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ASSESSING THE AVAILABILITY AND ALLOCATION OF PRODUCTION CAPACITY IN A FABRICATION FACILITY THROUGH SIMULATION MODELING: A CASE STUDY

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For a tier two automobile supplier's fabrication facility, the manufacturing process required producing two classes of products, those produced on a repetitive and those produced on a periodic basis. Static capacity analysis determined if sufficient gross capacity existed in the production system in order to meet customer demand but was unable to determine if the capacity was available at the desired times to preserve an acceptable service level. A simulation model was developed to confirm the sequencing and scheduling of both classes of products. The model also incorporated the logistical constraints of customer supplied materials used in the production process. The simulation output was able to evaluate the system performance metrics regarding material availability, transportation efficiencies, product backorders, and interruptions to the production process. The model provided a planning tool that assessed the quarterly production plan; identified customer service issues and evaluated the impact of continuous improvement efforts.

Significance: Production plans are often evaluated in a static environment. This paper describes a tier two automotive supplier's process of integrating the simulation model into the production planning and scheduling process.

Keywords: Simulation, capacity analysis, capacity allocation.

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1. INTRODUCTION

Although many companies have adopted lean methods as their preferred approach to addressing design and operational issues of their production systems, many discrete part manufacturers still depend on manufacturing resource planning or MRPII systems. These systems approach production and capacity planning as integrated processes. Aggregate production and resource requirement plans produce the master production schedules (MPS) and rough-cut capacity plans (RCCP) respectively. The RCCP identifies capacity issues for critical work centers. Additional capacity issues become obvious after bill of material (BOM) explosions create the materials requirement plan (MRP). Using information from the MRP plan, the capacity requirements plan (CRP) validates the capacity of individual work centers before assigning shop floor schedules (Sipper and Bulfin, 1997). The MRP approach to setting shop floor schedules has well documented limits (Watson et al. 1997), and affects of demand variability and equipment availability compel the use of alternate techniques to ensure that sufficient capacity exists for production schedules. The objective of this paper is to describe the approach of a make to order (MTO) company in the fabricated metal product industry incorporating discrete event simulation to assess their methods of allocating production capacity.

This manufacturer's production system contains many of the same manufacturing processes that are common in stamped and fabricated metal wire products industries. The manufacturer receives orders for customized products and fills them based on customer due dates. Long-term customer contracts produce most of the customer demand but shorter term contracts create production demand for periodically produced products. A product's processing characteristics determine the specific flow line assignment for manufacture. All of the product's processing operations occur within their assigned

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flow line since there is no intra-flow line travel. Steel coils, varying in material type, gage, and slit width, are the raw material needed for this manufacturing process. These coils run through a continual forming operation that transforms the steel into flexible, usable subcomponents in the automotive industry. Winding the final product onto spools is the last step in the manufacturing process. These spools are stored in finished goods inventory until shipments of product are sent to the customers. The customer, a tier two automotive supplier, assembles the products with other items to form a subassembly for the original equipment manufacturer (OEM).

The production planning process identifies which products, out of over seventy current products, are scheduled for production on a repetitive cycle and assigns those products to their associated flow line. The production of the products, not scheduled for repetitive production, occurs when the flow lines have available or "open" capacity gaps. The production planning process does not have the ability to account for variability in spool availability caused by logistics of spool transport between the manufacturer and the customer. At the beginning of a product launch the customer supplies the manufacturer with a negotiated quantity of spools. As the manufacturer fulfills customer orders and winds the finished product onto these spools, they are then shipped to over twenty customers. The customers use these products in their manufacturing processes, emptying the spools of product, then returning the empty spools to the manufacturer. A significant constraint in the system is that only customer specific product can be wound onto each individual customer's spools and spool sharing between customers does not occur. Managing the spools in the system is a key operational issue in the production system. Since the number of spools in the system is finite, the production system acts as a closed queuing system. The objective of integrating the simulation analysis into the production planning process is not only to assess the available capacity in the system but also to evaluate the required number of customer spools to allow for the most efficient operation of the production system.

2. LITERATURE SURVEY

A significant amount of literature on capacity allocation problems are either approached by developing mathematical models to analyze capacity costs or by implementing optimization approaches, such as discrete event simulation, to address capacity concerns. Some recent literature has been addressing strategic capacity issues. Dekkers (2003) examined capacity management of companies that developed and manufactured products based on customer demands on a strategic level. Results suggested that companies that did not effectively manage capacity decisions incurred increased manufacturing costs and lead time delays. Huh et al. (2006) also examine capacity decisions based on strategic issues. Two different capacity allocation procedures, lost sales cost minimization and uniform fill rate production, were considered when demand exceeded supply. Chou et al. (2001) described a process for integrating the three most common methods of capacity analysis; simulation, static capacity and queuing capacity modeling.

Various mathematical modeling approaches are also evident. Ozdamar and Yazgac (1997) discussed developing a linear capacity planning model which focused on leveling production loads in bottleneck departments. The model that they developed created a MPS that was feasible in terms of capacity utilizations. Abdul-Kader and Gharbi (2002) considered the case of serial multistage production lines with defined sequences. Their approach used experimental design to determine the size and placement of buffers as well the affect of these buffers on the capacity of the production line. The previous work of Furmero and Vercellis (1994) reasoned the volatility and uncertainty in mixed make-to-order/assemble-to-order environments have great difficulty in establishing required capacity levels. They developed a mixed integer optimization model for determining capacity levels.

Specific capacity allocation policies and their cost implications for firms trying to address short-term variation in product demand were analyzed by Bish et al. (2005). They considered nonflexible, fixed proportion and fully flexible allocation policies. Comparison of these policies included the impact of product contribution margins and customer locations. Akinc and Meredith (2006) analyzed capacity decisions in a make-to-forecast (MTF) environment. They considered a MTF environment a special case of a make-to-stock (MTS) environment in which production occurs in anticipation of customer demand and is not driven by forecasts or firm orders. A Markov analysis was used to compared order orphans (products without customers) to order rejections (insufficient capacity).

There was a wide variety of literature that incorporated simulation techniques into their approach for solving capacity allocation issues. Gutierrez and Crispin (2005) developed a decision support system that provided production personnel with recommendation for scheduling products on individual machines in hybrid production environments. Although simulation was not directly incorporated into their approach, they suggested that simulation modeling would improve the provided solutions by incorporating the effect of variability into the solution. Volker and Gmilkowsky (2003) discussed that effective simulation modeling of production systems require a significant amount of simulation runs to analyze alternative production plans. They proposed a model reduction method and use of simulation metamodels that would reduce the cost of simulation runs. Although discrete event simulation has been used widely for analysis of discrete production systems Mehra et al. (2006) discussed the effects of reducing batch times in continuous process industries. The reduction of batch sizes in continuous process industries showed improvement to the production systems using Theory of Constraint performance measures. Byrne and Heavey (2006) expanded the use of simulation to develop a decision support system for an integrated supply chain to address strategic decisions in addition to production stocking strategies.

Improvements to the direct application of simulation models were discussed by Kumar and Nottestad (2006) and Truong and Azadivar (2003). Kumar and Nottestad (2006) incorporated design of experiments (DOE) into their simulation analysis. Their research suggested that high order interactions are often ignored in analyzing production systems with simulation models. Integrating DOE into the simulation analysis reduced time required to develop an understanding of the production system characteristics. Truong and Azadivar (2003) used simulation analysis to analyze structural decisions, including capacity considerations, and coordination decisions to analyze the performance of a supply chain network. The simulation analysis incorporated genetic algorithms and mixed integer programming as well as simulation to analyze the complexities of a supply chain configuration.

3. METHODOLOGY

The production planning process begins by classifying the customer's products as either high volume or low volume. Manufacture of the high volume products, referred to as the repetitive products, occurs each production cycle, while manufacture of the low volume products, referred to as the periodic products occurs on an intermittent basis. A Pareto analysis of the production volumes during the previous planning periods identified each product as either low volume or high volume. The results of this analysis identified that 30% of the products manufactured produced 80% of the demand for the production resources. These high volume products were assigned to part families, and subsequently assigned to process specific flowlines, using clustering techniques that identified similarities in the processing features. The production system design focused on producing the high volume products efficiently by scheduling their production in repeating production cycles. The low volume products were produced on an "as-needed" basis, based on customer orders, during the periods in the production cycle when "open" gaps of capacity were available.

3.1 Daily Demand Kanban

A fundamental task of the production planning process is computing the daily demand kanbans for both the repetitive and periodically manufactured products. The daily demand kanbans represented the effective daily demand for the products and not the daily production quantities. These products would be manufactured in specific sequences during the production cycle on each flowline. Different flowlines cycles would not necessarily be designed with the same duration. Multiplying the production cycle length and the daily demand kanban calculated the required production quantities for each product. The previous quarter's production shipment requirements helped set the daily production kanban for each product. An example of a product's daily shipment pattern is shown in Figure 1.

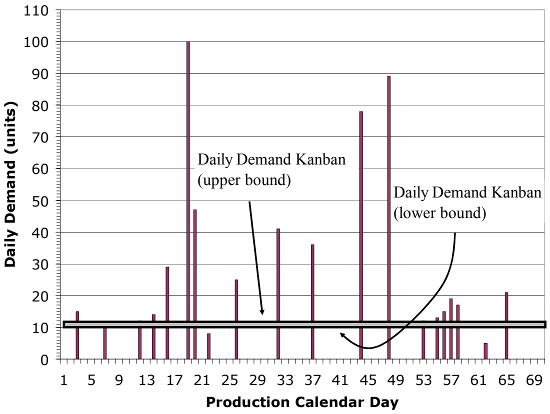


Figure 1: Daily Production Demands with Upper and Lower Bound Demand Kanbans

The historical shipment patterns facilitated calculating the upper bound and lower bound daily demand kanbans. A linear programming model, shown in Equation 1, calculated the upper bound kanban ensuring all production demands would be met with no backorders or delays. An issue with this approach was there would be overproduction of products toward the end of the quarter. Three large shipments on production calendar days 19, 44, and 48 caused the overproduction in this example. Since production control would be aware of these large orders well in advance and could adjust production capacities with overtime or additional shifts, the lower bound production quota was calculated based on preprocessing of the daily shipment data. The demand data was preprocessed so that the maximum demand used in the linear programming model for any single day would not exceed twice the average demand for the previous period.

The results for the calculations for the upper and lower bound daily kanbans, based on an initial inventory of 20 units for this product, are shown in Table 1. As expected the upper bound quota eliminated any backorders but resulted in an average inventory more that twice that of the lower bound and an ending inventory level over 300% larger than that of the lower bound. The lower bound resulted in 21 days where inventory levels were inadequate to meet demand. The upper and lower bounds were fences for the actual daily demand kanbans. The actual demand kanbans were set using this information in consultation with marketing and sales to identify the proper daily demand kanban. In this example, if the daily demand kanban were 10 units, halfway between the upper and lower bound, there would have been only two days where demand could not be met with inventory. This scenario would result in an average inventory of 58.5 units.

minimize $\quad Z = \sum_{i=1}^{n} K_n$

s.t.

$I_i - I_{i-1} - K_i + d_i \geq 0 \quad$ for i = 1 to n

$K_{i+1} - K_i = 0 \quad$ for i = 1 to n-1

K_i integer $\quad$ for i = 1 to n

where:

I_i = inventory position at the end of production calendar day i

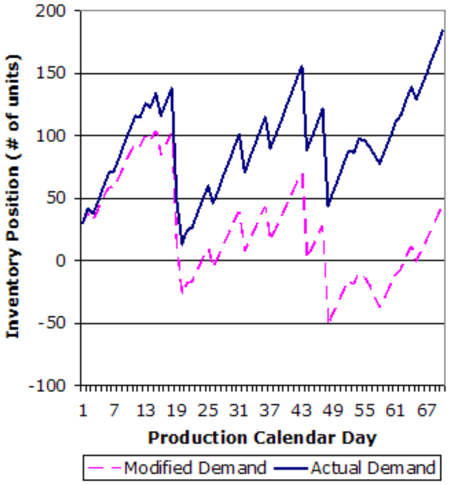
I_0 = inventory position at the end of the previous analysis period

d_i = production demand for production calendar day i

K_i = daily demand kanban for production calendar day i

n = number of production calendar days

… (1)



	Daily Kanban (units)	Ending Inventory (units)	Avg Inventory (units)	# of Days w/Backorders
Upper bound	11	184	93.9	0
Lower bound	9	44	41.9	21

Table 1: Inventory Level Comparisons for Upper and Lower Bound Daily Demand Kanbans

3.2 Production Cycle Selection and Implications

After assigning products to their flowlines, the next step was setting the production cycle length for each flowline. The production cycle length, representing the number of productive days, acts as a multiplier for the daily demand kanban. Selecting cycle days is not arbitrary and has a significant impact on the inventory coverage. A representation of a flowline cycle (see Figure 2) shows that within the set number of cycle days four of the repetitively manufactured products will be produced as well as an empty slot of open capacity.

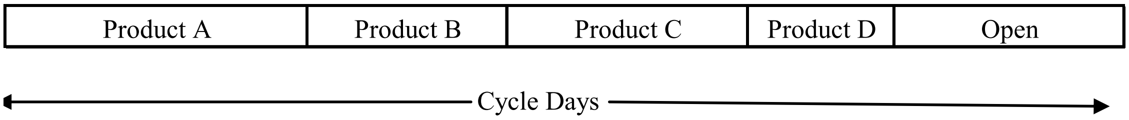


Figure 2: Example of Flowline Cycle

The empty slot of open capacity is reserved for producing the periodic products. These products represent 70% of the products that produce the lower 20% of the product demand. For example, if the number of cycle days for Flowline #1 is 12 days, then on Day 1 of that production cycle, twelve times the daily demand quota of Product 1 is scheduled for production. The production plan will not schedule Product 1 to be run on that flowline again until Day 13. The focus of the product cycle selection process is to ensure that there is enough gross capacity to satisfy the demand requirements for the repetitively produced products and to allow open slots of capacity to exist in the production cycle in order to manufacture the periodic products.

3.3 Incorporating Simulation into the Capacity Allocation Analysis

A static spreadsheet analysis could evaluate the gross capacity of the production system after: 1) assigning the repetitive products to the flowlines; 2) calculating the daily demand kanbans for the products and 3) setting production cycle length for each flowline. There are several critical issues that cannot be addressed by spreadsheet analysis which require a production system simulation. Some of the issues that a gross capacity analysis could not address include:

> Are there enough spools in the system to meet the market demand requirements considering logistical constraints?
> Are there enough open capacity slots to meet the demand for the periodic products?
> Does the sequencing of products impact the system performance?
> How efficient are the schedules for product transportation to the customer?

The simulation model, as described in Section 4, using the production system design outputs as model inputs, was designed to provide answers to these questions.

4. SIMULATION MODEL

The simulation model analyzed production system performance, specifically for capacity allocation and availability, based on the production plan outputs. Since the production system acted as a closed queuing network, because of the finite number of spools in the system, the simulation model tracked spools as the primary entity flowing through the manufacturing and distribution system. Each flowline processed a specific sequence of repetitive products as determined by the production plan. At the beginning of the product cycle, the required number of empty spools for processing the current product, was sent to the flowline. As the product was manufactured it was wound onto the empty spool. After winding a spool with product, the spool was move to finished goods inventory (FGI). Subsequent to receiving customer orders for the products, the spools were transported to the customer. As these products were used in their processes, producing the subassemblies for the OEM, the spools would be depleted of product and the customer would then accumulate a batch of empty spools. Based on transportation policies, the empty spools would be returned to the manufacturer. Figure 3 shows how the spools flow through the manufacturing and distribution system.

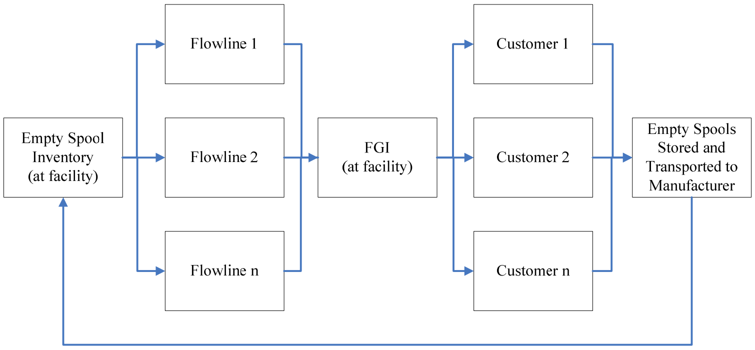


Figure 3: Customer Spool Flow through Manufacturing and Distribution System

4.1 Model Inputs

The simulation model was designed to be as flexible as possible to changes in products, customers, and processes. The outputs from the production plan created the inputs to the simulation model. A spreadsheet model integrated these outputs into user interface that allowed production personnel to interact with the simulation model. This was an important part of the simulation project since the production personnel using this simulation model to evaluate changes in the production system did not have any training using simulation software.

The user interface integrated all of the necessary system data into six major modules. These modules were: production plan parameters, product attributes, spool inventories, customer orders, product transportation policies, and system parameter modifications (see Figure 4).

4.1.1 Production Plan Parameters

The production planning process' primary outputs were assigning and scheduling of repetitive products to flowlines and setting the production cycle length for each flowline as well as adjusting the daily demand kanban to the correct level. Other flowline specific information transferred from the production plan to the simulation model includes the shift schedules for the flowlines and any planned overtime or weekend shifts. Although a gross capacity analysis is performed in the production planning process, the simulation model uses this information in calculating the "open" capacity that exits on each flowline at the end of the product cycle. The simulation model decides which periodic products should be scheduled into the open capacity gaps based of due dates, total processing time, etc.

4.1.2 Product Attributes

Product attributes transferred to the simulation model include the processing parameters such as production rates, product changeover times, spool capacity, customer, and product code. Product codes are customer specific so it is possible for different customers to purchase similar product with unique product codes. Parameters for periodic products also include identifying which flowline can process these products.

4.1.3 Spool Inventories

Since the number of spools in the system is finite, the simulation model's initialization procedures must identify the spools location, whether they are located at the manufacturer's or the customer's facility, and quantity of spools at these locations. Further, the system must be able to identify whether the spools are empty or contain product.

4.1.4 Customer Orders

The customer orders are entered into the system to validate the production plan. These orders identify the customers and their product requirements.

4.1.5 Product Transportation Policies

Although customer orders identify specific order dates, most of the customers have negotiated product transportation policies with the manufacturer. Product transportation policies include frequency of shipments as well as days of the week in which deliveries can be made. As part of evaluating the production plan performance, late deliveries occur when the products are not available for transport on their appointed schedule. Products are scheduled by either individual product or batches of products for customers. Transportation policies are evaluated by examining vehicle utilizations of the transports during the planning horizon.

4.1.5 System Parameter Adjustments

The simulation model evaluates the production plan in an iterative fashion. The user interface allows changing plan parameters without reentering the production plan. At the end of the simulation run the modified parameters are output to the production plan. The user interface allows overriding the production plan parameters of daily kanban requirements, production rates, and production cycle length. The user has the ability to adjust these parameters in order to improve system performance. Another parameter controlled by the user can control is the percentage of spools required to start the production run. Users have the ability to allow the production system to start producing an order for a product without a full complement of spools. The theory is that some of these production runs will span multiple days and the balance of spools needed to complete the order could be in transport. Also, the user has the ability to select which customers can use common spools which are held in reserve by the manufacturer. The use of these common spools is discussed further in Section 4.2.

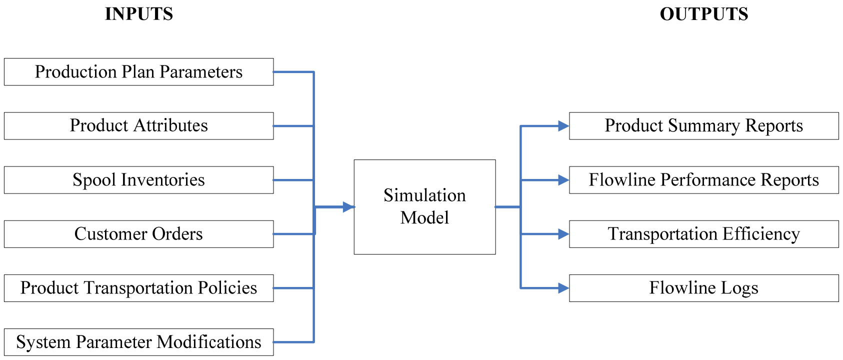


Figure 4: Simulation Model Inputs and Outputs

4.2 Spool Processing Logic

The model tracks and reacts to the flow of a finite number of spools through the production and distribution system. The spools are assigned to specific customers and only customer specific product could be placed on these spools. Typically any individual customer would not contract the manufacture of more than 5 unique products. When the contracts were established between the customer and the manufacturer, the customer agreed to supply a fixed number of spools to the manufacturer before the initial production run. A major disruption to the production system occurs when the manufacturer does not have available the correct amount of spools for a production run. In this case, the production run would need to be rescheduled or canceled resulting in delays of customer shipments. The manufacturer owns a supply of “common” spools to prevent these types of disruptions to the production system. The production schedule’s integrity can be maintained by using these common spools to supplement any customer spool shortage. Production control decides when to use these common spools in the process but also has knowledge of the shipments of customer spools to the manufacturer. Operations allows production runs to start without the necessary amount of customer spools needed to complete the production run if there is evidence that the balance of customer spools will arrive during the production process. The model incorporates this logic by allowing the user to set a “start percentage”. The simulation logic uses the start percentage to evaluate if the quantity of spools available is sufficient to start the production run (see Figure 5).

The simulation model processing will follow the logic shown in Figure 5 to process all repetitive products for each flowline. If the lack of spools, customer or common, causes a repetitive product to be skipped in the sequence, the simulation logic will attempt to reschedule at the end of the production cycle.

4.3 Scheduling Periodic Products

The simulation model logic attempts to process all repetitive products during the product cycle. After processing all required repetitive products, the model evaluates the remaining open capacity in the current product cycle. It is during this time when the flowlines have open capacity the periodic products will be scheduled for production. The model logic examines unfulfilled orders for these products, up to 28 days in the future, that can be processed on that flowline in the allowable amount of time until the beginning of the next product cycle. The earliest due date (EDD) is the selection scheme for assigning these products into the available capacity. Products with the same due date are then prioritized by the percentage of business that these products represent. Daily kanban requirements do not control the periodic products production quantities, but instead they follow a strict make-to-order approach, producing only the product quantity ordered by the customer. After producing all of the periodic products using the available capacity in the flowlines, the simulation will wait until the beginning of the next product cycle to repeat this process of production.

4.4 Additional Modeling Issues

The projected demand for the products controls the daily kanban requirements. There will be production cycles in which the production of one or more of the repetitive products is not necessary. The simulation logic will examine scheduled shipment requirements for the products and evaluate whether the current cycle’s production for that product can be skipped. Skipping a production run for a product occurs when there is sufficient inventory to cover the demand for the product and there will be no impact of shipments of that product.

As part of the prioritization logic for selecting product processing on the flowlines, the simulation logic identifies products that have backorders. In backorder situations, the spool requirement logic for starting a production run is ignored, and the production will attempt to produce as many spools as possible with the current inventory of empty spools.

Processing periodic products is authorized when there exists sufficient capacity to produce that customer order. There are situations when logic would not approve production when the capacity of the flowline was slightly inadequate. For example, a customer order that needed 10 hours of production time would not be authorized if the open capacity on the flowline was only 9 hours. In practice, operations would authorize the extra hour of overtime to complete this product. The simulation also incorporates this logic. If the required amount of overtime to complete an order is fewer than two hours, the simulation logic will adjust the shift time to complete the order.

Table 4. The fuzzy relationship between CR and TM

	TM1	TM2	TM3	TM4	TM5
CR1	(4.57,6,7.43)	(5.43,7.43,8.86)	(3.14,4.29,6)	(5.14,6.57,8)	(4,5.43,6.86)
CR2	(5.71,7.43,8.57)	(5.43,7.14,8.57)	(3.71,4.86,6.57)	(2.86,4.57,6.29)	(3.43,5.14,6.86)
CR3	(4.29,6,7.71)	(4.29,6.29,7.71)	(5.43,7.43,8.86)	(4.86,6.29,7.71)	(5.43,7.43,8.86)

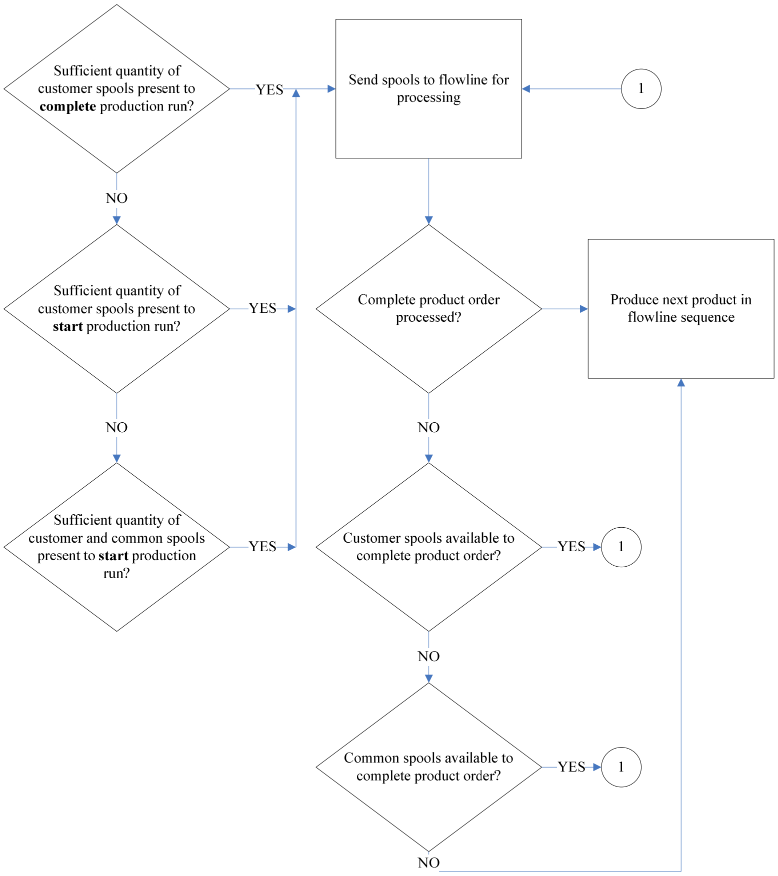


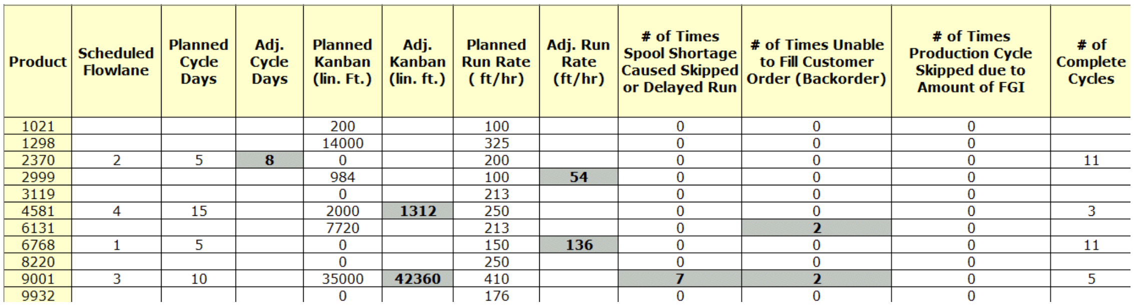
Figure 5: Simulation Model Inputs and Outputs

5. SIMULATION RESULTS

The simulation model was built using commercial off-the-shelf discrete event simulation software that was capable of importing and exporting data between the model and spreadsheet software. The interface was designed in the spreadsheet program to allow production planning personnel to use the simulation tool without having expertise in programming the simulation model.

The simulation results answered the four questions posed in the Methodology section. Figure 6 shows, by product, the summarized results of the simulation run. The first question addressed was to decide if there were sufficient spools in the system to meet the current production plan. The output identified the number of instances when spool shortages caused delays to the scheduled runs of the products or when the scheduled production runs were delayed until later in the production cycle. This output provided production planners with the identity of products whose spool supplies caused interruptions in the production system. The production planners could then perform "what-if" analyses to determine how to resolve the problem. The “what-if” analyses were also able to evaluate the affect of the sequencing of the repetitive products within each flowline. The product sequence in the flowlines were changed to discover if there was a positive impact on system performance parameters such as backorders and skipped or delayed production runs.

The production planners can adjust certain parameters, such a daily kanban, processing speeds, and the sequence of scheduled products during a simulation run. The adjusted quantities in the column titles in Figure 6 identify when the simulation model user has adjusted an input parameter.



Product	Scheduled Flowlane	Planned Cycle Days	Adj. Cycle Days	Planned Kanban (lin. Ft.)	Adj. Kanban (lin. ft.)	Planned Run Rate (ft/hr)	Adj. Run Rate (ft/hr)	# of Times Spool Shortage Caused Skipped or Delayed Run	# of Times Unable to Fill Customer Order (Backorder)	# of Times Production Cycle Skipped due to Amount of FGI	# of Complete Cycles
1021				200		100		0	0	0	
1298				14000		325		0	0	0	
2370	2	5	**8**	0		200		0	0	0	11
2999				984		100	**54**	0	0	0	
3119				0		213		0	0	0	
4581	4	15		2000	**1312**	250		0	0	0	3
6131				7720		213		0	**2**	0	
6768	1	5		0		150	**136**	0	0	0	11
8220				0		250		0	0	0	
9001	3	10		35000	**42360**	410		**7**	**2**	0	5
9932				0		176		0	0	0	

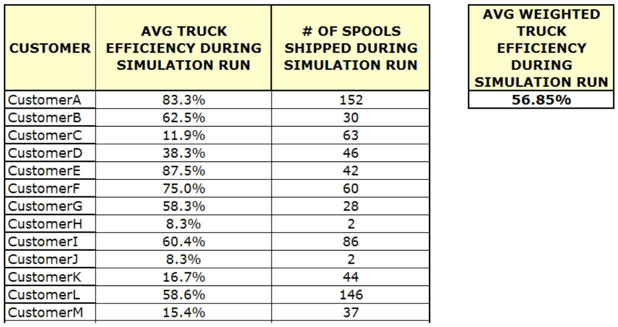
Figure 6: Summarized Simulation Output

The second question to be answered related to the adequacy of the amount of open capacity for producing periodic products. The simulation output identified the number of times that customer orders could not be filled. For the periodic products this correlated to the availability of open capacity slots into which the periodic products could be scheduled. Additional output from the simulation was also able to show the length of time that these products remained in backorder.

The last major question addressed by the simulation results related to the efficiency of transporting the finished product to the customer. Product shipments were arranged based on customer and product on weekly, biweekly, and monthly schedules. Based on the production schedules there were instances when less than 50% of the capacity of the truck storage capacity was utilized. The simulation model integrated the customer shipment schedules and was able to provide the production planners with an analysis of the efficiency, based on percentage of truck capacity utilized, of the customer shipments (see Figure 7). The weighted efficiency calculation accounted for the number of spools shipped to the customers so inefficient shipments of only a few spools did not skew the calculation. The production planners were then able to modify shipment schedules to improve shipment efficiencies.

5.1 Simulation Validation and Verification

The simulation model was designed as a closed-queuing network based on a finite number of spools in the system. The validation and verification techniques described by Sargent (1999) were used to evaluate the model. The model was run for a simulated 90 days of production. During this run there were 3376 entities in the system and the simulation output verified the total entities in the system remained constant during the processing of all the entities. Static spreadsheet modeling of one of the flowlines, using deterministic processing values, verified the logic for shift time consumption during the production runs of the repetitive products as well as the scheduling and processing of the periodic products into open capacity gaps was correct.



CUSTOMER	AVG TRUCK EFFICIENCY DURING SIMULATION RUN	# OF SPOOLS SHIPPED DURING SIMULATION RUN
CustomerA	83.3%	152
CustomerB	62.5%	30
CustomerC	11.9%	63
CustomerD	38.3%	46
CustomerE	87.5%	42
CustomerF	75.0%	60
CustomerG	58.3%	28
CustomerH	8.3%	2
CustomerI	60.4%	86
CustomerJ	8.3%	2
CustomerK	16.7%	44
CustomerL	58.6%	146
CustomerM	15.4%	37

AVG WEIGHTED TRUCK EFFICIENCY DURING SIMULATION RUN
56.85%

Figure 7: Customer Shipment Efficiencies

6. CONCLUSION

A tier two automobile supplier's production facility required manufacturing two classes of products; those produced on a repetitive basis and those produced on a periodic basis. Linear programming techniques were used to set the daily demand kanbans. A simulation model was developed, using the daily demand kanbans as well as other system parameters, to aid the production planners in evaluating the quarterly production plan. The model's outputs were able to assess the system performance regarding spool availability, transportation efficiencies, backorders and delayed or skipped production runs. The production planners used the model's output to trace interruptions in production back to the root cause. The "what-if" analyses provided quantitative impacts on proposed improvements to production system parameters.

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