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Broton-Anderson, J. Maxwell ***Sheet Metal Process Capacity Planning***

Abstract

Company XYZ – Facility A was working a full schedule and was lacking 47 hours of machine capacity weekly in the sheet metal department. Forecasted demand required an additional 1,022 production hours per week. Thus, Facility A was no longer able to meet demand if current capacity was not increased. As a result, an initiative to increase the capacity of the sheet metal department was conducted. The purpose of this project was to analyze various capacity constraints and opportunities and purchase a new punch shear machine with a steel tower storage system to facilitate the forecasted production plans for Facility A.

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Chapter I: Introduction

An organization, referred to as Company XYZ to protect the company's confidentiality for proprietary information, designs and manufactures technologically advanced commercial heating, ventilation, and air conditioning (HVAC) systems for consumers worldwide. It is the organization's goal to provide superior air quality and energy efficiency through the use of industry leading technologies to every product and solution provided. Company XYZ is consistently looking toward the future, not only in regards to the organization itself, but also the environment. Company XYZ always ensures compliance with all state and government standards when it comes to unit footprint and the support of various initiatives, such as climate change. Company XYZ employs more than 67,000 individuals worldwide and has reported revenues in excess of $17 billion. With more than 90 production sites globally and customers in more than 150 countries, Company XYZ is positioned for market share leadership.

Company XYZ has three essential locations that produce air handlers, Company XYZ Facility A, Facility B, and Facility C. Facility A is responsible for the production of semi-custom modular air handlers that can be manufactured in two-inch increments to fit specific customer needs. Facility A's main focus is to provide space saving solutions that increase efficiency, air quality, and comfort. Facility B is responsible for producing the organization's cooling and heating products. The components contained within the products differ from Facility A's in the sense that refrigerants and compressors are required for the units to properly alter the temperature of the incoming atmosphere. Lastly, Facility C is used as a kitting area for the other facilities. This ensures that products that arrive at either Facility A or Facility B are prepped and ready to be installed on the production line. These facilities rely heavily on sheet metal processes for their production. The typical process goes from flat sheet metal, through punch/shear machines to cut required shapes and dimensions, to brake presses that form the flat sheets, and finally, to assembly. Facility A was experiencing a shortage of punch shear capacity for the previous eight months. There were multiple reasons as to why the plant has ran out of capacity. These causes included material moves from one machine to another to level load production hours, being delayed during unexpected downtime events, and the type of sheet metal needing to be punched with the machines that are available since only long and heavy-gauge parts can be processed on a sole machine.

An increase in required production hours to meet demand has caused Facility A to move some of its sheet metal punching responsibilities to Facility B; mainly parts that are 120" or longer and all .093-gauge materials, which is 15 miles away. Fiscal year (FY) 2018 plans required all of Company XYZ's sectional product line being produced at Facility B to be moved to Facility A, which created additional longer than average parts being processed through the punch/shear machines. This effectively and immediately overloaded Facility A's Finn Power Shear Genius (SG6) punch/shear machine. The SG6 had a difficult time running long parts, as well as parts that are .022 gauge, which are typically what the longer parts are made of. On average, the SG6 ran 25 hours/week of just long parts, which does not take into consideration that the machine needed to be turned down to 20% of its normal operating speed to prevent it from crashing the material into the tooling to process these parts.

The average weekly goal for assembly hours for Facility A's summer months was 4,000 hours. Facility A was forced to add a weekend shift and increase standard shifts from four, ten-hour days to four, twelve-hour days.

Facility A's punch shear capacity was 672 hours based on a seven-day work week. Facility A was forecasted to experience a demand that required 708 hours of punch shear time according to Fusion 20 plans. This capacity increase could only be met through the addition of a new punch shear machine. With the increased efficiency of this machine, this work load was able to be completed in a five-day work week. It is not until fiscal FY2019 that Facility A will again need to be on a six-day work week and not until FY2020 that Facility A will again need to be on a seven-day work week in order to meet demand. If Facility A would not have taken action on this issue, lead times would have increased, demand would have decreased, and overall market share would have been lost as a result. This time savings, along with various logistics and material handling savings, and maintained market share justified why a new punch/shear machine was a viable option for Facility A.

Statement of the Problem

Facility A was working a full schedule and was lacking 47 hours of machine capacity weekly in the sheet metal department. Fusion 20 forecasted demand required an additional 1,022 production hours per week. Facility A was no longer able to meet demand if current capacity was not increased.

Purpose of the Study

The purpose of this project was to analyze various capacity constraints and opportunities and purchase a new punch shear machine with a steel tower storage system to facilitate Fusion 20 production plans for Facility A. This was achieved by removing Facility A's Finn Power SG6 machine and sending it to Facility B. Removing the SG6 was required to free up floor space in Facility A for a new machine and allowed for increased capacity for Facility B, as an added bonus. This gave all facilities the greatest opportunity to meet Fusion 20 production plans. The SG6 was replaced with a new Prima Power Shear Brilliance (SBe8). This nomenclature signified the companies' eighth generation of right angle shear combination machines. The SBe8 offered many benefits to Facility A. First and foremost, it was fast. State-of-the-art composite materials were utilized to reduce component weight and are operated through a series of powerful and efficient servo-electric linear drives. The SBe8 was capable of a staggering 3,000 hits per minute when nibbling, unleashing a cacophony of steel on steel crashes. The system as a whole allowed for fully integrated and automated loading, punching, and shearing. Other benefits of the SBe8 that were experienced include: reduction in direct labor that was assigned to punching and shearing activities, reduction in direct labor that was assigned to setup activities, reduction in the number of manual operators required, reduction of the total number of traditional operations, reduction in the number of production lot sizes, reduction of work-in-process inventory, and the utilization of standard sheet sizes for cost control.

Assumptions of the Study

There were two main assumptions that were discussed regarding this project that determined its viability and potential success. The first assumption was that the demand forecasts were correct and that there was going to be the required production hours to financially support the new system. As a result, Facility A was going to be starved of capacity. The capacity analysis was heavily based on forecasted demand numbers and would be the determining factor on the viability of the project. The second assumption was that Prima Power was going to be able to deliver on their described machine capabilities and specifications. Capacity calculations were made with machine efficiency, capability, and productivity numbers directly provided by Prima Power.

Definition of Terms

The definition of terms contained in this research was that of a manufacturing background, specifically focused within the capacity planning arena. These terms were used to effectively describe the research that was conducted.

Fiscal year. An accounting period of 365 days that does not necessarily correspond to the calendar year beginning on January 1st. This is an established period of time when an organization's annual financial records commence and conclude (Merriam-Webster, 2019).

Fusion 20. Company XYZ's internal goal plan which is revised every five years.

Level load. The balancing of production by both volume and product mix. It does not build products according to the actual flow of customer orders, which can swing up and down wildly, but takes the total volume of orders in a period and balances them out so the same amount and mix are being made each day (Liker, 2004, p. 129).

Work-in-process inventory. The amount of semi-finished products waiting to be used which adjusts the delivery flow to consumption flow (Kissani & Bouya, 2014, p. 2493).

Limitations of the Study

There were various limitations when performing this capacity analysis. One aspect that was not addressed was the ability of other departments to maintain the increased production capacity of the new equipment. The overall forecasted production hours required were known, but the analysis of the downstream operations was not conducted. The most pressing capacity issue was at the beginning of the manufacturing process, which happened to be involving the punch/shear machines. Company XYZ will need to evaluate the downstream components of the manufacturing process in the near future to determine and eliminate any new bottlenecks.

Another limitation of this study that was not covered was in regards to the processing of sheet metal parts with large, radius geometry and other complicated shapes. Company XYZ determined that resources were better utilized by focusing on the higher, more repeatable production parts. This decision allowed for the greatest utilization of the machine, resulting in the most possible production and met demand.

The final limitation of this study had to do with the facility layout. Company XYZ would not consider a building addition to maximize the benefit that this project could have provided. This decision could have been based on a multitude of factors. Whether it was purely due to the capital cost it would have required or future organizational plans, Company XYX believed that it was the best decision to develop a layout that worked within the available footprint.

Methodology

The methodology that was used to complete this project was done through the use of various capacity planning tools and theories. The study focused on forecasted demand to determine what the next steps for Company XYZ would have been. The study also analyzed the processes of the sheet metal cell from beginning to end. This approach systematically determined where the point of focus was to be directed due to where the greatest potential for positive impact was.

Forecasted sales dollars were utilized to determine the demand that Company XYZ was to meet. This was done by translating the forecasted sales dollars into assembly hours and then comparing them against the punch/shear hours that were needed to facilitate that level of production load. This allowed for a model to be produced that clearly showed where the threshold of not having enough capacity for each working shift structure was. This was represented by where the punch/shear capacity hours intersected the various five, six, and seven day production hours. When related back to forecasted demand determined whether or not Company XYZ was able to meet the production requirements of Fusion 20 goals.

The study also looked at which part families had the greatest room for processing improvement. This analysis was critical to accurate capacity calculations as the processing times for the various parts and part families varied drastically. Specifically, the long, heavy gauge parts that Facility A was unable to produce. The conclusions found in this analysis laid the groundwork in the specification development for machine capability and performance that was sought after.

Summary

Company XYZ designs and manufactures technologically advanced commercial heating, ventilation, and air conditioning (HVAC) systems for consumers worldwide. Of the three facilities, Facility A was nearing its available capacity constraints with its manufacturing equipment. Based on Fusion 20 plans, Facility A was in need of an additional 1,022 production hours per week and was not be able to meet demand by simply increasing production hours. Through extensive capacity analysis, it was determined that the most viable solution to Facility A’s capacity issues was to implement a new, state-of-the-art sheet metal punch/shear machine with steel storage tower. The study proved that a new machine was able to process all of the sheet metal parts that were required for the site’s products, reduced material moves from machine to machine for level loading, and allowed the team to flourish through Fusion 20. It was essential that Company XYZ invested in capacity to maintain their competitive edge and market share.

Chapter II: Literature Review

Company XYZ Facility A is responsible for the manufacturing of space saving heating, ventilation, and air conditioning (HVAC) solutions that increase efficiency, air quality, and comfort. The manufacturing of these products relies heavily on various sheet metal processes. Facility A was experiencing a shortage of capacity in their sheet metal department, specifically on their punch shear machines. A lack of capacity was a frequent occurrence for the eight months prior to this project.

The average weekly goal for assembly hours for Facility A's summer months was 4,000 hours. What this translated into for the sheet metal department was a lack of 47 hours of machine capacity while working a full schedule seven days per week. Not only was there an immediate need for additional machine capacity, but Fusion 20 forecasts calculated that an additional 1,022 production hours per week were needed.

This project was to analyze the various capacity constraints and opportunities that were presented to Facility A. The goal was to determine a solution that fulfilled the current production needs of the sheet metal cell, as well as the Fusion 20 forecasted demand. This was done through the implementation of a state-of-the-art punch shear machine which had the ability of a higher throughput.

Capacity Planning

Today's global markets frequently call for a flexible manufacturing system that is able to supply goods precisely when they are requested. Shorter product lifecycles and an increased number of new models and variations have forced companies to meet the demands of a diversified customer base (Alexopoulos, Papkostas, Mourtzis, & Chryssolouris, 2010). This demand has made what used to be relatively simple production scheduling much more complicated. The majority of insights show that the performance of productive systems is affected by the loading of the system well before capacity is utilized (Sampaio, Wollmann, & Vieira, 2017). A key factor of production scheduling is to understand what demand the organization is able to meet, also known as capacity. Unfortunately, the demand management concepts that are currently widely employed are 20 to 25 years old (Chase, 2016). In order to effectively manage the potentially thousands of part numbers an organization may produce, it is imperative to focus demand forecasting on what the market and channel are demanding, rather than forecasting what manufacturing should make (Chase, 2016). This is where many organizations struggle.

Capacity planning in a non-flexible manufacturing system is typically conducted during the acquisition of the capacity and stops once that capacity is implemented (Lenz, 2015). It is imperative to the metrics of the manufacturing system that the capacity planning is continuously reviewed (Lenz, 2015). This review should take place whenever a product mix is altered in order to reconfigure the new requirements (Lenz, 2015). The key to any flexible manufacturing system is to have multiple alternative paths for all products being produced (Lenz, 2015). A lack of alternative paths would cause bottlenecks in the production system.

When it comes to machine capacity and the planning of that capacity, there are a multitude of factors that need to be considered. Questions such as: does the operation have the technical capability to handle the order, does the operation have the production capacity to accommodate the order, can the operation complete the order in time for delivery, and how much is the profit from the order all need to be answered (Chen, Mestry, Damodaran, & Wang, 2009). What it boils down to is the machine capacity needs to exceed demand in order to meet that demand (Chen, Mestry, Damodaran, & Wang, 2009). If machine capacity is continually exceeded, alternative options must be explored, such as the acquisition of new and improved equipment, in order to remain competitive in the marketplace.

Manufacturing Flexibility

As markets became more and more complex, speed of delivery became a higher customer priority (Shivanand, 2006). A strategy involving customizability was formulated as companies realized the need to adapt their environments in which they operate to be more flexible in order to satisfy these new demands (Shivanand, 2006). A flexible manufacturing system is a group of processing work stations that are related to each other by a means of an automated material handling and storage system, typically controlled by a computer system (Shivanand, 2006). What makes a manufacturing system flexible is its capability of processing a variety of parts simultaneously and quantities can quickly be adjusted in response to changing demand patterns (Shivanand, 2006). The elimination of interruptions in the operation of the bottleneck would be where the benefits of flexibility are most noticed. In a process where the manufacturing is machine limited, alternative paths using machines would be the essential form of flexibility. In this environment, having flexible labor would not provide a benefit to the operation of the bottleneck (Lenz, 2015). Alternative paths all for uninterrupted manufacturing flow.

Flexible manufacturing systems change the system behavior itself without changing its configuration (Elmaraghy, 2008). Changeability is defined as the characteristics to economically accomplish early and foresighted adjustments of the factory's structures and processes on all levels, in response to change impulses (Elmaraghy, 2008). The characteristics of a physical change enabler include things such as, machinery or buildings (Elmaraghy, 2008). Defining which type of change enabler is present will optimize opportunities.

Market demand, not only quantity, but the products themselves are all based off of forecasts. The study, A Method for Comparing Flexibility Performance for the Lifecycle of Manufacturing Systems Under Capacity Planning, clearly shows that it is possible to create a system that is less impacted by a diverse market environment through the use of complex logic rules (Alexopoulos et al., 2010). Another question, possibly the most important question still goes unanswered: what flexibility is required for the future? There is not an algorithm or sight into the future that can possibly give planners a known figure of what products will need to be made and when.

Manufacturing flexibility is usually considered the main strategy for success in today's hectic markets of short lead times, tight product tolerances, pressure on costs, frequent changes in demand, and continuous evolution of technology (Tolio, 2009). Even if flexibility can be achieved on one hand, on the other the firm needs to consider viewing system flexibility on a global scale and consider both the advantages and disadvantages related to the acquisition of flexibility (Tolio, 2009). Designing manufacturing systems that can optimally satisfy current needs, as well as the current needs of the reasonably foreseeable future is a complex issue.

Planning for the Lifecycle

Product lifecycle management is the activity of managing a company's products all the way across their lifecycles in the most effective way (Stark, 1948). Product lifecycle management enables the value of a product to be maximized, gives transparency about what is happening of the lifecycle, and offers many ways to solve problems and seize market opportunities (Stark, 1948). Strategies such as fast response time have been introduced as a result of technological advances and changing customer behavior (Stark, 1948). For a company to be successful in an environment such as this, a strategy that allows for it to develop new products quickly, get them into production quickly, change production volume quickly as demand builds, and to switch to the production of other products when demand drops is essential (Stark, 1948). This sort of rapid response is what it takes to be competitive in today's global markets.

Investing in advanced manufacturing systems has strategic impacts that essentially have the ability to affect the long-term competitiveness in the market place of organizations, thus improving the ability of firms to create new markets, introduce new products, and react quickly and effectively to competitors (Matta, Semeraro, & Tolio, 2005). This is why planning for the entire lifecycle of a product goes hand-in-hand with capacity planning. Product lifecycle planning needs to include all stages of production: from the initial concept through the phasing out stages of the product. Failure to do this can have serious business implications. For instance, in 1996, the demand for Tamagotchi (a virtual pet) rapidly grew beyond production capacity, which in return led to lost sales. Not long after this event, Bandai Co. expanded their capacity and the demand started to decline which in turn resulted in $123 million in losses (Higuchi & Troutt, 2004). Another case-in-point is when the PlayStation 3 was released. Sony lost $1.8 billion in its game division and as a result was forced to remove 3% of its workforce due to their demand overestimation, excessive production, and inventory costs (Sony Corporation Annual Report, 2009). Machine capacity has a direct effect on the production required to smooth over the peaks and valleys of demand.

Investing in Capacity

Flexible systems have the ability to reduce many of the headaches associated with the production of multiple products within the same organization. More often than not, these require technologies that have an unproved aspect with a high initial investment. This factor frequently rules out organizations that are not necessarily at the top of the marketplace food chain from taking a risk on this hopefully business saving improvement. It is expected that the installation of flexible manufacturing systems provides the benefits and returns required to justify the initial upfront investment (Mgwatu, 2011). The benefits that are often expected to be seen from implementing a flexible manufacturing system include increased machine utilization, less machines, reduced floor space, greater responsiveness to changes, reduced inventories, lower manufacturing lead times, and higher labor productivity (Mgwatu, 2011). It takes extensive analysis to develop a flexible manufacturing system that meets the specific needs of an organization.

There is a time when it makes sense to make the investment in more or upgraded technology to increase capacity. As described in, Stochastic Optimal Capacity Management in Reconfigurable Manufacturing Systems, "the production of the produced good or service costs a certain dollar amount per unit to produce and is sold at a fixed price per unit with a certain percentage profit. Unsatisfied market demand has a certain penalty cost per unit. The available has a certain capacity at a certain time and it takes a proportional holding or overhead cost per unit of capacity at each time period to maintain this level of capacity" (Asl, Farshid, & Ulsoy, 2003, p. 2). So, to sum this up, excess capacity and excess production is not free. Direct and indirect costs are all added to the bottom line of the production of every part or product. As a result, insufficient capacity has the ability to cause an organization that is deteriorating delivery performance and increasing work-in-process. All the while excess capacity can be costly and unnecessary (Hill, 2012). The next generation demand management process is a business analytics function embedded downstream in the sales and marketing arenas of the organization, providing analytics support in order to drive demand generation (Chase, 2016). This is where the capacity driven planning system works hand-in-hand with the demand planning system. The capacity planning system decouples the procurement from the independent demand and acquires the necessary materials and quantities of those materials to support the predetermined operating capacity based on the quantity that can be produced, the quantity that is expected to be sold, and related managerial policies (Mohebbi, Choobineh, & Pattanayak, 2006). Capacity planning affects all levels of an organization.

Summary

It is imperative that effective capacity planning not only for current, but also future demands is thoroughly analyzed and evaluated throughout every organization. Today's global markets are calling for shorter product lifecycles and an increased number of new models and variations. The constant wave between having a lack and influx of demand can wreak havoc on a business. Having the ability to reduce the peaks and valleys of demand to a more consistent level allows for better controlled systems and processes with increased predictability.

Through the implementation of flexible manufacturing systems, organizations are able to invest in the future. This can only be done if a plan for the future of the organization has been accurately developed. This has a direct effect on capacity planning. The organization needs to know what the forecasted demand will be, so they can develop the manufacturing process accordingly. This is important as a lack of capacity has a direct and negative impact on the business unit and excess capacity does not come without a cost.

There are various tools that organizations can use to better control demand variations and level load capacity. This could be done through the cross-training methodology where team members are involved with the forecasting of demand, as well as the capacity planning on the manufacturing level. The use of various resource planning tools to help analyze the vast amount of data coming in is of significant help, as well. Even though there are many tools and methods at the disposal of corporations, there will always be the need for human interaction to analyze and determine the markets and how the business will be impacted due to various shifts.

Chapter III of this paper will discuss the methodologies and processes used throughout the study. This section will go in depth as to how the data regarding the capacity of Facility A's sheet metal department was obtained, used, and analyzed.

Chapter III: Methodology

Company XYZ – Facility A was working a full schedule and was lacking 47 hours of machine capacity weekly in the sheet metal department. Fusion 20 forecasted demand required an additional 1,022 production hours per week. Fusion 20 by definition is Company XYZ's internal goal plan that is revised every five years. Thus, Facility A was no longer able to meet demand if current capacity was not increased.

As a result, an initiative to increase the capacity of the sheet metal department was conducted. The purpose of this project was to analyze various capacity constraints and opportunities and purchase a new punch shear machine with a steel tower storage system to facilitate the Fusion 20 production plans for Facility A.

The methodology section of this project is meant to provide a description of the process that was used during the development of this study. This section will specifically and clearly describe how the data was obtained, used, and analyzed through written explanations, as well as tables and figures. The purpose of the methodology section is to define and provide a process that is repeatable.

Subject Selection and Description

Company XYZ determined that additional capacity was needed to meet Fusion 20 production plans. Upon a thorough investigation, it was decided that Facility A's sheet metal department was a main contributor to production shortcomings in the sense that other production processes could meet the extra load of the forecasted sales dollars increase, while the sheet metal department would continue to struggle. The bottleneck at the punch shear machines was to be the focus of this capacity increasing project.

The process of obtaining and analyzing the data set utilized forecasted demand. The forecasted demand was based off of the sales dollars that was determined by Company XYZ's marketing team for Fusion 20. These sales dollars were translated into assembly hours and then compared against how many punch shear production hours it would take to fulfill the demand of the assembly hours. In return, a model was able to be created that clearly showed where the threshold of not having enough capacity for each production shift structure was when compared to the increased Fusion 20 production plans. The model showed at what level of demand the production planning team had to increase from a five day week production schedule to a six or seven day week production schedule. This method was also utilized when fluctuations in demand reduced the required number of production hours. Ultimately, the calculations that were derived from this study were used to define the requirements and specifications of a sheet metal processing system that would best benefit Facility A's business unit goals in regards to throughput, maintenance, reliability, capability, efficiency, and flexibility.

Phase 1

The first phase for Facility A was to determine their current capacity position. Facility A needed to determine the amount of production hours they could achieve on all of their machines based on their current shift schedule. This was essential to the success of the project, because a baseline was needed to effectively show if the benefits of the plan would come to fruition. The data that was used to determine the current hours was generated by compiling the current production loads on the machines in comparison to the assembly hours being produced. The data sets were gathered by referring to production assembly load hour reports for the previous fifteen months. This data is recorded by supervisors and distributed to Facility A's production team. The programming team was able to provide the punch shear load hours for the correlating fifteen months. This made the connection between assembly hours and the punch shear production hours required to meet them internally to Facility A.

Table 1 is an example of the available production hours for each machine based on the current seven day production schedule. The Machine column in Table 1 lists the available machines that were currently being utilized by Facility A. The Current Seven Day column represents the hours that were available for production based on the current seven day work week. These hours were then totaled for a Total Capacity Hours figure.

Table 1

Example of Machine Capacity Based on a Seven Day Work Week

Machine	Current 7 Day
S4-1	0
S4-2	0
SG-5	0
SG-6	0
S4-3	0
S4-4	0
SBe8	0
Laser	0
Total	0

Phase 2

Facility A then needed to determine what the capacity of the sheet metal department was going to look like when the machine moves and added punch shear machine were implemented. Table 2 shows the Future One Day column and how it was used as the baseline to extrapolate the

Future 1 Day production hours to the future production schedules of a five, six, and seven day work week. In order to determine a future scenario, the current seven day data baseline was multiplied by factors that were generated to represent added machine speed based off of the higher capacity of the additional machines. Table 2 accounted for the SG-5 and SG-6 being removed from production process of Facility A, in addition to the SBe8 added. This data was used to determine the total capacity hours for each production schedule and the total production load each schedule could effectively handle. This was done by multiplying the Future One Day column data by the number of days available in the working schedule for each option. For example, to determine what the future five day available capacity was, the future one day capacity for each machine was multiplied by five and totaled.

Phase 3

Once the available capacity hours were determined for the three production schedule options, Facility A could then focus on how the Fusion 20 forecasts would affect the sheet metal department. Since the Fusion 20 forecasts were in sales dollars, Facility A needed to translate how many production hours are needed from the sheet metal department to meet the demand of the sales dollars. In order to achieve a fair comparison, the sales dollars per assembly hour was calculated. This was number was supplied by Company XYZ's corporate marketing team. This figure was used as a baseline to determine the assembly hours required per week to meet the forecasted sales dollars demand for the factory. This was achieved by dividing the forecasted sales dollars by the dollars per assembly ours and then again by twenty-five. The punch shear hours required to meet the assembly hours per week were then calculated. The punch shear hours required were calculated by dividing the correlating production schedule available time by the projected workloads that were based off of the Fusion 20 forecasts and multiplying the

Table 2

Example of Future Capacity

Machine	Future 1 Day	Future 5 Day	Future 6 Day	Future 7 Day
S4-1	0	0	0	0
S4-2	0	0	0	0
SG-5	0	0	0	0
SG-6	0	0	0	0
S4-3	0	0	0	0
S4-4	0	0	0	0
SBe8	0	0	0	0
Laser	0	0	0	0
Total	0	0	0	0

solution by a factor to account for increased demand. Furthermore, these figures were then compared to the total capacity hours available that were calculated in Table 2 for the future five, six, and seven day production schedules. These calculations were performed by subtracting the punch shear hours required from the available time for each of the three schedules. This is represented in Table 3. Wherever the numbers in the future five day, future six day, or future seven day approached zero or became a negative number, capacity was either running short or there was not any excess capacity available.

Analyze Phase

Facility A was able to use the information that was calculated in Table 3 to construct a model that depicts when more and how much more capacity will be needed based off of Fusion

20 sales dollars. This was done by using the available production time for the three options for production schedules as baselines. The baselines for the three production schedule options would be shown as horizontal lines, each at their correlating maximum capacity levels. The

Table 3

Example of Required Future Capacity

Year	Forecasted Sales Dollars	Dollars per Assembly Hour	Assembly Hours per Week	Punch Shear Hours per Week	5 Day Capacity	6 Day Capacity	7 Day Capacity
FY 2015 q3-q4	0	0	0	0	0	0	0
FY 2016	0	0	0	0	0	0	0
FY 2017	0	0	0	0	0	0	0
FY 2018	0	0	0	0	0	0	0
FY 2019	0	0	0	0	0	0	0
FY 2020	0	0	0	0	0	0	0

punch shear hours required were then applied to the model to see where the punch shear hour's line intersected the three production schedule's maximum capacity levels. Figure 1 represents the model that was created. Wherever the lines intersected, the overall capacity was met for that particular production schedule and any additional production hours are not achievable without increasing the available machine hours. This tool allowed for production planning based off of the available capacity of the sheet metal cell.

The information presented in this model was used to not only show that there were capacity issues in the foreseeable future, but also what the timeline of the capacity issues would be. This model solidified the idea that capacity needed to be increased in the sheet metal department in order to meet the Fusion 20 forecasted demand. The data that was calculated in this process was the framework to set the capacity initiative in motion including capital funding, layout design, system requirement development, and talks with potential system suppliers.

A model was able to be created from this data. The model was used as a means to illustrate at what level of production the sheet metal department for Facility A will be short of capacity. This allowed for Facility to accurately plan production schedules depending on the demand that was forecasted.

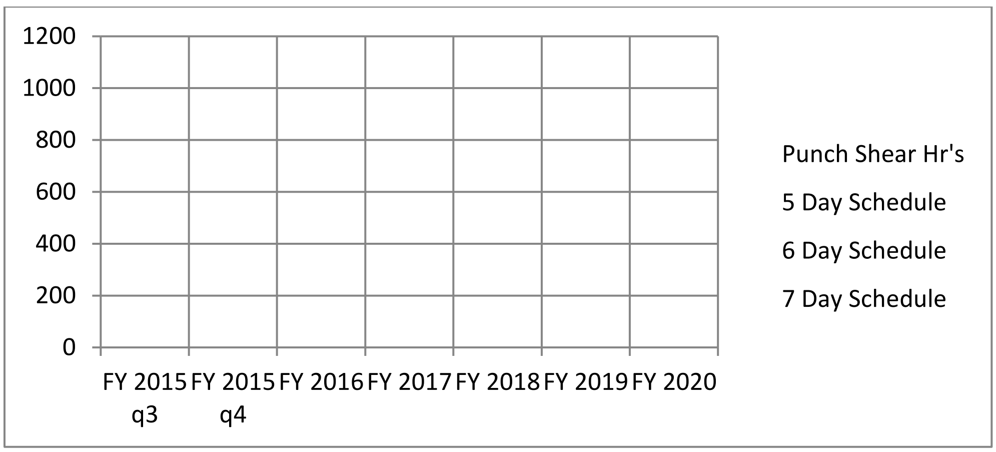

Figure 1. Example of the model that depicts the capacity required for Fusion 20.

Summary

Facility A was working a full seven day work week production schedule and still lacking capacity. Fusion 20 forecasts showed sales dollars only increasing. It was determined that an initiative to increase capacity in the sheet metal department was required to remain competitive and meet customer demand.

This chapter went through the process of how the data was gathered, analyzed, and used in determining what future capacity planning would be capable of after conducting various machine moves and adding a new, state of the art punch shear machine. This was done through converting the forecasted sales dollars into dollars per assemble hour. This figure was used as a baseline to calculate the assembly hours per week that were required and then translated into how many punch/shear production hours were required to meet those assembly hours. As a result, Facility A was then able to extrapolate the data to a five, six, and seven day production schedule.

Chapter IV will expand on the information presented in Chapter III. The data that was collected during the study will be presented in the figures used in this chapter and the model will be created. This data will then be reported on and what it meant for Facility A and their capacity planning initiatives.

Chapter IV: Results

Company XYZ Facility A was working a full schedule and was lacking 47 hours of machine capacity weekly in the sheet metal department. Fusion 20 forecasted demand required an additional 1,022 production hours per week. Fusion 20 by definition is Company XYZ's internal goal plan that is revised every five years. Thus, Facility A was no longer able to meet demand if current capacity was not increased.

As a result, an initiative to increase the capacity of the sheet metal department was conducted. The purpose of this project was to analyze various capacity constraints and opportunities and purchase a new punch shear machine with a steel tower storage system to facilitate the Fusion 20 production plans for Facility A.

The results section of this project will present the data that was collected during the study. This section will discuss what the data meant for facility A's current capacity constraints and what the next steps should be to remain competitive in the market.

Phase 1

The first phase for Facility A was to determine their current capacity position. Facility A needed to determine the amount of production hours they could achieve on all of their machines based on their current shift schedule. This was essential to the success of the project, because a baseline was needed to effectively show if the benefits of the plan would come to fruition. The data that was used to determine the current hours was generated by compiling the current production loads on the machines in comparison to the assembly hours being produced. The data sets were gathered by referring to production assembly load hour reports for the previous fifteen months. This data is recorded by supervisors and distributed to Facility A's production team. The programming team was able to provide the punch shear load hours for the correlating fifteen months. This made the connection between assembly hours and the punch shear production hours required to meet them internally to Facility A.

Table 4 shows the results of the available production hours for each machine based on the current seven day production schedule. The Machine column in Table 4 lists the available machines that were currently being utilized by Facility A. The Current Seven Day column represents the hours that were available for production based on the current seven day work week. These hours were then totaled for a Total Capacity Hours figure. Facility A determined there was a total of 672 available hours for production with the current punch shear machine setup based on a seven day work week.

Table 4

Machine Capacity Based on a Seven Day Work Week

Machine	Current 7 Day
S4-1	168
S4-1	168
SG-5	168
SG-6	168
S4-3	0
S4-4	0
SBe8	0
Laser	0
Total	672

Phase 2

Facility A then needed to determine what the capacity of the sheet metal department was going to look like when the machine moves and added punch shear machine were implemented. Table 5 shows the Future One Day column and how it was used as the baseline to extrapolate the Future 1 Day production hours to the future production schedules of a five, six, and seven day work week.

Table 5

Future Capacity

Machine	Future 1 Day	Future 5 Day	Future 6 Day	Future 7 Day
S4-1	23	120	144	168
S4-2	16.8	84	101	168
SG-5	0	0	0	0
SG-6	0	0	0	0
S4-3	36	180	216	252
S4-4	31.2	156	187	218
SBe8	33.6	168	202	235
Laser	12	30	72	84
Total	153.6	768	922	1075

In order to determine a future scenario, the current seven day data baseline was multiplied by factors that were generated to represent added machine speed based off of the higher capacity of the additional machines. The factor for the S4-3 was 1.5, the S4-4 was 1.3, the SBe8 was 1.4, and the Laser was 0.5. Table 5 accounted for the SG-5 and SG-6 being removed from production process of Facility A, in addition to the SBe8 added. This data was used to determine the total capacity hours for each production schedule and the total production load each schedule could effectively handle. This was done by multiplying the Future One Day column data by the number of days available in the working schedule for each option. For example, to determine what the future five day available capacity was, the future one day capacity for each machine was multiplied by five and totaled.

Facility A realized that the punch shear moves and machine addition would make a significant difference in the overall capacity for the sheet metal department. The future five day production schedule allowed for 768 production hours. This exceeded the current seven day production schedule capacity by 96 hours. By working a six day production schedule, Facility A would be able to utilize 922 production hours and 1,075 production hours with a seven day production schedule in the sheet metal department.

Phase 3

Once the available capacity hours were determined for the three production schedule options, Facility A could then focus on how the Fusion 20 forecasts would affect the sheet metal department. Since the Fusion 20 forecasts were in sales dollars, Facility A needed to translate how many production hours are needed from the sheet metal department to meet the demand of the sales dollars. In order to achieve a fair comparison, the sales dollars per assembly hour was calculated. This was number was supplied by Company XYZ's corporate marketing team. The value for this figure was $0.614. This figure was used as a baseline to determine the assembly hours required per week to meet the forecasted sales dollars demand for the factory. This was achieved by dividing the forecasted sales dollars by the dollars per assembly ours and then again by twenty five. The punch shear hours required to meet the assembly hours per week were then calculated. The punch shear hours required were calculated by dividing the correlating production schedule available time by the projected workloads that were based off of the Fusion 20 forecasts and multiplying the solution by a factor of 1.36 to account for increased demand. Furthermore, these figures were then compared to the total capacity hours available that were calculated in Table 5 for the future five, six, and seven day production schedules. These calculations were performed by subtracting the punch shear hours required from the available time for each of the three schedules. This is represented in Table 6. Wherever the numbers in the future five day, future six day, or future seven day approached zero or became a negative number, capacity was either running short or there was not any excess capacity available.

Analyze Phase

Facility A was able to use the information that was calculated in Table 6 to construct a model that depicts when more and how much more capacity will be needed based off of Fusion 20 sales dollars. This was done by using the available production time for the three options for production schedules as baselines. The baselines for the three production schedule options would be shown as horizontal lines, each at their correlating maximum capacity levels. The punch shear hours required were then applied to the model to see where the punch shear hour's line intersected the three production schedule's maximum capacity levels. Figure 2 represents the model that was created. Wherever the lines intersected, the overall capacity was met for that particular production schedule and any additional production hours are not achievable without increasing the available machine hours. This tool allowed for production planning based off of the available capacity of the sheet metal cell. The information presented in this model was used to not only show that there were capacity issues in the foreseeable future, but also what the timeline of the capacity issues would be.

Table 6 shows that based on Fusion 20 forecasts, the added capacity of the machine moves and added machine will be sufficient until somewhere between FY (fiscal year) 2015 and FY 2016 with a five day production schedule. The added capacity if Facility A were to work a six day schedule would be sufficient until between FY 2018 and FY 2019. It is not until FY 2020 when Facility A will again be in need of a capacity increase, because the seven day production schedule will not be able to meet forecasted demand.

Table 6

Required Future Capacity

Year	Forecasted Sales Dollars	Dollars per Assembly Hour	Assembly Hours per Week	Punch Shear Hours per Week	5 Day Capacity	6 Day Capacity	7 Day Capacity
FY 2015 q3-q4	58,210	0.614	3,792	708	60	213	367
FY 2016	133,988	0.614	4,364	815	-47	106	260
FY 2017	143,368	0.614	4,670	872	-104	49	203
FY 2018	153,403	0.614	4,997	933	-165	-12	142
FY 2019	164,142	0.614	5,347	999	-231	-77	76
FY 2020	175,631	0.614	5,721	1,069	-301	-147	6

This model solidified the idea that capacity needed to be increased in the sheet metal department in order to meet the Fusion 20 forecasted demand. The data that was calculated in this process was the framework to set the capacity initiative in motion including capital funding, layout design, system requirement development, and talks with potential system suppliers.

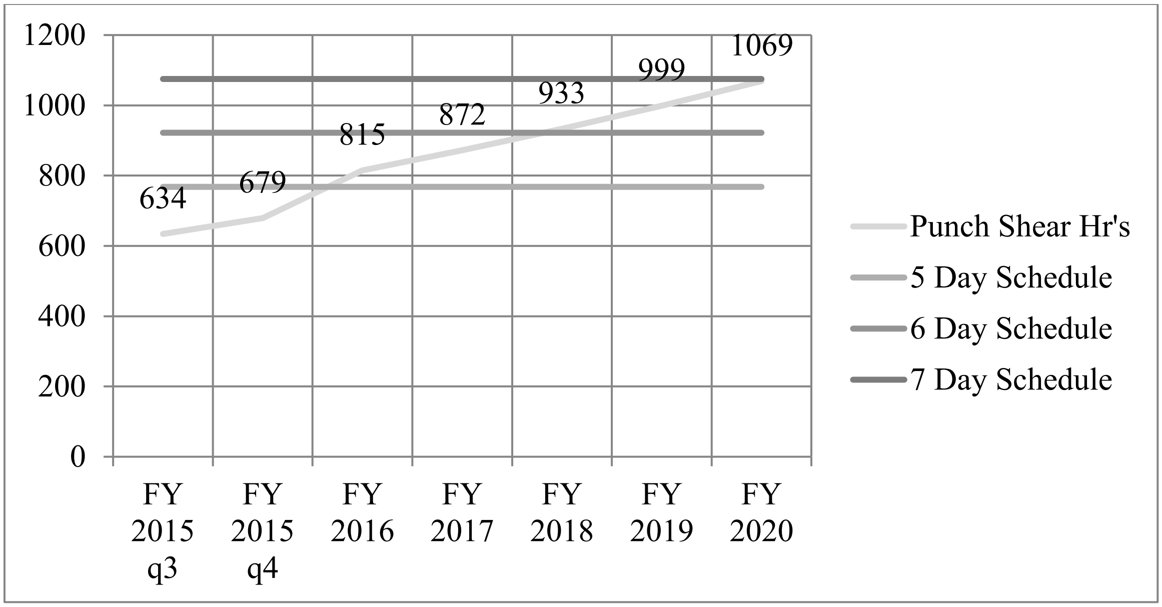

Figure 2. Model of the capacity required for Fusion 20.

Summary

Facility A was working a full seven day work week production schedule and still lacking capacity. Fusion 20 forecasts showed sales dollars only increasing. It was determined that an initiative to increase capacity in the sheet metal department was required to remain competitive and meet customer demand.

This chapter went through the data that was gathered, analyzed, and used in determining what future capacity planning would be capable of after conducting various machine moves and adding a new, state of the art punch shear machine. This was done through converting the forecasted sales dollars into dollars per assemble hour. This figure was used as a baseline to calculate the assembly hours per week that were required and then translated into how many punch/shear production hours were required to meet those assembly hours. As a result, Facility A was then able to extrapolate the data to a five, six, and seven day production schedule.

A model was able to be created from this data. The model was used as a means to illustrate at what level of production the sheet metal department for Facility A will be short of capacity. This allowed for Facility to accurately plan production schedules depending on the demand that was forecasted.

The model clearly showed that when working a five day production schedule, Facility A was able to meet demand until late FY 2015. In FY 2016, Facility would need to increase production hours to a six day work week to meet demand. The six day production schedule would be sufficient until late FY 2018, where the capacity would once again exceed the available production for the sheet metal department. It is in FY 2018 where Facility A will need to begin another study to add capacity to the sheet metal department as a result of low capacity hours while working a seven day work week into FY 2020.

Chapter V will be utilized as a discussion section to review the previous chapters. This section will reflect on each chapter and will be analyzed through an encompassing point of view.

Chapter V: Discussion

Company XYZ – Facility A was working a full schedule and was lacking 47 hours of machine capacity weekly in the sheet metal department. Fusion 20 forecasted demand required an additional 1,022 production hours per week. Fusion 20 by definition is Company XYZ's internal goal plan that is revised every five years. Thus, Facility A was no longer able to meet demand if current capacity was not increased.

As a result, an initiative to increase the capacity of the sheet metal department was conducted. The purpose of this project was to analyze various capacity constraints and opportunities and purchase a new punch shear machine with a steel tower storage system to facilitate the Fusion 20 production plans for Facility A.

Chapter I began by introducing Company XYZ and their various sites and locations. It was communicated that Facility A relies heavily on sheet metal processes for the manufacturing of their commercial heating, ventilation, and air conditioning (HVAC) products. Within this chapter, the statement of the problem and purpose of the study were developed. This included the process of defining the assumptions of the study, defining terms that were specific to the project, developing the limitations of the study, and describing how the study was conducted.

Chapter II provided a literature review to support the methodologies and tools used throughout the project. The topics explored heavily focused on capacity planning, flexible manufacturing systems, forecasting demand, planning for product lifecycles, and investing in capacity. The analysis of these various literature helped justify Facility A's processes for defining what factors were essential to their specific business unit and the path forward for successful planning for the future.

Chapter III provided a detailed description of how the study was conducted. This chapter illustrated how the data was gathered and how it was to be presented in order to provide a platform for an analysis that was easily repeatable. Chapter III also included explanations as to why the sheet metal department of Facility A was the main focus for this project. Chapter III provided the framework for the model that was used to determine the capacity needs for Facility A.

Chapter IV used the processes developed in Chapter III to provide actual data regarding the Facility A sheet metal department capacity project. This chapter was used to present the real data in a way that is repeatable and in a manner that conclusions and recommendations are able to be drawn from it. The model developed in this chapter is the basis of the recommendations presented to Facility A.

Limitations

There were various limitations when performing this capacity analysis. One aspect that was not addressed was the ability of other departments to maintain the increased production capacity of the new equipment. The overall forecasted production hours required were known, but the analysis of the downstream operations was not conducted. The most pressing capacity issue was at the beginning of the manufacturing process, which happened to be involving the punch/shear machines. Company XYZ will need to evaluate the downstream components of the manufacturing process in the near future to determine and eliminate any new bottlenecks.

Another limitation of this study that was not covered was in regards to the processing of sheet metal parts with large, radius geometry and other complicated shapes. Company XYZ determined that resources were better utilized by focusing on the higher, more repeatable production parts. This decision allowed for the greatest utilization of the machine, resulting in the most possible production and met demand.

The final limitation of this study had to do with the facility layout. Company XYZ would not consider a building addition to maximize the benefit that this project could have provided. This decision could have been based on a multitude of factors. Whether it was purely due to the capital cost it would have required or future organizational plans, Company XYX believed that it was the best decision to develop a layout that worked within the available footprint.

These limitations affected the outcome of the study in various ways. The trend was a lack of future planning. The scope of the project was contained to the punch/shear machines. Capacity analysis that did not occur after the increase capacity analysis was conducted of the downstream processes could have simply shifted the bottleneck down stream.

The study also only focused on overall production hours and the main goal was to develop a manufacturing system that allows for the most production hours output. Future market analysis to determine if the products that require the large, radius geometry and complicated shape parts that are unable to be produced with a simple punch/shear machine would see an increase in demand was not conducted, potentially leaving a gap in their market strategy.

The lack of flexibility when it came to the facility layout hindered the optimal design of the punch/shear and storage system. The new system was required to fit in the same footprint as the previous system that was manufactured by a different supplier. This lead to a storage system that was less than optimal for Facility A's various sheet metal types.

Conclusion

Facility A was working a full schedule and was lacking 47 hours of machine capacity weekly in the sheet metal department. Fusion 20 forecasted demand required an additional 1,022 production hours per week. Fusion 20 by definition is Company XYZ's internal goal plan that is revised every five years. Thus, Facility A was no longer able to meet demand if current capacity was not increased.

Facility A determined there was a total of 672 available hours for production with the current punch shear machine setup based on a seven day work week. The future five day production schedule allowed for 768 production hours. This exceeded the current seven day production schedule capacity by 96 hours. By working a six day production schedule, Facility A would be able to utilize 922 production hours and 1,075 production hours with a seven day production schedule in the sheet metal department.

Through this analysis, is was determined that based on Fusion 20 forecasts, the added capacity of the machine moves and added machine will be sufficient until somewhere between FY (fiscal year) 2015 and FY 2016 with a five day production schedule. The added capacity if Facility A were to work a six day schedule would be sufficient until between FY 2018 and FY 2019. It is not until FY 2020 when Facility A will again be in need of a capacity increase, because the seven day production schedule will not be able to meet forecasted demand.

Recommendations

Facility A is able to use the model produced with the added capacity information to move forward with the requisition of a new SBe8 punch/shear machine. This project will require intensive manpower and scheduling. The machines that are currently in use need to be focused on first. The hours that they are currently producing need to be loaded on the other punch/shear machines through the use any excess capacity they have. This will allow for the machines that are being moved or decommissioned to be taken out of service without disastrously interrupting the manufacturing process.

While this is taking place, a team will need to define the specifications required of the new system and insure they align with the current and future production needs. The exact SBe8 system will need to be evaluated by a structural engineer to determine the required foundation that will need to be constructed. Rigging, electrical, and construction crews will need to be simultaneously managed for this project to be successful.

The manufacturing system that is developed should be flexible for the manufacturing environment of Facility A and the products being produced with a keen eye focused on future capacity expansion initiatives. This will help Company XYZ maintain a competitive edge in the market place as customer demand shift on shorter timelines.

The processes developed in this study can be applied to other capacity constrained areas. Since the model is data driven, it is flexible enough to be incorporated into any analysis that utilizes the format of comparing production hour capacity and a desired forecasted demand. It is recommended that Facility A uses this model to perform capacity continuous improvement activities through the entire manufacturing process to effectively eliminate any new bottlenecks that will be created through the implementation of this new manufacturing system.

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