rule orders the jobs in decreasing order of their processing times. When there are machines in parallel, this rule tends to balance the workload over the machines.

Shortest Setup Time First (SST) Rule Whenever a machine is freed, this rule selects for processing the job with the shortest setup time. This rule tends to minimize make span objective.

Least Flexible Job First (LFJ) Rule This rule is used when there are a number of non-identical machines in parallel and the jobs are subject to machine eligibility constraints. Whenever a machine is freed, the job that can be processed on the smallest number of other machines is selected, that is, the job with the fewest processing alternatives.

Dispatching rules have been applied consistently to scheduling problems. They give quick and simple solutions that can be used to support real-time decision making because they are not iterative procedures. Dispatching rules can be easily integrated as rules in intelligent control systems as part of a dynamic scheduler.

As would be expected, the use of dispatching rules is limited. The performance of rules varies under different conditions. Different rules perform better in some situations.

Therefore, the choice of rule used depends on the problem in question. In our problem EDD (earliest due date) rule is applied.

3.2 Simulation Modeling

Simulation has been successfully employed as an analysis tool for predicting the effect changes have on existing and hypothetical systems. This insight allows for more informed appraisals of alternatives, greatly enhancing the planning function.

Simulation modeling allows microscopic analysis of complex system dynamics giving the intimate understanding required to maximize the efficiency of such systems. As well as being used to predict the future and explain the operation of complex processes, simulation models are also used in real-time control systems to provide decision support for automated (intelligent) decision makers.

Simulation is certainly more tractable than mathematical programming formulations of FMS scheduling problems. With simulation, there is no concern about feasibility, since there is no need to make any simplifying assumptions. The simulation model can be built as close to reality as one needs to however, simulation is carried out with just one rule for each type of decision, then simulation does not serve any decision support purposes then, the only purpose of simulation would be prediction-when a job can be expected to be completed, what machine utilizations can be expected, etc.

Simulation can work as a decision support tool when there is the possibility to simulate under different decision alternatives. The informed decisions could be made by looking at the simulation results.

Current research suggests that a combination of simulation and ‘meta-heuristic’ optimization techniques- applied to analytically intractable problems- can yield optimal or near optimal solutions.

3.2.1 The Role of Simulation in Manufacturing

Simulation , in addition to giving the user insight into how complex systems function and how variables interact with each other, provides the user an informative approximation of “what-if” scenarios. To date much discussion has centered on using simulation to assist in supporting long-term strategic decisions.

The success of simulation modeling in this role has however been mixed. In the past decade simulation modeling has taken on a new role providing analytical support to real-time decision makers. In the context of completely automated and flexible manufacturing systems, these decision makers are often AI components. Thus simulation models have become completely integrated as modules of automated control systems. McNally and Heavey (2002) describe this emerging niche.

Other researchers have been proposing the extension of simulation tools beyond a traditional design role (Dewhurst 2001, Kosturiak and Gregor 1999). With this approach the same model can be extended with control functions and interfaces with the environment (shop floor data collection systems and production planning and control databases) to support dynamic scheduling of production orders, capacity plans, labor allocations etc.

One area to emerge over the last decade has been the real time control and planning of manufacturing systems using computer simulation; especially in the area of flexible manufacturing systems. The simulation model is linked to the controllers of the flexible manufacturing system. Real time activities primarily refer to daily operations that require efficient, timely, and adaptive responses to short-term planning, scheduling and execution problems.

3.2.1.1 Use of Simulation in Scheduling

Discrete event simulation has been successfully employed as an analysis tool for predicting the effect of changes on existing and hypothetical systems. This insight allows for more informed appraisals of alternatives, greatly enhancing the planning function.

Simulation modeling allows microscopic analysis of complex system dynamics giving the intimate understanding required to maximize the efficiency of such systems. As well as being used to predict the future and explain the operation of complex processes, simulation models are also used in real-time control systems to provide decision support for automated (intelligent) decision makers. Current research suggests that a combination of simulation and 'meta-heuristic' optimization techniques applied to analytically intractable problems can yield optimal or near optimal solutions.

The versatility of simulation modeling allows it to explore new challenges easing comfortably into a variety of roles. Its marriage to optimization and approximation search techniques has lead to the development of sophisticated yet practical and understandable systems that can take-on mammoth scheduling tasks. Even though many of these techniques are still in their infancy, promising results could have far reaching consequences for optimization problems in other domains.

To date, much discussion has centered on using simulation to assist in supporting long-term strategic decisions. The success of simulation modeling in this role has however been mixed. The simulation model is an important part of the overall control system.

“The major function of the simulation model is to evaluate control policies in a flexible manufacturing cell by examining the effect of the scheduling rules on an on-line test base.”

“Thus at the end of all simulation passes, the best scheduling rule that results from the simulation is applied to the physical manufacturing system. The basic principle behind the simulator is the use of a deterministic simulation as a short-term predictive tool for alternative control strategies in a manufacturing.” Wu (1989).

Rembold (1993) echo this concept in their description of the Amherst-Karslruhe dynamic scheduling system.

“The heart of the system is a knowledge-based selector for scheduling methods and a library of logic scheduling algorithms. The system knows from a given order and manufacturing status which logic scheduling algorithms have to be used to obtain the desired manufacturing goal and to meet due dates.”

Taha (1997) goes on to explain that one of the main advantages simulation modeling has over rigid mathematical systems is the flexibility that results from its simplicity, stating:

“Simulation models are much more flexible in representing systems than their mathematical counterparts. The main reason for this flexibility is that simulation views the system at elemental level, whereas mathematical models tend to represent the system from a more global standpoint.”

Simulation is begun to be used in many different service and production areas for different purposes and proposes many advantages compared to other techniques. The increasing role of simulation in manufacturing, its application areas and the possible advantages of using simulation are introduced under the following sections.

3.2.2 Applications of Simulation Modeling

The applications of simulation modeling are wide and varied. McLean et al (2001), give a summary of general problem classes that are not industry specific. Simulation can be used in manufacturing to:

- Model "as-is" and "to-be" manufacturing and support operations from the supply chain level down to the shop floor.
- Evaluate the manufacturability of new product designs.
- Support the development and validation of process data for new products.
- Assist in the engineering of new production systems and processes.
- Evaluate their impact on overall business performance.
- Evaluate resource allocation and scheduling alternatives.
- Analyze layouts and flow of materials within production areas, lines and workstations.
- Perform capacity planning analyses.
- Determine production and material handling resource requirements
- Develop metrics to allow the comparison of predicted performance against "best in class" benchmarks to support continuous improvement of manufacturing operations.

Normally one resorts to simulation only when a conveniently implemental solution is not available for the problem at hand .Often the case is that , to use both analytical and simulation models and getting different solutions from each model and comparing the each perspective. In this study , to deal with a real-world scheduling problem we employed a hybrid approach which combines analytical and simulation modeling. The following section presents the survey of current literature employing analytical methods and simulation modeling.

3.3 Survey of Current Relevant Literature

During the survey of current literature we noted quite number of studies employing analytical methods and simulation .

Hung and Leachman present a linear programming based planner and scheduler. The results given by the system are used as an input to a simulation model that validates the result. When the LP and simulation systems do not agree, the LP is reformulated until satisfactory agreement between the two models in obtained. The LP minimizes a weighted production cost and includes capacity, demand and processor availability.

The linear control rules are based on intersecting hyper-planes and determine the time of release. The model developed by Wein , Lou and Kager worked along the same direction. They minimize the WIP while maintaining the output. The validation of their model is achieved by comparing its results to two other simulation-based schedulers.

Connors and Yao paid attention to the total demand for a multi-product factory. The authors define numerous technological constraints and assume a random yield.

Burstall et al. (1966) uses the Branch and Bound algorithm to solve the problem of minimization of total costs.

Bai, Srivastsan and Gershwin decompose the scheduling problem into a hierarchical structure to allow for the integration of non-linear and linear programming. The program applies non-linear programming data to establish long run values such as the set-up rate. At a lower level, the system executes linear programming computations to find the production rate etc. The lower level is controlled by different dispatching rules that depend on the results previously obtained.

Uzsoy et al.(1991) employs branch and bound techniques to solve the maximum lateness problem with precedence constraints.

Ovacik and Uzsoy (1995) present a family of rolling horizon procedures to minimize the maximum lateness with parallel identical machines, sequence dependent setups and dynamic job arrivals. They first develop a technique for the single machine problem and then extend it to solve parallel machine problem. They report that the performance of their technique can be improved if better lower bounds are found.

Mehta and Uzsoy deal with the scheduling of several incompatible product families. The minimization of total tardiness appears to be NP-hard. Dynamic Programming (DP) optimally solves small size systems but larger problems cannot be treated within reasonable amount of time. By applying a decomposition algorithm to the large size problem, they divide it into smaller ones that can be solved using DP.

Ghosh (1994) shows that the problem with the objective of minimizing the weighted completion time in the presence of sequence dependent setups is strongly NP-hard for arbitrary numbers of batches and machines which are identically parallel.

Bianco et al. (1988) uses a branch and bound procedure for the maximum flow time problem with release times.

Ovacik and Uzsoy (1994) considered the maximum lateness criterion in a complex job shop with sequence dependent setups. They use deterministic simulation to predict the arrivals of jobs at each work center and solved the resulting the sub problems separately. They developed scheduling techniques with dispatching rules in a job shop environment, semiconductor testing facility and reentrant flow shop; they found that performance improvements were more significant for shop configurations with constraint resources and reentrant product flow.

Low et al.(1995) proposed a heuristic algorithm that could also handle some complex constraints such as multiple machines, multiple resources and alternate routes. He evaluated the performance of his algorithms for various criteria using simulation. The statistical results showed that his algorithm performs better than algorithms that consider either no setup or sequence independent setups.

Loo Hay Lee ,F.H. Abernathy and Yu-Chi Ho et al.(2000) studied on production scheduling for apparel manufacturing systems via optimization and they made the decisions on the total production capacity to be allocated to each individual line the production schedules so as to maximize the overall profits. In this problem, searching for the best solution is prohibited in view of the tremendous computing budget involved.

Bobrowski (1997) investigated the impact of setup time variations on sequencing decisions. In this study setup times were stochastic including the job variations and simulation was used.

The study investigated that; how much variation in setup time could be tolerated while retaining the benefit of the setup conscious sequencing rules when compared to conventional sequencing rules and how important it was to accurately estimate setup time. During the simulation step, experimental design was used to make a comparison between setup time's variations, due date tightness and sequencing rules.

Byrne and Bakir use mathematical models and simulation together in order to achieve a feasible yet optimal result. Bokang Kim and Sooyoung Kim extended the model for the hybrid approach of Byrne and Bakır.

The scheduling problem of a flexible job shop problem (FJSP) consists of a routing sub problem, that is, assigning each operation to a machine in a related set and the scheduling sub problem, which consists of sequencing the assigned operations on each machine in order to obtain a feasible schedule.

CHAPTER FOUR

PRODUCTION SCHEDULING IN A TEXTILE COMPANY USING HYBRID APPROACH

In this chapter the proposed hybrid approach employed to schedule production in a textile company operating in Izmir is explained. This approach consists of two phases. The first phase deals with the capacity planning problem using mathematical programming. The solution to the capacity planning problem serves as input for the second phase which involves running a stochastic dynamic discrete-event simulation model of the production floor. The ultimate objectives through this two-phase hybrid approach are to use the production resources of the company as efficiently as possible and to give the customers realistic due dates for orders received. The following sections explain the details of this two-phase hybrid approach.

4.1 Application Environment

Textile companies are a rich field for the study of parallel machine scheduling problems (Guinet, 1991). The problem considered here is a standard and academic scheduling problem in which jobs with costs must be assigned optimally to unrelated machines while satisfying release dates and deadlines while considering the stochastic factors such as delays. The objective is to find a minimum cost assignment of the jobs to the facilities such that all release dates and deadlines are met.

ROTEKS which was founded in 1986 is a leading textile company which produces mostly denim apparel. At the beginning, Roteks commenced its operations as an international garments trader, however, the necessity of controlling quality at all phases pushed the company down the chain to become a manufacturer.

Since 1991, Roteks has been conducting its operations in İzmir Atatürk Organized Industrial Zone at its facilities over an 18.000 sqm. indoor area with a flexible and rapid garment manufacturing structure. Roteks has adopted customer oriented manufacturing and marketing practices for better conforming to ever increasing demands of the competitive environment, and for assuring its prevalence in the future.

Roteks' manufacturing units comprise five departments which are cutting, sewing, washing, quality control and finishing with a total capacity of 100.000 units/month. Among these five departments, the sewing department is the most critical department. Because a great portion of the manufacturing lead time is spent in this department. Hence, any efficiency gained in this department has great contribution to the success of the company. Owing to these reasons, this thesis study has been carried out in the sewing department. The types of products and the production volume for each type are given in Appendix A.

In today's highly competitive industrial environment, Roteks does not want to keep stock so it operates on the basis of make-to-order policy. It should be noted that the success of make-to-order policy closely is related to how good the company is in delivering the orders to the customers as promised. The purpose of this study is to employ a two-phase hybrid approach for scheduling the production in the sewing department as efficient as possible so that the delivery dates promised to the customers can be kept. The following section presents the production scheduling problem in the sewing department.

4.2 Problem Definition

As mentioned earlier ROTEKS is operating on the basis of make-to-order policy and lately, it is experiencing problems such as late deliveries, lost customers while dealing with increasing amount of customer orders. Hence, to make sure that the company gives the customers realistic due dates which do not force the capacity constraints of the company, in this study we suggest combining two approaches: Mathematical Programming and Simulation.

The current practice in ROTEKS is to carry out a rough-cut capacity planning without taking into consideration the stochastic nature of labor-intensive operations in the sewing department. This practice often leads company to employ overtime which increases the cost of production.

To illustrate how our two phase hybrid approach can be implemented in this textile company, the length of production planning horizon has been taken as one month. In the first phase, we employed mathematical programming to allocate the jobs to the production facilities under given capacity and demand constraints. Secondly, we developed a dynamic stochastic and discrete-event simulation model of the sewing department and as input we used the output of this mathematical model which defines to which resources the jobs are assigned. This simulation model serves as a scheduling tool and its output represents in which order the jobs will be processed in these production resources along with job start and job completion times. Moreover, for validation of the simulation model developed we considered this production scheduling problem as a deterministic one and solved it using mathematical programming. The proposed hybrid approach is explained in the fore-coming sections.

4.3 Proposed Hybrid Approach

The “Multi Period Multi Product Production Planning Problem” is well known in the literature. The problem consists of matching production levels of individual products to the fluctuations of demand for a number of periods into the future, subject to constraints of capacity. Solution approaches to this problem can be categorized into two classes: Analytic methods (mathematical programming, numerical search etc.) and simulation. Using either one of them may have some shortcomings such as :

- By using the mathematical approaches we won’t be able to reflect the realistic and stochastic behavior of the system.

- If the system behaviour is too complex it’s hard to interpret the solutions by simulation.

- .In a pure simulation model, one completely simulates the complex system even when a portion of it is simple enough to be analytically solved.

- In contrast to analytic models, the simulation model approach describes only the behaviour of a system, and the results are descriptive. It normally does not require explicit mathematical formulations and analytic solution algorithms.

Classical LP planning model may be infeasible for the real production system, due to the non-linear behavior of the workloads at the machines. The reason for the infeasibility of the LP solution is that the classical capacity constraints assume the workloads from the decision variables (i.e., the production quantities) to be linear in each period. The total workload in a period is defined as the sum of the processing time multiplied to the production quantity for each product type at the machine. The capacity constraint says the workload should be less than the capacity of the machine in that period.

To overcome above mentioned shortcomings, in this study we propose a hybrid approach which combines simulation and mathematical programming to find a capacity-feasible production plan. Analytic optimization models can, in particular for a production planning problem, easily produce optimal aggregate levels of decision variables, and often permit relatively easy sensitivity analysis. On the other hand a simulation model of the system can incorporate dynamic queuing considerations into the model.

Proposed approach is shown in the Figure 4.1.

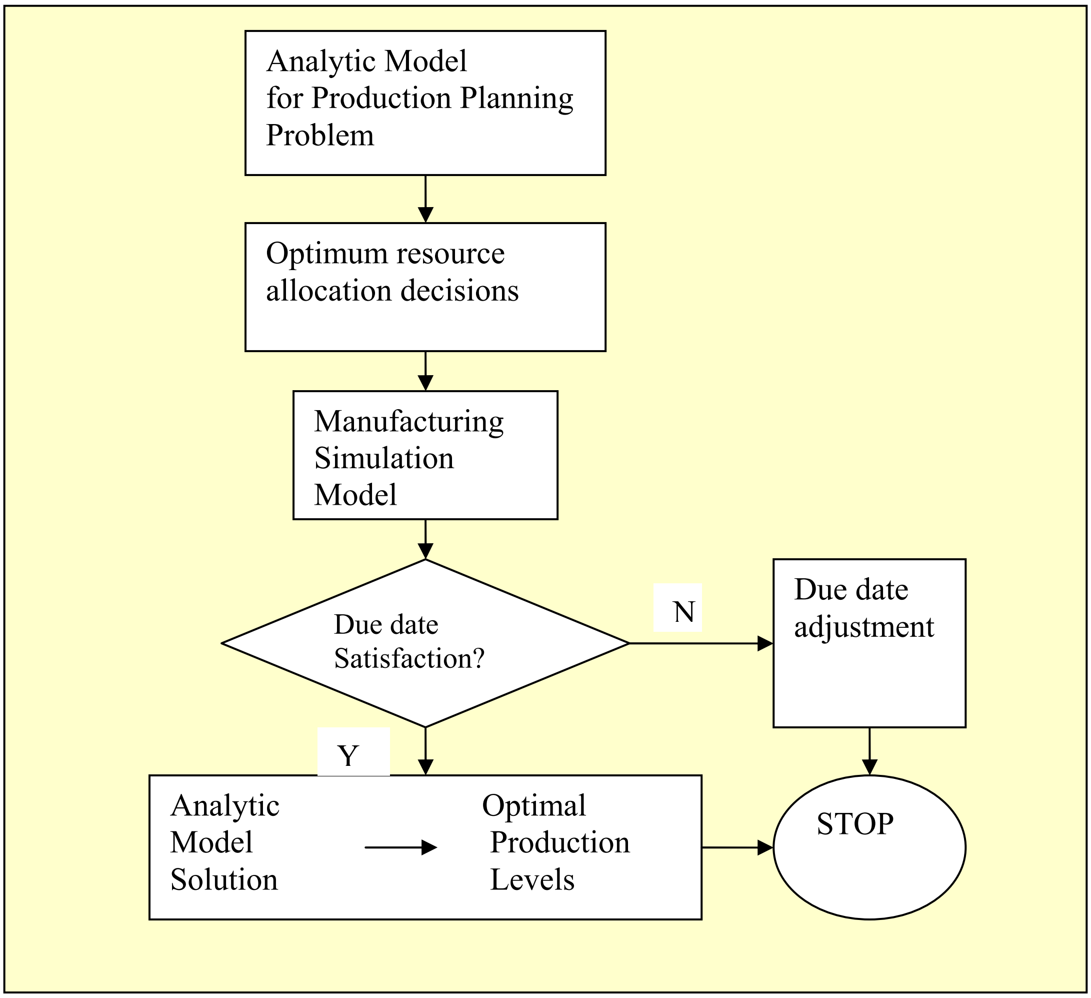

Figure 4.1 Proposed hybrid approach

The hybrid modeling logic is explained below:

1. Generate an analytic model to solve the resource allocation problem.
2. Load the resource allocation decisions generated by the analytical model as input to the manufacturing simulation model.
3. Run the simulation model to estimate order completion times.
4. Check to see whether the order completion times generated by the simulation model are in compliance with the customer given due dates, if not revise the customer given due dates.

This procedure uses independently developed simulation and analytic models .The case study employed to illustrate this hybrid approach is explained in the following section.

4.3.1 Production Planning Using Mathematical Programming

In parallel machine scheduling problem, there are m machines on which n jobs are to be scheduled. Each job has to be scheduled on any one of the machines during the fixed processing time. The aim is to find out the schedule that optimizes a certain performance measure (Mokotoff, 2001). A typical formulation of the LP planning model has the objective of minimizing the total production-related costs, such as variable production costs, inventory costs, and shortage costs, over the fixed planning horizon . In our case no inventory is held, the only cost that occurs is the cost of production.

In order to achieve the desired goal of meeting the demands without exceeding the available capacity and also to minimize the tardiness two models are formed. The first mathematical model allocates the jobs to the facilities. It should be noted that the second mathematical model which uses the output of the first model to schedule the jobs on given resources under the objective of minimizing tardiness has been developed for validation of the simulation model.

These two mathematical models have been developed under the following assumptions:

- The order or the precedence of the operations for each order is fixed and known.
- Processing times are same for the same operation performed on alternative facilities.
- Parts are produced in batches and the order quantity of a part determines the batch size of that part.
- There is no machine failure during the scheduling horizon.

- Preemption of the job strings is not allowed, i.e., once they are started, they should be processed until completion.
- Operators are continuously available for the specified scheduling horizon.
- Operator transfer times between machines in relation to job processing times are negligible.
- All the operators are fully cross-trained workers.
- A facility of the same type is assumed identical in respect of operation capabilities and working speed.
- The input queue capacities at each machine are assumed as infinite.

4.3.1.1 The Allocation Model

To minimize the cost of production, this model allocates the jobs to the facilities under the given capacity and demand constraints and it allows working overtime. As indicated in Appendix A, in the sewing department, 49 types of jobs are produced using 42 facilities. The mathematical model is shown below:

<u>INDICES:</u>

j, j': indices for jobs

k: index for facilities

<u>SETS:</u>

J set of jobs (j=1,2,…49)

A set of all facilities (k = 1,2, …42)

M set of main facilities (k = 1,2)

S set of subcontractors (k = 3, 4, …42)

<u>PARAMETERS:</u>

p_j processing time of job j.

D_j demand (in terms of units) of job j

$CAP_{k,j}$ capacity (in terms of units) of facility k for manufacturing job j

$Over_{k,j}$ overtime capacity (in terms of units) of facility *k* for manufacturing job *j*

CR unit-time cost of production for main facilities, $j \in M$

CF unit-time cost of production for subcontractors, $j \in S$

CRO unit-time cost of production for main facilities during overtime , $j \in M$

CFO unit-time cost of production for main facilities during overtime , $j \in S$

R a sufficiently large number

<u>DECISION VARIABLES:</u>

$x_{k,j}$ the amount of manufactured units for job *j* in facility *k*

$$z_{k,j} = \begin{cases} 1, \text{if at least one unit of job } j \text{ is manufactured in facility } k \\ 0, \text{otherwise} \end{cases}$$

Minimize

$$CR\sum_{j\in J}\sum_{k\in M} p_j x_{k,j} + CRO\sum_{j\in J}\sum_{k\in M} A_k Over_{k,j} + CF\sum_{j\in J}\sum_{k\in S} p_j x_{k,j} + CFO\sum_{j\in J}\sum_{k\in M} A_k Over_{k,j} \quad (1)$$

Subject to:

$$\sum_k x_{k,j} \geq D_j \qquad j \in J \qquad (2)$$

$$x_{k,j} \leq CAP_{k,j} + A_k Over_{k,j} \qquad k \in A, j \in J \qquad (3)$$

$$x_{k,j} \leq z_{k,j} \; R \qquad k \in M, j \in J \qquad (4)$$

$$\sum y_{k,j} \leq 10 \qquad (5)$$

$$x_{k,j} \in \{0,1\} \qquad k \in A, j \in J \qquad (6)$$

$$A_k \in \{0,1\} \qquad k \in A, j \in J \qquad (7)$$

Objective function (1) minimizes the total manufacturing cost in all facilities, including the two main ones and all other subcontractors together with overtime costs.

Equation (2) ensures that the demand of all jobs is satisfied.

Equation (3) guarantees that the total amount of production in all facilities is within the capacity limits.

Equation (4) determines whether a job is assigned to a facility or not.

In equation (5) by adding a max. load of 10 jobs per facility constraint to the allocation model the scheduling model is relaxed.

Equation (6) ensures that all A_k variables which determine whether overtime is done or not are zero or one.

Finally, Equation (7) ensures that all $x_{k,j}$ variables are zero or one.

Roteks wants to determine their capacity plan considering the customer given due dates. They want to find out what portion of the orders received should be subcontracted (i.e., the company has an agreement with 40 subcontractors) and how many units should be produced in house either on regular or overtime while meeting the due dates as closely as possible.

Both the company and the subcontractors work 9hrs. 1 shift per day , 45 hrs per week. The company has 2 parallel facilities. Each facility has a different number of workers and different efficiencies. The worker cost is 0.07Euro/min both for Roteks and subcontractors and the cost of overtime is 0.112 Euro/min for Roteks and 0.105 Euro/min for the subcontractors. There are 49 different products to be delivered for the planning horizon. The efficiencies differ from facility to facility. The demand and capacities are known in advance.

The model is analyzed by using Lingo version 8.0 software. The optimum solution has been found as a result 368 iterations The solution to the allocation problem which can be found at Appendix B indicates in which resources the jobs are to be processed .These decisions are used as input to the second mathematical model which schedules jobs on given resources under the objective of minimizing tardiness.

4.3.1.2 The Scheduling Model

The due date for a work order is the date by which the customer should receive the work order. The shipping and handling lead-time of the completed work order is not covered by the scope of the problem and is assumed to be constant. Hence, the due date of a work order is the date by which the work order should be completed in the confection section.

In this section we present the scheduling model developed to minimize the total tardiness. It should be noted that the output of this model is used to validate the simulation model.

The mathematical model developed to minimize the total tardiness is shown below:

PARAMETERS:

p_j processing time of job j.

$pt_{k,j}$ processing time of job j at facility k , $k \in A$

d_j due date of job j

R a sufficiently large number

$x_{k,j}$ the amount of manufactured units for job j in facility k (from the previous model)

$$z_{k,j} = \begin{cases} 1, \text{if at least one unit of job } j \text{ is manufactured in facility } k \\ 0, \text{otherwise} \end{cases}$$

(from the previous model)

DECISION VARIABLES:

$start_{k,j}$ beginning time of job j on facility k

t_j tardiness of job j.

end_j ending time of all sub-parts of job j

$completion_{k,j}$ completion time of job j on facility k

$$y_{k,j,j'} = \begin{cases} 1, \text{if job } j \text{ precedes job } j' \text{ at facility } k \\ 0, \text{otherwise} \end{cases}$$

$$Minimize \sum_{j \in J} t_j \qquad (8)$$

Subject to:

$$p_j x_{k,j} = pt_{k,j} \qquad j \in J, k \in A \qquad (9)$$

$$start_{k,j} + pt_{k,j} \le start_{k,j'} + R(1 - y_{k,j,j'}) \tag{10}$$
$$k \in A, j \in J \mid z_{k,j} = 1, j' \in J \mid z_{k,j'} = 1, j \ne j'$$

$$start_{k,j'} + pt_{k,j'} \le start_{k,j} + y_{k,j,j'} R \tag{11}$$
$$k \in A, j \in J \mid z_{k,j} = 1, j' \in J \mid z_{k,j'} = 1, j \ne j'$$

$$y_{k,j,j'} + y_{k,j',j} = 1 \quad k \in A, j \in J \mid z_{k,j} = 1, j' \in J \mid z_{k,j'} = 1, j \ne j' \tag{12}$$

$$start_{k,j} + pt_{k,j} \le completion_{k,j} \quad j \in J, k \in A \tag{13}$$

$$completion_{k,j} \le end_j \quad j \in J, k \in A \tag{14}$$

$$y_{k,j,j'} \in \{0,1\} \quad j \in J, k \in A \tag{15}$$

$$y_{k,j} \in \{0,1\} \quad j \in J, k \in A \tag{16}$$

Objective function (8) minimizes the total tardiness. Equation (9) calculates the processing time of divided jobs. Equations (10), (11) and (12) give sequencing constraints for each facility. Equation (13) calculates completion time of divided jobs on each facility. Equation (14) determines the completion time of the whole job. Equation (15) and (16) gives the binary variables, $y_{k,j,j'}, y_{k,j}$.

It is well known in discrete optimization literature that in order to solve reasonably sized instances of challenging classes of problems, two particular features must come into play. First, a good model of the problem must be constructed in the sense that it affords a tight underlying linear programming representation, and second, any inherent special structures must be exploited, both in the process of model formulation and in algorithmic development .

Most of the commercially available software for solving integer programming models use the LP relaxation within their solution process to compute lower (upper) bounds at the nodes of a branch and bound procedure. A tighter LP relaxation will mean that the B&B procedure will not require extensive branching to obtain an integer solution.

One possible option to overcome a large value of the integrality gap is to reduce it before solving the problem by the B&B procedure. This will require a reformulation of the problem into a tighter model. The characteristic of this “tight” model is that it more closely approximates the convex hull of integer feasible solutions. Thus, the model should “chop off” a large region from the convex hull of LP feasible solutions and should be closer to the convex hull of integer feasible solutions.

Additional constraints can be incorporated into the problem that will chop off regions from the convex hull of LP feasible solutions, and make the formulation tighter. Thus, by the addition of the right type of constraints to integer programs, the solvability of the problem will be enhanced, even though the problem size is increased.

This scheduling model minimizes the total tardiness. The output of the allocation model that shows in which facility the job will be processed is an input of the scheduling model.Total tardiness for 49 jobs in the given planning period is 2275478 minutes which corresponds to 3.5 days for 42 facilities.

As mentioned earlier, the next phase involves developing a dynamic stochastic discrete-event simulation model of the sewing department. Checking the need for any changes in customer given due dates using simulation modeling is explained in the next chapter.

4.3.2 Checking The Need for Changes in Customer given Due Dates Using Simulation

The simulation model is able to accommodate manufacturing system characteristics, such as queuing and transportation delays, into the modeling procedure. These features were difficult to include in the analytic model, and hence the optimal solution identified by the analytic model on its own may not be feasible in practice. The proposed hybrid procedure enabled these discrepancies to be addressed, and a realistically feasible optimal solution to be identified.

After generating an optimum production plan from the analytic model we load the optimum resource allocation decisions obtained from the analytic model as an input to the manufacturing simulation model. Then we simulate the manufacturing system subject to stochastic factors. If the results of the simulation model regarding to the job completion times are in compliance with customer given due dates, then the current optimum production levels found by the analytic model may be considered realistically optimal, otherwise, the customer given due dates are revised as indicated by the simulation model..

The simulation model has been developed using Arena 10.0 simulation language. Since a production planning horizon starts with no work-in-process around, the simulation model to represent such a production environment can be considered as a terminating one and hence, no warm-up period is needed. All 49 jobs are created at time zero and they are sent to the facilities where they will be processed. The processing time in these facilities are stochastic. We employed the Input Analyzer in ARENA to fit a distribution to the company collected data.

It should be noted that, in order to control the delays that occur probabilistically during a month so that the efficiency of each day can be calculated, these data were recorded daily in ROTEKS. As a result of employing Input Analyzer, it is shown that the efficiencies can be represented by the following beta distribution:

(0.43 + 0.44 * BETA(3.53, 1.98)) with ;

Number of Data Points	= 42
Min Data Value	= 0.47
Max Data Value	= 0.83
Sample Mean	= 0.712

Sample Std Dev = 0.0827

Thus, in order to reflect the delays that occur during the process ,the processing times are increased as indicated by this beta distribution. The average efficiency of each facility can be seen in the Table 4.1.

Table 4.1 Average efficiencies from replications

Facility	Total no of jobs allocated to the facility	Average Efficiency
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	1	0.738819
15	8	0.74228
16	0	0
17	0	0
18	0	0
19	1	0.752836
20	1	0.714248
21	0	0
22	0	0
23	9	0.677201
24	2	0.690732
25	0	0
26	1	0.65488
27	1	0.680152
28	0	0
29	0	0
30	0	0
31	0	0
32	0	0
33	0	0
34	0	0
35	1	0.724673
36	3	0.725452
37	2	0.703416
38	0	0
39	0	0
40	0	0

41	5	0.706901
42	25	0.721621

The simulation model has been developed to process 49 types of orders which have different routings and processing times. The job routings obtained from the mathematical programming part of the hybrid structure, the processing times and due dates for each part order are given at the Appendix A . The simulation model has been run for 10 times to collect performance measures regarding average completion time for each order, average total tardiness, average total number of jobs completed.

The control structure of the simulation model developed is given in Figure 4.2.

The block diagram of the simulation model is shown in Figure 4.3

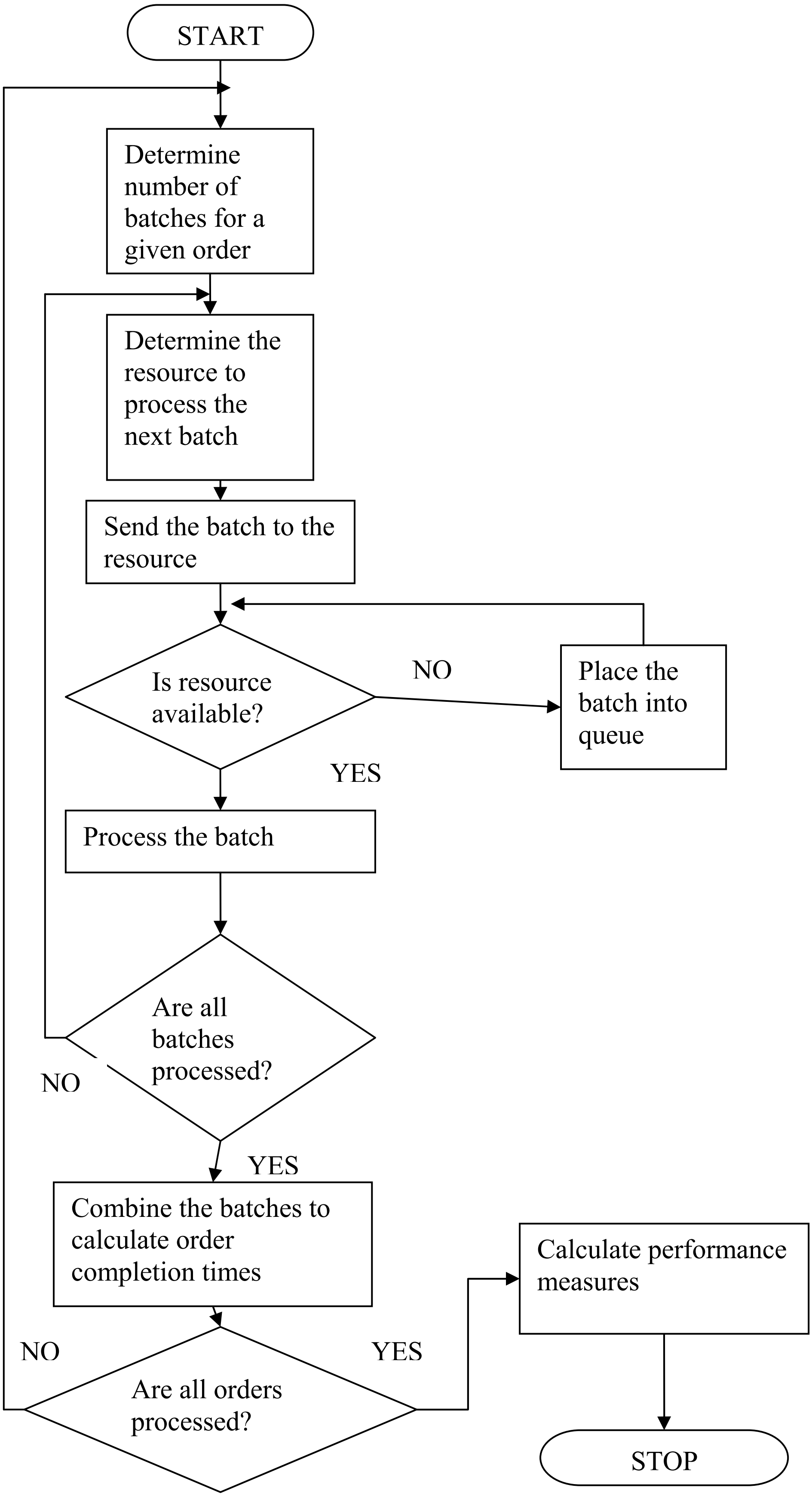

Figure 4.2 Control structure of the simulation model

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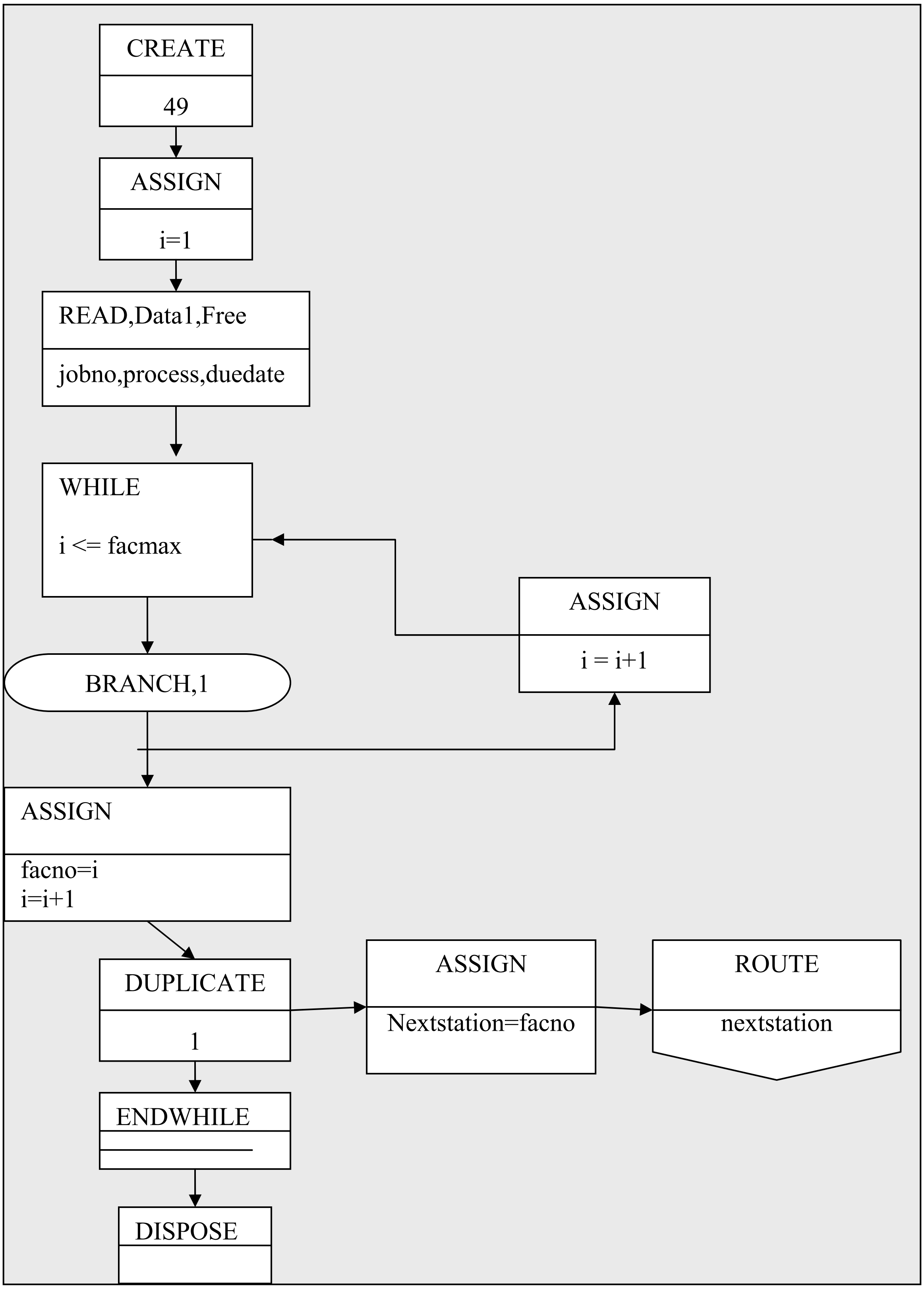

Figure 4.3 Block Diagram

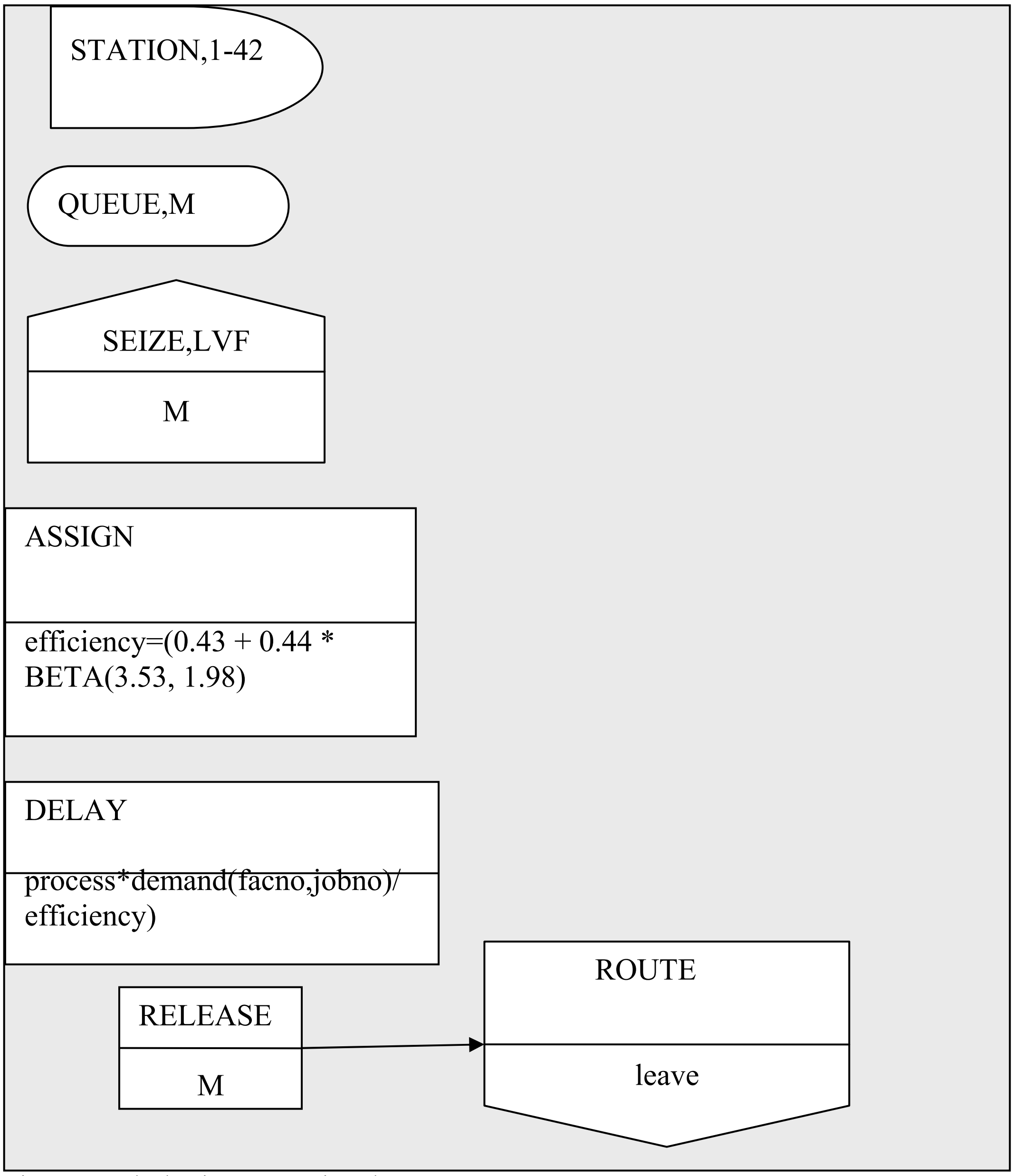

Figure 4.3 Block Diagram continued.

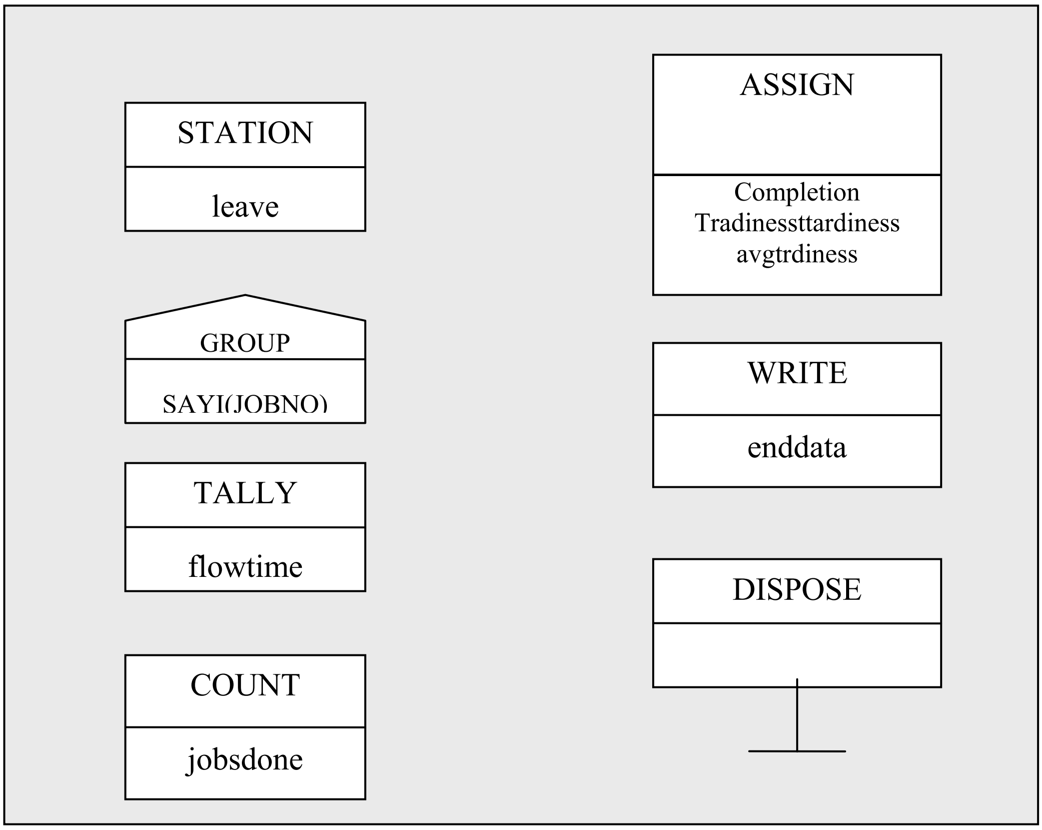

Figure 4.3 Block Diagram continued.

As seen in Figure 4.3, all 49 jobs enter the system at the same time. The allocation data from the linear programming model is read such as the job number , process time, due date and the allocation information. The jobs are sent to the facilities accordingly. Since some of the jobs are split into different facilities they are duplicated and later in the station block named "leave" the jobs are re-grouped using the GROUP block. The jobs that are split into batches are processed according to the allocation data in the corresponding facilities. In the station block the jobs are taken into the queue according to the priority rule given. The jobs are delayed by their processing time divided by the efficiency which is modeled using beta distribution based on the historical data kept by the company. When the jobs are finished processing they are sent to a station called leave. In the leave station batches are re-grouped to form the orders.

In simulation modeling the process of determining the correctness of the model operation consists of two functions: verification and validation. These two functions and how they are done in our case are explained in the next chapter.

4.4 Verification and Validation

Simulation models are increasingly being used to solve problems and to aid in decision making. The developers and users of these models, the decision makers using information obtained from the results of these models, and the individuals affected by decisions based on such models are all rightly concerned with whether a model and its results are correct. This concern is addressed through model verification and validation. Model verification is often defined as ensuring that the computer program of the computerized model and its implementation are correct and is the definition adopted here. Model validation is usually defined to mean substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model. Model verification ensures that the computer programming and implementation of the conceptual model are correct. For this purpose different methods are used.

In this thesis the verification has been done with the help of the trace element Trace is used to observe the movements of a part through the model. By the help of trace, it is possible to observe that whether a part moves in a way harmonized to the system logic or not. By the help of trace it was seem that the parts followed the routing specified, and the correct tools and process times were used. Specifically, the following events were checked for correct occurrence:

- Creation of Order Flow of work part: Creation, choosing the most appropriate machine in a work center, waiting for machine, seize of machine and operation, truly further movements in the system between work centers, completion of an order, data collection on performance measures
- Use of alternate routing

- Priority rule (queue discipline) operation

Validation of the simulation model is done by running the simulation model with deterministic input data and its output (i.e., total tardiness) is compared with the output of the mathematical model developed for the same purpose. Having found the same amount of total tardiness for both of the approaches we can state the simulation model truly represents the scheduling problem studied.

4.5 Discussion of Findings

This section presents the output of the simulation model developed to obtain realistic due dates.

Table 4.2 presents both the average completion time and also upper limit of the %95 confidence interval obtain for order completion time. Solution table 4.2 is shown below.

The fourth column in this table gives the customer given due dates and the symbol "*" placed in the last column indicates the late orders whose customer given due dates need to be revised.

It should be noted that in determining late orders, rather than average completion time the upper limit of %95 confidence interval for order completion time has been taken into account. In doing so it has been desired to reduce the risk of not completing the orders on time.

Table 4.2 Solution table of the simulation study

Job No	Completion time (days)	Upper limit of completion time gathered from 0.95 confidence interval on the mean (days)	Due Date (days)	Late orders
1	28	29	6	*
2	30	32.45324	6	*
3	4.5	4.89098	6	
4	6.5	6.922106	6	*

5	11.5	12.62905	6	*
6	17	18.51839	6	*
7	6.5	7.098011	6	*
8	11	11.8786	7	*
9	7.5	8.554337	7	*
10	3.5	3.777257	7	
11	9.5	10.70145	7	*
12	22.5	23.64508	7	*
13	11	11.98568	7.5	*
14	18	18.84435	7.5	*
15	24.5	26.27122	8	*
16	8	8.529711	8	*
17	27.5	30.02647	8	*
18	36	38.32606	8	*
19	17.5	18.74247	8	*
20	18.5	19.65703	8.5	*
21	19.5	20.94251	8.5	*
22	18	18.76164	8.5	*
23	3	2.927657	9	
24	27	29.50154	9	*
25	1.5	1.425872	9	
26	2	1.857966	9	
27	34.5	36.346	9.5	*
28	34	35.28925	9.5	*
29	36.5	37.57955	9.5	*
30	19	20.85569	9.5	*
31	22.5	23.58907	9.5	*
32	38	40.36691	9.5	*
33	38	39.57763	9.5	*
34	29	31.33122	9.5	*
35	39	40.54596	9.5	*
36	13.5	15.30994	10	*
37	7.5	8.236189	10	
38	24	26.00223	10.5	*
39	23	24.92866	10.5	*
40	17.5	18.90337	10.5	*
41	8	8.882946	11	
42	29	30.8986	11	*
43	13	13.90325	11.5	*
44	11.5	12.74821	11.5	*
45	6.5	6.705035	11.5	
46	5.5	5.827843	11.5	
47	1	0.903427	12	
48	7.5	8.346876	12.5	
49	7	7.508819	12.5	

From the simulation analysis it’s seen that only 12 jobs are finished prior to their due dates. Moreover average total tardiness as a result of 10 replications has been found as 12 days which is much longer than the total tardiness indicated by the mathematical model developed for scheduling purposes. This can be attributed to the stochastic factors which have been taken into account in manufacturing simulation model. The output of the simulation model can be found in Appendix E.

By the help of this new realistic production plan which is generated combining both analytical models and simulation, the company can give more efficient , cost worthy due dates to the customer or can decide whether to accept the orders or not. Even in a situation where the capacity constraints are tight the company has the opportunity to see if they need to work overtime or not and to meet the customer given due dates.

It should be noted that it would be up to the policy of company management to change the customer given due dates for late orders or to use additional subcontractor capacity to meet the given due dates, if it is cost effective.

CHAPTER FIVE

CONCLUSION

5.1 Concluding Remarks

In today's competitive environment the unavailability of resources, high production costs with tight due dates are the major concern of every industrial organization. Sometimes returning an order may be more cost worthy rather than accepting it if the promised due dates can not be met.

Bitran and Tirupati (1993) define production as;

"The process of converting raw materials into finished products. Manufacturing systems are typically composed of large numbers of components, which have to be managed effectively in order to deliver the final products in right quantities, on time and at an appropriate cost. In systems characterized by multiple products, several plants and warehouses, a wide variety of equipment and operations, production management encompasses a large number of decisions that affect several organization echelons".

If the final products can not be delivered on time and in right quantities then the company may have to pay some penalty costs together with loss of reputation in the market.

This research has been motivated by the potential of mathematical programming to provide optimal or near optimal solutions to the scheduling problems and also by simulation to realistically model the stochastic and dynamic features of real industrial system. Thus, a hybrid approach integrating simulation and mathematical programming has been proposed in this study to deal with production planning and scheduling problem in a textile company.

The solution methodology takes into consideration several different types of performance measures to evaluate the effectiveness of the proposed scheduling policies:

- Cost
- Capacity
- Tardiness

In this thesis, first an optimal capacity plan is formed for a pre-determined planning horizon. For this purpose an allocation model is developed and it is solved using Lingo 8.0 Linear Programming tool. The objective function of this allocation model is based on minimizing the cost of production. Next, the output of this mathematical model which is in the form of optimal resource allocation decisions is downloaded as input to the simulation model of production floor. The simulation model is developed using SIMAN/ARENA 10.0 and its output which is the form of average job completion times is used to give the customers due dates for on-time delivery of orders received. Moreover, we validated the simulation model by running it with deterministic input data and comparing its output (i.e., total tardiness) with the output of the mathematical model developed and solved for the same purpose.

It is hoped that this study illustrating the use of simulation and mathematical modeling in detail for solving production planning and scheduling problem in a textile company will provide guidance for practitioners and enhance its acceptance in textile industry.

5.2 Summary

The purpose of this study was to determine which items should be produced locally and which should be outsourced to external subcontractors to meet the demands while minimizing the tardiness when the stochastic factors are taken into account.

Chapter 2 gives an in depth overview to production and capacity planning.

Chapter 3 gives the literature survey and background information about production planning and scheduling problem.

Chapter 4 presents the case problem studied to illustrate the implementation of the proposed hybrid approach.

Chapter 5 is the conclusion and is continued with references and the appendices.

5.3 Future Research Directions

In this study , the production planning and scheduling problem was solved under given capacity constraints by combining analytical methods and simulation modeling.The only stochastic component involved in simulation modeling was random processing times due to the delays that occurred during production.

In a future study , the simulation model developed can be made more realistic by adding more stochastic components such as machine failures, operator availability and etc.

In this study as a queueing discipline , we used the Earliest Due Date Heuristic in simulation modeling . A further research issue , could be to develop a problem-specific scheduling heuristic and to search its performance under various experimental conditions.

REFERENCES

Bai X., Srivatsan N., and Gershwin S. B., (1990), *Hierarchical Real Time Scheduling of a Semiconductor Fabrication Facility.* IEEE/CMPT International Electronics Manufacturing Technology Symposium, 312-317, 1990

Baker K. R., (1974), *Introduction to Sequencing and Scheduling.* John Wiley & Sons

Billington,P.J. , J.O. McClain, & L.J. Thomas, (1983), Mathematical programming approaches to capacity constrained MRP systems: review, formulation and problem reduction, *Management Science 29* (15)

Bitran, G.R., & Gilbert S.M. (1990). Sequencing production on parallel machines with two magnitudes of sequence dependent setup cost. *Journal of Manufacturing and Operations Management, 3*, 24-52

Brandimarte, P.,&Villa A. (1995). *Advanced models for manufacturing systems management,* Florida: CRC Press, Inc

Burstall, R.M., (1966). A heuristic method for a job shop scheduling problem *Operational Research Quarterly, 17,* 291-304

Cheng, T.C.E., (1987) A simulation study of MRP capacity planning with uncertain operation times, *International Journal of Prod. Research 25* (2)

Connors D. P., & Yao D. D.,(1996), Methods for Job Configuration in Semiconductor Manufacturing, *IEEE Transactions on Semiconductor Manufacturing, Vol. 9,* No. 3,401-411

Glover F., (1968), Surrogate Constraints ,*Operations Research, Vol. 16*, 741-749

Goldratt E., and Cox J., (1992) *The Goal*, North River Press

Guinet., A.,& Dussauchoy , A. (1993). Scheduling sequence dependent jobs on identical parallel machines to minimize completion time criteria. *International Journal of Production Research, 31*, 1579-1594

Law, A. M., P. A. Farrington, H. B. Nembhard, D. T. Sturrock., & G. W. Evans (Eds.) (1999). *Simulation of Manufacturing Systems*. In Proceedings of the 1999 Winter Simulation Conference.

Law, A. M., & Kelton, W.D. (1991). *Simulation Modelling & Analysis.* Singapore McGraw-Hill.

Lee, Y.H. and Pinedo, M. (1997). Scheduling jobs on parallel machines with sequence dependent setups. *European Journal of Operational Research, 100*, 464-474

Mehta S. V., and Uzsoy R.,(1998),Minimizing Total Tardiness on a Batch Processing Machine with Incompatible Job Families, *IIE Transactions, Vol. 30,* 165-178

McLean, C. & Leong, S. (2001). *The expanding role of simulation in future manufacturing.* Proceedings of the 2001 Winter Simulation Conference, ed. B. A.

McNally, P. & Heavey, C. (2002) *Simulation as a desktop resource: the limitations and future requirements of simulation technologies.* Proceedings of the nineteenth Conference of the Irish Manufacturing Committee. Queens University, Belfast.

M.D. Byrne, M.A. Bakir (1999) Production planning using a hybrid simulation - analytical approach, *International Journal of Production Economics 59,*305-311.

Musselman, K., J. O'Reilly, and S. Duket. (2002). The role of simulation in advanced planning and scheduling. In Proceedings of the 2002 Winter Simulation Conference, 1825-1830.

Ozdamar,L and T. Yazgac, Capacity driven due date settings in make-to-order production systems, (1997) *International Journal of Production Economics 49*, 29-44

Parunak. (1990). *Characterizing Manufacturing Scheduling Problem.*

Pegden, C. D., Shannon, R. E., & Sadowski, R.P. (1990). *Introduction to Simulation Using Siman.*

Pinedo, M. (1995). *Scheduling, Theory, Algorithms, and Systems.* New Jersey: Prentice- Hall.

Pinedo, M., & Chao, X. (1999). *Operations scheduling with applications in manufacturing and services.* Singapore: McGraw-Hill

Shanthikumar , J.G & Sragent, R.G. (1983) A unifying view of hybrid simulation/analytic models and modelling, *Operations Research 31*

Taha, H.A (1997). *Operations Research an Introduction, 6th Ed.*, New Jersey: Prentice-Hall

Uskup, G., & Smith, S.B. (1975). A branch and bound for two stage production sequencing. *Operations Research, 23*, 118-136

Uzsoy, R., Martin-Vega, L.A., Lee, C.Y., & Leonard, P.A. (1991). Production scheduling algorithms for a semiconductor test facility. *IEEE Transactions*

Vaidyanathan, B. S., D. M. Miller, and Y. H. Park. (1998). *Application of discrete event simulation in production scheduling.* In Proceedings of the 1998 Winter Simulation Conference, 965-971.

APPENDICES

APPENDIX A : THE PROBLEM DATA

JOB NO.	DEMAND (unit)	PROCESSING TIME(min.)	DUE DATE(days)
1	18000	30	6
2	18000	30	6
3	2848	18	6
4	3000	25	6
5	4720	27	6
6	6500	28	6
7	4120	19	6
8	4650	25	7
9	3950	21	7
10	1600	24	7
11	5040	21	7
12	9655	21	7
13	3500	20	7.5
14	6000	23	7.5
15	11161	18	8
16	55	18	8
17	14000	33	8
18	26000	20	8
19	3680	23	8
20	3170	27	8.5
21	3958	21	8.5
22	920	23	8.5
23	1530	21	9
24	16818	18	9
25	660	21	9
26	1100	18	9
27	7000	28	9.5
28	12000	17	9.5
29	8000	30	9.5
30	8000	27	9.5
31	2000	25	9.5
32	12000	23	9.5
33	12000	25	9.5
34	12000	29	9.5
35	12000	20	9.5
36	7300	21	10
37	3000	28	10
38	12000	24	10.5
39	13470	21	10.5
40	9340	21	10.5
41	1300	70	11
42	35000	16	11
43	5000	30	11.5
44	5000	27	11.5
45	3000	26	11.5

46	2387	27	11.5
47	417	21	12
48	3000	30	12.5

APPENDIX B: LINGO CODE FOR THE ALLOCATION PROBLEM

```
sets:
facility/1..42/:A,workload,normal;
jobs/1..49/:D,PT;
match(facility,jobs):CAPACITY,OVER, x,yy,z;
endsets

data:
D=@OLE('R.XLS','DEMAND');
@OLE('R.XLS','OUTPUT')=x;

PT= 30 30 18 25 27 28 19 25 21 24 21 21 20 23 18 18 33 20 23 27 21
23 21 18 21 18 28 17 30 27 25 23 25 29 20 21 28 24 21 21 70 16 30 27
26 27 21 30 27;

CAPACITY = @OLE('R.XLS','CAP');
OVER = @OLE('R.XLS','OVER');

Enddata

CR= 0.07;
CRO= 0.112;
CF= 0.07;
CFO= 0.105;

MIN=@SUM(MATCH(k,j)|k#EQ#1#OR# k#EQ#2 :
x(k,j)*PT(j)*CR+ A(k)*OVER(k,j)*CRO)+
@SUM(MATCH(k,j)|k#GE#3:x(k,j)*PT(j)*CF+A(k)*OVER(k,j)*CFO);

@FOR(jobs(j):@SUM(facility(k):x(k,j))>=D(j));
@FOR(facility(k):@FOR(jobs(j):x(k,j)<=(CAPACITY(k,j) +
A(K)*OVER(k,j))));
@FOR(facility(k):@SUM(jobs(j):x(k,j)+A(k)*over(k,j))=workload(k));
@for(facility(k):@SUM(jobs(j):x(k,j))=normal(k));
@for(facility(k):@sum(jobs(j):yy(k,j))<=20);
@for(jobs(j):@for(facility(k):x(k,j)<=yy(k,j)*10000000000));
@for(facility(k):@BIN(A(k)));
  @for(MATCH(k,j):@BIN(yy(k,j)));
```

APPENDIX C: LINGO CODE FOR THE SCHEDULING PROBLEM

```
sets:
facility/1..42/;
jobs/1..49/:d,PT,endingtime,tardiness;
match(facility,jobs):s,y,C,ELG2,P;
set(facility,jobs,jobs):x;
```

```
endsets

data:
y=@ole('R.XLS','OUTPUT');
d=@OLE('R.XLS','DUE');
ELG2=@ole('R.XLS','DATA');
pt = @ole('R.XLS','ptime');

Enddata
!lateness minimization , C=completion time,d=due,s=start time
,y=hangi iş nerde bir önceki lingonun çıktısı;

min= @sum(jobs(j):tardiness(j));
@for(jobs(j):endingtime(j)-d(j)<=tardiness(j));


@for(jobs(j):@for(facility(m): PT(j)* y(m,j)=P(m,j)));

@for(facility(k):@for(jobs(j)|ELG2(k,j)#EQ#1:@for(jobs(jj)|ELG2(k,jj
)#EQ#1#AND#j#NE#jj:s(k,j)+P(k,j)<=s(k,jj)+100000000000000000000*(1-
x(k,j,jj)))));
@for(facility(k):@for(jobs(j)|ELG2(k,j)#EQ#1:@for(jobs(jj)|ELG2(k,jj
)#EQ#1#AND#j#NE#jj:s(k,jj)+P(k,jj)<=s(k,j)+100000000000000000000*x(k,
j,jj))));

@for(facility(k):@for(jobs(j)|ELG2(k,j)#EQ#1:@for(jobs(jj)|ELG2(k,jj
)#EQ#1#AND#j#NE#jj:x(k,j,jj)+x(k,jj,j)=1)));

@for(jobs(j):@for(facility(k):C(k,j)<=endingtime(j)));

@for(facility(k):@for(jobs(j):P(k,j)+s(k,j)<=C(k,j)));



@for(jobs(j):@for(jobs(jj):@for(facility(k):@BIN(x(k,j,jj)))));
```

APPENDIX D: RESULT OF THE ALLOCATION PROBLEM

```
  Local optimal solution found at iteration:            453
  Objective value:                                 595532.3


    Export Summary Report
    ---------------------
    Transfer Method:        OLE BASED
    Spreadsheet:            R.XLS

    Ranges Specified:                1
        OUTPUT
    Ranges Found:                    1
    Range Size Mismatches:           0

    Values Transferred:           2058
```

Variable	Value	Reduced Cost
WORKLOAD(1)	0.000000	0.000000
WORKLOAD(2)	0.000000	0.000000
WORKLOAD(3)	0.000000	0.000000
WORKLOAD(4)	0.000000	0.000000
WORKLOAD(5)	0.000000	0.000000
WORKLOAD(6)	0.000000	0.000000
WORKLOAD(7)	0.000000	0.000000
WORKLOAD(8)	0.000000	0.000000
WORKLOAD(9)	0.000000	0.000000
WORKLOAD(10)	0.000000	0.000000
WORKLOAD(11)	0.000000	0.000000
WORKLOAD(12)	0.000000	0.000000
WORKLOAD(13)	4590.000	0.000000
WORKLOAD(14)	3000.000	0.000000
WORKLOAD(15)	490014.0	0.000000
WORKLOAD(16)	0.000000	0.000000
WORKLOAD(17)	0.000000	0.000000
WORKLOAD(18)	0.000000	0.000000
WORKLOAD(19)	0.000000	0.000000
WORKLOAD(20)	3680.000	0.000000
WORKLOAD(21)	0.000000	0.000000
WORKLOAD(22)	0.000000	0.000000
WORKLOAD(23)	270506.0	0.000000
WORKLOAD(24)	18210.00	0.000000
WORKLOAD(25)	0.000000	0.000000
WORKLOAD(26)	0.000000	0.000000
WORKLOAD(27)	0.000000	0.000000
WORKLOAD(28)	0.000000	0.000000
WORKLOAD(29)	0.000000	0.000000
WORKLOAD(30)	0.000000	0.000000
WORKLOAD(31)	0.000000	0.000000
WORKLOAD(32)	0.000000	0.000000
WORKLOAD(33)	0.000000	0.000000
WORKLOAD(34)	0.000000	0.000000
WORKLOAD(35)	1600.000	0.000000
WORKLOAD(36)	2903.000	0.000000
WORKLOAD(37)	0.000000	0.000000
WORKLOAD(38)	0.000000	0.000000
WORKLOAD(39)	0.000000	0.000000
WORKLOAD(40)	770768.0	0.000000
WORKLOAD(41)	0.000000	0.000000
WORKLOAD(42)	49460.00	0.000000
NORMAL(1)	0.000000	0.000000
NORMAL(2)	0.000000	0.000000
NORMAL(3)	0.000000	0.000000
NORMAL(4)	0.000000	0.000000
NORMAL(5)	0.000000	0.000000
NORMAL(6)	0.000000	0.000000
NORMAL(7)	0.000000	0.000000
NORMAL(8)	0.000000	0.000000
NORMAL(9)	0.000000	0.000000
NORMAL(10)	0.000000	0.000000
NORMAL(11)	0.000000	0.000000
NORMAL(12)	0.000000	0.000000

NORMAL(13)	4590.000	0.000000
NORMAL(14)	3000.000	0.000000
NORMAL(15)	98676.00	0.000000
NORMAL(16)	0.000000	0.000000
NORMAL(17)	0.000000	0.000000
NORMAL(18)	0.000000	0.000000
NORMAL(19)	0.000000	0.000000
NORMAL(20)	3680.000	0.000000
NORMAL(21)	0.000000	0.000000
NORMAL(22)	0.000000	0.000000
NORMAL(23)	55451.00	0.000000
NORMAL(24)	18210.00	0.000000
NORMAL(25)	0.000000	0.000000
NORMAL(26)	0.000000	0.000000
NORMAL(27)	0.000000	0.000000
NORMAL(28)	0.000000	0.000000
NORMAL(29)	0.000000	0.000000
NORMAL(30)	0.000000	0.000000
NORMAL(31)	0.000000	0.000000
NORMAL(32)	0.000000	0.000000
NORMAL(33)	0.000000	0.000000
NORMAL(34)	0.000000	0.000000
NORMAL(35)	1600.000	0.000000
NORMAL(36)	2903.000	0.000000
NORMAL(37)	0.000000	0.000000
NORMAL(38)	0.000000	0.000000
NORMAL(39)	0.000000	0.000000
NORMAL(40)	125279.0	0.000000
NORMAL(41)	0.000000	0.000000
NORMAL(42)	49460.00	0.000000

Variable	**Value**	**Reduced Cost**
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	0.000000
X(1, 3)	0.000000	0.000000
X(1, 4)	0.000000	0.000000
X(1, 5)	0.000000	0.000000
X(1, 6)	0.000000	0.000000
X(1, 7)	0.000000	0.000000
X(1, 8)	0.000000	0.000000
X(1, 9)	0.000000	0.000000
X(1, 10)	0.000000	0.000000
X(1, 11)	0.000000	0.000000
X(1, 12)	0.000000	0.000000
X(1, 13)	0.000000	0.000000
X(1, 14)	0.000000	0.000000
X(1, 15)	0.000000	0.000000
X(1, 16)	0.000000	0.000000
X(1, 17)	0.000000	0.000000
X(1, 18)	0.000000	0.000000
X(1, 19)	0.000000	0.000000
X(1, 20)	0.000000	0.000000
X(1, 21)	0.000000	0.000000
X(1, 22)	0.000000	0.000000
X(1, 23)	0.000000	0.000000
X(1, 24)	0.000000	0.000000

X(1, 25)	0.000000	0.000000
X(1, 26)	0.000000	0.000000
X(1, 27)	0.000000	0.000000
X(1, 28)	0.000000	0.000000
X(1, 29)	0.000000	0.000000
X(1, 30)	0.000000	0.000000
X(1, 31)	0.000000	0.000000
X(1, 32)	0.000000	0.000000
X(1, 33)	0.000000	0.000000
X(1, 34)	0.000000	0.000000
X(1, 35)	0.000000	0.000000
X(1, 36)	0.000000	0.000000
X(1, 37)	0.000000	0.000000
X(1, 38)	0.000000	0.000000
X(1, 39)	0.000000	0.000000
X(1, 40)	0.000000	0.000000
X(1, 41)	0.000000	0.000000
X(1, 42)	0.000000	0.000000
X(1, 43)	0.000000	0.000000
X(1, 44)	0.000000	0.000000
X(1, 45)	0.000000	0.000000
X(1, 46)	0.000000	0.000000
X(1, 47)	0.000000	0.000000
X(1, 48)	0.000000	0.000000
X(1, 49)	0.000000	0.000000
X(2, 1)	0.000000	0.000000
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	0.000000
X(2, 4)	0.000000	0.000000
X(2, 5)	0.000000	0.000000
X(2, 6)	0.000000	0.000000
X(2, 7)	0.000000	0.000000
X(2, 8)	0.000000	0.000000
X(2, 9)	0.000000	0.000000
X(2, 10)	0.000000	0.000000
X(2, 11)	0.000000	0.000000
X(2, 12)	0.000000	0.000000
X(2, 13)	0.000000	0.000000
X(2, 14)	0.000000	0.000000
X(2, 15)	0.000000	0.000000
X(2, 16)	0.000000	0.000000
X(2, 17)	0.000000	0.000000
X(2, 18)	0.000000	0.000000
X(2, 19)	0.000000	0.000000
X(2, 20)	0.000000	0.000000
X(2, 21)	0.000000	0.000000
X(2, 22)	0.000000	0.000000
X(2, 23)	0.000000	0.000000
X(2, 24)	0.000000	0.000000
X(2, 25)	0.000000	0.000000
X(2, 26)	0.000000	0.000000
X(2, 27)	0.000000	0.000000
X(2, 28)	0.000000	0.000000
X(2, 29)	0.000000	0.000000
X(2, 30)	0.000000	0.000000
X(2, 31)	0.000000	0.000000
X(2, 32)	0.000000	0.000000
X(2, 33)	0.000000	0.000000
X(2, 34)	0.000000	0.000000

X(2, 35)	0.000000	0.000000
X(2, 36)	0.000000	0.000000
X(2, 37)	0.000000	0.000000
X(2, 38)	0.000000	0.000000
X(2, 39)	0.000000	0.000000
X(2, 40)	0.000000	0.000000
X(2, 41)	0.000000	0.000000
X(2, 42)	0.000000	0.000000
X(2, 43)	0.000000	0.000000
X(2, 44)	0.000000	0.000000
X(2, 45)	0.000000	0.000000
X(2, 46)	0.000000	0.000000
X(2, 47)	0.000000	0.000000
X(2, 48)	0.000000	0.000000
X(2, 49)	0.000000	0.000000
X(3, 1)	0.000000	0.000000
X(3, 2)	0.000000	0.000000
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	0.000000
X(3, 5)	0.000000	0.000000
X(3, 6)	0.000000	0.000000
X(3, 7)	0.000000	0.000000
X(3, 8)	0.000000	0.000000
X(3, 9)	0.000000	0.000000
X(3, 10)	0.000000	0.000000
X(3, 11)	0.000000	0.000000
X(3, 12)	0.000000	0.000000
X(3, 13)	0.000000	0.000000
X(3, 14)	0.000000	0.000000
X(3, 15)	0.000000	0.000000
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X(3, 17)	0.000000	0.000000
X(3, 18)	0.000000	0.000000
X(3, 19)	0.000000	0.000000
X(3, 20)	0.000000	0.000000
X(3, 21)	0.000000	0.000000
X(3, 22)	0.000000	0.000000
X(3, 23)	0.000000	0.000000
X(3, 24)	0.000000	0.000000
X(3, 25)	0.000000	0.000000
X(3, 26)	0.000000	0.000000
X(3, 27)	0.000000	0.000000
X(3, 28)	0.000000	0.000000
X(3, 29)	0.000000	0.000000
X(3, 30)	0.000000	0.000000
X(3, 31)	0.000000	0.000000
X(3, 32)	0.000000	0.000000
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X(3, 34)	0.000000	0.000000
X(3, 35)	0.000000	0.000000
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X(3, 39)	0.000000	0.000000
X(3, 40)	0.000000	0.000000
X(3, 41)	0.000000	0.000000
X(3, 42)	0.000000	0.000000
X(3, 43)	0.000000	0.000000
X(3, 44)	0.000000	0.000000

X(3, 45)	0.000000	0.000000
X(3, 46)	0.000000	0.000000
X(3, 47)	0.000000	0.000000
X(3, 48)	0.000000	0.000000
X(3, 49)	0.000000	0.000000
X(4, 1)	0.000000	0.000000
X(4, 2)	0.000000	0.000000
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X(4, 4)	0.000000	0.000000
X(4, 5)	0.000000	0.000000
X(4, 6)	0.000000	0.000000
X(4, 7)	0.000000	0.000000
X(4, 8)	0.000000	0.000000
X(4, 9)	0.000000	0.000000
X(4, 10)	0.000000	0.000000
X(4, 11)	0.000000	0.000000
X(4, 12)	0.000000	0.000000
X(4, 13)	0.000000	0.000000
X(4, 14)	0.000000	0.000000
X(4, 15)	0.000000	0.000000
X(4, 16)	0.000000	0.000000
X(4, 17)	0.000000	0.000000
X(4, 18)	0.000000	0.000000
X(4, 19)	0.000000	0.000000
X(4, 20)	0.000000	0.000000
X(4, 21)	0.000000	0.000000
X(4, 22)	0.000000	0.000000
X(4, 23)	0.000000	0.000000
X(4, 24)	0.000000	0.000000
X(4, 25)	0.000000	0.000000
X(4, 26)	0.000000	0.000000
X(4, 27)	0.000000	0.000000
X(4, 28)	0.000000	0.000000
X(4, 29)	0.000000	0.000000
X(4, 30)	0.000000	0.000000
X(4, 31)	0.000000	0.000000
X(4, 32)	0.000000	0.000000
X(4, 33)	0.000000	0.000000
X(4, 34)	0.000000	0.000000
X(4, 35)	0.000000	0.000000
X(4, 36)	0.000000	0.000000
X(4, 37)	0.000000	0.000000
X(4, 38)	0.000000	0.000000
X(4, 39)	0.000000	0.000000
X(4, 40)	0.000000	0.000000
X(4, 41)	0.000000	0.000000
X(4, 42)	0.000000	0.000000
X(4, 43)	0.000000	0.000000
X(4, 44)	0.000000	0.000000
X(4, 45)	0.000000	0.000000
X(4, 46)	0.000000	0.000000
X(4, 47)	0.000000	0.000000
X(4, 48)	0.000000	0.000000
X(4, 49)	0.000000	0.000000
X(5, 1)	0.000000	0.000000
X(5, 2)	0.000000	0.000000
X(5, 3)	0.000000	0.000000
X(5, 4)	0.000000	0.000000
X(5, 5)	0.000000	0.000000

X(5, 6)	0.000000	0.000000
X(5, 7)	0.000000	0.000000
X(5, 8)	0.000000	0.000000
X(5, 9)	0.000000	0.000000
X(5, 10)	0.000000	0.000000
X(5, 11)	0.000000	0.000000
X(5, 12)	0.000000	0.000000
X(5, 13)	0.000000	0.000000
X(5, 14)	0.000000	0.000000
X(5, 15)	0.000000	0.000000
X(5, 16)	0.000000	0.000000
X(5, 17)	0.000000	0.000000
X(5, 18)	0.000000	0.000000
X(5, 19)	0.000000	0.000000
X(5, 20)	0.000000	0.000000
X(5, 21)	0.000000	0.000000
X(5, 22)	0.000000	0.000000
X(5, 23)	0.000000	0.000000
X(5, 24)	0.000000	0.000000
X(5, 25)	0.000000	0.000000
X(5, 26)	0.000000	0.000000
X(5, 27)	0.000000	0.000000
X(5, 28)	0.000000	0.000000
X(5, 29)	0.000000	0.000000
X(5, 30)	0.000000	0.000000
X(5, 31)	0.000000	0.000000
X(5, 32)	0.000000	0.000000
X(5, 33)	0.000000	0.000000
X(5, 34)	0.000000	0.000000
X(5, 35)	0.000000	0.000000
X(5, 36)	0.000000	0.000000
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X(5, 40)	0.000000	0.000000
X(5, 41)	0.000000	0.000000
X(5, 42)	0.000000	0.000000
X(5, 43)	0.000000	0.000000
X(5, 44)	0.000000	0.000000
X(5, 45)	0.000000	0.000000
X(5, 46)	0.000000	0.000000
X(5, 47)	0.000000	0.000000
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X(5, 49)	0.000000	0.000000
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X(6, 3)	0.000000	0.000000
X(6, 4)	0.000000	0.000000
X(6, 5)	0.000000	0.000000
X(6, 6)	0.000000	0.000000
X(6, 7)	0.000000	0.000000
X(6, 8)	0.000000	0.000000
X(6, 9)	0.000000	0.000000
X(6, 10)	0.000000	0.000000
X(6, 11)	0.000000	0.000000
X(6, 12)	0.000000	0.000000
X(6, 13)	0.000000	0.000000
X(6, 14)	0.000000	0.000000
X(6, 15)	0.000000	0.000000

X(6, 16)	0.000000	0.000000
X(6, 17)	0.000000	0.000000
X(6, 18)	0.000000	0.000000
X(6, 19)	0.000000	0.000000
X(6, 20)	0.000000	0.000000
X(6, 21)	0.000000	0.000000
X(6, 22)	0.000000	0.000000
X(6, 23)	0.000000	0.000000
X(6, 24)	0.000000	0.000000
X(6, 25)	0.000000	0.000000
X(6, 26)	0.000000	0.000000
X(6, 27)	0.000000	0.000000
X(6, 28)	0.000000	0.000000
X(6, 29)	0.000000	0.000000
X(6, 30)	0.000000	0.000000
X(6, 31)	0.000000	0.000000
X(6, 32)	0.000000	0.000000
X(6, 33)	0.000000	0.000000
X(6, 34)	0.000000	0.000000
X(6, 35)	0.000000	0.000000
X(6, 36)	0.000000	0.000000
X(6, 37)	0.000000	0.000000
X(6, 38)	0.000000	0.000000
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X(6, 40)	0.000000	0.000000
X(6, 41)	0.000000	0.000000
X(6, 42)	0.000000	0.000000
X(6, 43)	0.000000	0.000000
X(6, 44)	0.000000	0.000000
X(6, 45)	0.000000	0.000000
X(6, 46)	0.000000	0.000000
X(6, 47)	0.000000	0.000000
X(6, 48)	0.000000	0.000000
X(6, 49)	0.000000	0.000000
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X(7, 2)	0.000000	0.000000
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X(7, 4)	0.000000	0.000000
X(7, 5)	0.000000	0.000000
X(7, 6)	0.000000	0.000000
X(7, 7)	0.000000	0.000000
X(7, 8)	0.000000	0.000000
X(7, 9)	0.000000	0.000000
X(7, 10)	0.000000	0.000000
X(7, 11)	0.000000	0.000000
X(7, 12)	0.000000	0.000000
X(7, 13)	0.000000	0.000000
X(7, 14)	0.000000	0.000000
X(7, 15)	0.000000	0.000000
X(7, 16)	0.000000	0.000000
X(7, 17)	0.000000	0.000000
X(7, 18)	0.000000	0.000000
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X(7, 20)	0.000000	0.000000
X(7, 21)	0.000000	0.000000
X(7, 22)	0.000000	0.000000
X(7, 23)	0.000000	0.000000
X(7, 24)	0.000000	0.000000
X(7, 25)	0.000000	0.000000

X(7, 26)	0.000000	0.000000
X(7, 27)	0.000000	0.000000
X(7, 28)	0.000000	0.000000
X(7, 29)	0.000000	0.000000
X(7, 30)	0.000000	0.000000
X(7, 31)	0.000000	0.000000
X(7, 32)	0.000000	0.000000
X(7, 33)	0.000000	0.000000
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X(7, 35)	0.000000	0.000000
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X(7, 37)	0.000000	0.000000
X(7, 38)	0.000000	0.000000
X(7, 39)	0.000000	0.000000
X(7, 40)	0.000000	0.000000
X(7, 41)	0.000000	0.000000
X(7, 42)	0.000000	0.000000
X(7, 43)	0.000000	0.000000
X(7, 44)	0.000000	0.000000
X(7, 45)	0.000000	0.000000
X(7, 46)	0.000000	0.000000
X(7, 47)	0.000000	0.000000
X(7, 48)	0.000000	0.000000
X(7, 49)	0.000000	0.000000
X(8, 1)	0.000000	0.000000
X(8, 2)	0.000000	0.000000
X(8, 3)	0.000000	0.000000
X(8, 4)	0.000000	0.000000
X(8, 5)	0.000000	0.000000
X(8, 6)	0.000000	0.000000
X(8, 7)	0.000000	0.000000
X(8, 8)	0.000000	0.000000
X(8, 9)	0.000000	0.000000
X(8, 10)	0.000000	0.000000
X(8, 11)	0.000000	0.000000
X(8, 12)	0.000000	0.000000
X(8, 13)	0.000000	0.000000
X(8, 14)	0.000000	0.000000
X(8, 15)	0.000000	0.000000
X(8, 16)	0.000000	0.000000
X(8, 17)	0.000000	0.000000
X(8, 18)	0.000000	0.000000
X(8, 19)	0.000000	0.000000
X(8, 20)	0.000000	0.000000
X(8, 21)	0.000000	0.000000
X(8, 22)	0.000000	0.000000
X(8, 23)	0.000000	0.000000
X(8, 24)	0.000000	0.000000
X(8, 25)	0.000000	0.000000
X(8, 26)	0.000000	0.000000
X(8, 27)	0.000000	0.000000
X(8, 28)	0.000000	0.000000
X(8, 29)	0.000000	0.000000
X(8, 30)	0.000000	0.000000
X(8, 31)	0.000000	0.000000
X(8, 32)	0.000000	0.000000
X(8, 33)	0.000000	0.000000
X(8, 34)	0.000000	0.000000
X(8, 35)	0.000000	0.000000

X(8, 36)	0.000000	0.000000
X(8, 37)	0.000000	0.000000
X(8, 38)	0.000000	0.000000
X(8, 39)	0.000000	0.000000
X(8, 40)	0.000000	0.000000
X(8, 41)	0.000000	0.000000
X(8, 42)	0.000000	0.000000
X(8, 43)	0.000000	0.000000
X(8, 44)	0.000000	0.000000
X(8, 45)	0.000000	0.000000
X(8, 46)	0.000000	0.000000
X(8, 47)	0.000000	0.000000
X(8, 48)	0.000000	0.000000
X(8, 49)	0.000000	0.000000
X(9, 1)	0.000000	0.000000
X(9, 2)	0.000000	0.000000
X(9, 3)	0.000000	0.000000
X(9, 4)	0.000000	0.000000
X(9, 5)	0.000000	0.000000
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X(9, 45)	0.000000	0.000000

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X(9, 47)	0.000000	0.000000
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X(14, 1)	6999.000	0.000000
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X(14, 13)	0.000000	0.000000
X(14, 14)	0.000000	0.000000
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X(14, 17)	0.000000	0.000000
X(14, 18)	19779.00	0.000000
X(14, 19)	0.000000	0.000000
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X(14, 22)	0.000000	0.000000
X(14, 23)	1530.000	0.000000
X(14, 24)	16818.00	0.000000
X(14, 25)	660.0000	0.000000
X(14, 26)	1100.000	0.000000
X(14, 27)	0.000000	0.000000
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X(14, 36)	0.000000	0.000000

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X(14, 49)	0.000000	0.000000
X(15, 1)	11001.00	0.000000
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X(15, 24)	0.000000	0.000000
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X(15, 29)	0.000000	0.000000
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X(15, 46)	0.000000	0.000000

X(15, 47)	0.000000	0.000000
X(15, 48)	0.000000	0.000000
X(15, 49)	0.000000	0.000000
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X(16, 13)	0.000000	0.000000
X(16, 14)	0.000000	0.000000
X(16, 15)	0.000000	0.000000
X(16, 16)	0.000000	0.000000
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X(16, 18)	0.000000	0.000000
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X(16, 20)	0.000000	0.000000
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X(16, 29)	0.000000	0.000000
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X(40, 11)	0.000000	0.000000
X(40, 12)	0.000000	0.000000
X(40, 13)	0.000000	0.000000
X(40, 14)	0.000000	0.000000
X(40, 15)	0.000000	0.000000
X(40, 16)	0.000000	0.000000
X(40, 17)	0.000000	0.000000
X(40, 18)	0.000000	0.000000
X(40, 19)	0.000000	0.000000
X(40, 20)	0.000000	0.000000
X(40, 21)	0.000000	0.000000
X(40, 22)	0.000000	0.000000
X(40, 23)	0.000000	0.000000
X(40, 24)	0.000000	0.000000
X(40, 25)	0.000000	0.000000
X(40, 26)	0.000000	0.000000
X(40, 27)	0.000000	0.000000
X(40, 28)	0.000000	0.000000
X(40, 29)	0.000000	0.000000
X(40, 30)	0.000000	0.000000
X(40, 31)	0.000000	0.000000
X(40, 32)	0.000000	0.000000
X(40, 33)	0.000000	0.000000
X(40, 34)	0.000000	0.000000
X(40, 35)	0.000000	0.000000
X(40, 36)	0.000000	0.000000
X(40, 37)	0.000000	0.000000
X(40, 38)	12000.00	0.000000
X(40, 39)	13470.00	0.000000
X(40, 40)	0.000000	0.000000
X(40, 41)	0.000000	0.000000
X(40, 42)	0.000000	0.000000
X(40, 43)	0.000000	0.000000
X(40, 44)	0.000000	0.000000
X(40, 45)	0.000000	0.000000
X(40, 46)	0.000000	0.000000
X(40, 47)	0.000000	0.000000
X(40, 48)	0.000000	0.000000
X(40, 49)	0.000000	0.000000
X(41, 1)	0.000000	0.000000
X(41, 2)	0.000000	0.000000
X(41, 3)	0.000000	0.000000
X(41, 4)	0.000000	0.000000
X(41, 5)	0.000000	0.000000
X(41, 6)	0.000000	0.000000
X(41, 7)	0.000000	0.000000
X(41, 8)	0.000000	0.000000
X(41, 9)	0.000000	0.000000
X(41, 10)	0.000000	0.000000
X(41, 11)	0.000000	0.000000

X(41, 12)	0.000000	0.000000
X(41, 13)	0.000000	0.000000
X(41, 14)	0.000000	0.000000
X(41, 15)	0.000000	0.000000
X(41, 16)	0.000000	0.000000
X(41, 17)	0.000000	0.000000
X(41, 18)	0.000000	0.000000
X(41, 19)	0.000000	0.000000
X(41, 20)	0.000000	0.000000
X(41, 21)	0.000000	0.000000
X(41, 22)	0.000000	0.000000
X(41, 23)	0.000000	0.000000
X(41, 24)	0.000000	0.000000
X(41, 25)	0.000000	0.000000
X(41, 26)	0.000000	0.000000
X(41, 27)	0.000000	0.000000
X(41, 28)	0.000000	0.000000
X(41, 29)	0.000000	0.000000
X(41, 30)	0.000000	0.000000
X(41, 31)	0.000000	0.000000
X(41, 32)	0.000000	0.000000
X(41, 33)	0.000000	0.000000
X(41, 34)	0.000000	0.000000
X(41, 35)	0.000000	0.000000
X(41, 36)	0.000000	0.000000
X(41, 37)	0.000000	0.000000
X(41, 38)	0.000000	0.000000
X(41, 39)	0.000000	0.000000
X(41, 40)	0.000000	0.000000
X(41, 41)	0.000000	0.000000
X(41, 42)	0.000000	0.000000
X(41, 43)	0.000000	0.000000
X(41, 44)	5000.000	0.000000
X(41, 45)	0.000000	0.000000
X(41, 46)	2387.000	0.000000
X(41, 47)	417.0000	0.000000
X(41, 48)	0.000000	0.000000
X(41, 49)	73.09942	0.000000
X(42, 1)	0.000000	0.000000
X(42, 2)	0.000000	0.000000
X(42, 3)	0.000000	0.000000
X(42, 4)	0.000000	0.000000
X(42, 5)	0.000000	0.000000
X(42, 6)	0.000000	0.000000
X(42, 7)	0.000000	0.000000
X(42, 8)	0.000000	0.000000
X(42, 9)	0.000000	0.000000
X(42, 10)	0.000000	0.000000
X(42, 11)	0.000000	0.000000
X(42, 12)	0.000000	0.000000
X(42, 13)	0.000000	0.000000
X(42, 14)	0.000000	0.000000
X(42, 15)	0.000000	0.000000
X(42, 16)	0.000000	0.000000
X(42, 17)	0.000000	0.000000
X(42, 18)	0.000000	0.000000
X(42, 19)	0.000000	0.000000
X(42, 20)	0.000000	0.000000
X(42, 21)	0.000000	0.000000

X(42, 22)	0.000000	0.000000
X(42, 23)	0.000000	0.000000
X(42, 24)	0.000000	0.000000
X(42, 25)	0.000000	0.000000
X(42, 26)	0.000000	0.000000
X(42, 27)	0.000000	0.000000
X(42, 28)	0.000000	0.000000
X(42, 29)	0.000000	0.000000
X(42, 30)	0.000000	0.000000
X(42, 31)	0.000000	0.000000d
X(42, 32)	2652.000	0.000000
X(42, 33)	3393.000	0.000000
X(42, 34)	0.000000	0.000000
X(42, 35)	1227.000	0.000000
X(42, 36)	7300.000	0.000000
X(42, 37)	3000.000	0.000000
X(42, 38)	0.000000	0.000000
X(42, 39)	0.000000	0.000000
X(42, 40)	0.000000	0.000000
X(42, 41)	1300.000	0.000000
X(42, 42)	0.000000	0.000000
X(42, 43)	0.000000	0.000000
X(42, 44)	0.000000	0.000000
X(42, 45)	3000.000	0.000000
X(42, 46)	0.000000	0.000000
X(42, 47)	0.000000	0.000000
X(42, 48)	3000.000	0.000000
X(42, 49)	2926.901	0.000000

APPENDIX E : SOLUTION TO THE SIMULATION MODEL

ARENA Simulation Results
Öğretim Üyeleri - License: 1953000492

Output Summary for 10 Replications

Project: TEZ **Run execution date : 6/17/08**
Analyst: EC **Model revision date:26/ 4/08**

OUTPUTS

Identifier	Average	Half-width	Minimum	Maximum	# Replications
DAVG(eff12)	.00000	.00000	.00000	.00000	10
DAVG(eff20)	.71425	.05468	.57760	.80457	10
DAVG(eff13)	.00000	.00000	.00000	.00000	10
DAVG(eff1)	.00000	.00000	.00000	.00000	10
DAVG(eff21)	.00000	.00000	.00000	.00000	10

DAVG(eff14)	**.73882**	**.06190**	**.57841**	**.84901**	**10**
DAVG(eff2)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff22)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff15)	**.74228**	**.07978**	**.47099**	**.84253**	**10**
DAVG(eff3)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff30)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff23)	**.67720**	**.08180**	**.55670**	**.82774**	**10**
DAVG(eff16)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff4)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff31)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff24)	**.69073**	**.05932**	**.53321**	**.80968**	**10**
DAVG(eff17)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff5)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff32)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff25)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff18)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff40)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff6)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff33)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff26)	**.65488**	**.03889**	**.59695**	**.76843**	**10**
DAVG(eff19)	**.75284**	**.04496**	**.65050**	**.84506**	**10**
DAVG(eff41)	**.70690**	**.07006**	**.57761**	**.84953**	**10**
DAVG(eff7)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff34)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff27)	**.68015**	**.06920**	**.51359**	**.77357**	**10**
DAVG(eff42)	**.72162**	**.05439**	**.55546**	**.81749**	**10**
DAVG(eff8)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff35)	**.72467**	**.07576**	**.50749**	**.83384**	**10**
DAVG(eff28)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff9)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff36)	**.72545**	**.04039**	**.66124**	**.82005**	**10**
DAVG(eff29)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff37)	**.70342**	**.04963**	**.60671**	**.77931**	**10**
DAVG(eff38)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff39)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff10)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
DAVG(eff11)	**.00000**	**.00000**	**.00000**	**.00000**	**10**
System.NumberOut	**.00000**	**.00000**	**.00000**	**.00000**	**10**

Simulation run time: 0.02 minutes.
Simulation run complete.