The Velocity Manufacturing Company -
Two Years Later

by

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Two years have past since Tom King, Velocity’s CEO and President, began implementing the recommendations proposed by his project team. He reflected on the magnitude of the product and process changes that were introduced during these two years, the risks that were taken, and the enthusiasm with which all of Velocity’s employees embraced their revolutionary activities. The company had truly re-invented itself, and had benefited in financial and operational terms; furthermore, Velocity’s customers were given more value for the products they purchased.

One reason why Velocity’s strategic transformation was successful was a result of the management team’s careful development of its guiding principles and business plans, which reflected customer needs, wants and desires. These customer requirements were clearly established during the extensive market survey and the subsequent visits with current and prospective customers. The data gathered through this process showed unequivocally that customers expected that there would be virtually no defects in the products they received. If a six-sigma level of product reliability were not provided, the data showed that slowly, but surely, Velocity would lose its key customer accounts. Thus, product quality, as it left the manufacturing facility, would have to be defect free in any revision to the system’s design.

The market survey data also showed that customers were becoming increasingly insistent that deliveries consistently be made on time. Furthermore, the time interval between the placement of a customer’s order until the time the customer wanted receipt of their material was becoming shorter. The management team believed that the only way to achieve a sustainable competitive advantage was to provide customers with very high fill rates and very quick delivery.

Although the company’s product pricing strategy had been a source of contention among the management team, the survey clearly showed that it was and is impossible for Velocity to exist by competing on the basis of price alone. While the market place was and is not insensitive to price, the growth in sales that would be needed to insure Velocity’s survival could not be achieved by simply lowering the selling prices.

The final factor that the survey showed to be important to future growth was the breadth of the product line. The data indicated that any further reduction in the breadth of the product offering would likely result in a significant reduction in sales. A doubling of the number of products offered would increase sales dramatically; however, there would be a large increase in the number of machined components that would be required in the additional products. This increase would result in a need for more and different machining equipment. More skilled labor would be needed and more setup time required. Furthermore, the complexity of planning and scheduling production would rise substantially too. Thus, after some debate, King and his staff decided that the breadth of the current product line was adequate. A few new products were added and a few others were deleted from its product line, but the number of products offered remained constant.

**CHANGES INTRODUCED INTO VELOCITY’S PRODUCTS AND PROCESSES**

After reviewing the market survey results, Tom King and his staff decided two years ago that investments were required in several key areas of the manufacturing
facility. Furthermore, the product and process designs should be rethought, vendor relationships restructured, the production and inventory control policies redesigned, and investments in information technology should be made.

Since quality was a key concern to all customers and total defect rates had been about 12% of produced units, the management team decided that all existing processes should be scrutinized carefully to determine what actions should be taken to virtually eliminate defects. Obviously the high defect rates resulted in lower profits, unhappy customers, and a less than optimal use of capacity. As a basic principle, therefore, the management team decided two years ago to invest in all the project team’s recommendations that improved quality, as long as there were no aggregate negative economic or risk consequences.

The first set of recommendations made by the project team related to investments in machining capacity. The desired capacity level had to meet the production requirements associated with Velocity’s marketing strategy. The performance objectives in this plan were to improve factory flow times, shorten order processing times, and to ship using premium freight so that the speed of delivery would surpass that provided by the best competitor by an average of two days. Furthermore, the team felt that if they reduced factory assembly flow times to less than a couple of hours that they could easily achieve a 98% on-time delivery without keeping more than the equivalent of a few days of finished goods stock on hand. Since the finished goods stock was concentrated entirely in the six highest demand rate items, not all part numbers had inventory targets of three days. By concentrating inventories in the higher demand rate parts, the risk of storing capacity in unneeded finished parts was deemed to be negligible. But the team felt that the effect of having this on-hand stock in these high demand rate parts would permit the assembly of the lower demand rate parts as demands arose for them. Thus King was comfortable with the 98% on-time delivery projection even though Velocity was, at the time, achieving only about a 60% fill rate. Finally, the management team decided to not increase or decrease prices immediately, although some pushed for a substantial price cut to stimulate sales. King and the CFO, Larry Judge, favored holding prices at the then current levels and then, after improving delivery and quality, raising prices 5% in each ensuing year.

Based on this marketing plan and the desire to have six-sigma quality in its manufacturing processes, King, Judge and Jerry Jackson, the plant manager, reviewed the project team’s recommendation for machining equipment. The team suggested upgrading one of the lathes by adding a new process controller to it, selling the second lathe, and purchasing a new CNC lathe.

Before deciding whether or not to accept the recommendation, Judge suggested that Jackson visit several companies that had modified their lathes with the new controllers. After several weeks of intensive study, Jackson met with King and Judge and reported that the yield rates he observed were much better than those Velocity was achieving; but, they were not as good as advertised. Obviously, there were many possible reasons for this lack of success. In every plant that he visited with his head machinist, Ed Michaels, there were practices in place that negatively affected yield rates. The conclusion that both Jackson and Michaels reached was that no matter how much effort they put into improving the training, tooling, sensors and software, the process was not
and would not be able to produce their complex machined parts to the quality level consistent with a six-sigma philosophy.

Both Judge and King were surprised by the conclusion. After they had reviewed the proposals given to them, they had initially felt that the low technical risk strategy for Velocity was to keep the brazed component product design in place and to simply improve the process quality by modifying and buying the machine tools, improving the controls and training for the brazing operation, developing an effective total productive maintenance program, purchasing the new proof test equipment for Sector 4, and laying out the factory to support the one-piece-flow concept and the reduced finished goods inventory policy. Jackson’s observations brought this entire plan into question. The questions that came to their minds transcended the investment decision for the lathes. Could they truly be the industry leader if they followed this conservative technical plan? Would they be the supplier of choice if they didn’t provide product and process leadership in the marketplace? Suppose their competitors introduced new manufacturing technology along with a new product design - the one piece fitting their engineers were pushing. Would they then be at a disadvantage, and even though they had made substantial strides in improving quality and on-time and rapid delivery, would they again lose market share?

The marketing survey didn’t address these questions adequately. Thus King faced a very difficult problem. Should he proceed with a plan that had low technical risk, a virtually certain positive market response, a very high projected NPV and RONA and acceptance by the staff and workforce, or should he move to make the company a true innovator? Along with innovation came the potential for significant technical and financial risk, but with the opportunity to obtain a sustainable competitive edge.

As King reflected on the decision he had made two years earlier and the risks he had chosen to take at that time, he realized that Velocity’s current success was based on the belief and guiding principle that quality throughout the process was an imperative. The quality focus within the manufacturing facility resulted in products that conformed to engineering tolerances consistently; the quality focus gave the customers defect free products; the quality focus in product design provided the ultimate user with a much more reliable and durable product. King clearly saw that Velocity’s success was a result of providing more value throughout the supply chain than was provided by Velocity’s competitors.

Ultimately, Velocity did radically change its product design, manufacturing processes, control systems and supplier relationships. To achieve simultaneously a high level of quality, a high production capacity and the flexibility to respond immediately to shifts in demand patterns for finished goods, Velocity did three key things that affected Sector 1:

First, the product was redesigned so that the one-piece design became the standard. By doing so, a major source of process variability was eliminated and the flow time and the production costs were reduced.

Second, to machine the blanks used to make the one-piece fitting, a new type of lathe was purchased. This machine was very costly to purchase ($750,000), and required expensive tooling. But, it is relatively easy to maintain, has low setup times and produces parts at a high rate. Most importantly, it produces virtually defect free parts - 1 part
defective per 300,000 units. As a consequence, one of these machines is capable of producing more effective parts per day than could be produced by two conventional machines. Table I shows the data for each of the 18 machined components used in the final assemblies that are produced on this machine.

**TABLE I: DATA FOR MACHINING BLANKS**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Setup Time (Minutes)</th>
<th>Run Time/Piece (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-R</td>
<td>3.74</td>
<td>3.05</td>
</tr>
<tr>
<td>R-B</td>
<td>3.89</td>
<td>3.08</td>
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<tr>
<td>R-G</td>
<td>4.60</td>
<td>3.85</td>
</tr>
<tr>
<td>B-R</td>
<td>4.31</td>
<td>3.28</td>
</tr>
<tr>
<td>B-B</td>
<td>4.89</td>
<td>4.16</td>
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<tr>
<td>B-G</td>
<td>4.46</td>
<td>3.57</td>
</tr>
<tr>
<td>O-R</td>
<td>5.46</td>
<td>4.59</td>
</tr>
<tr>
<td>O-B</td>
<td>4.74</td>
<td>4.08</td>
</tr>
<tr>
<td>O-G</td>
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<td>4.41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Setup Time (Minutes)</th>
<th>Run Time/Piece (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y-R</td>
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</tr>
<tr>
<td>Y-B</td>
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</tr>
<tr>
<td>Y-G</td>
<td>5.60</td>
<td>4.73</td>
</tr>
<tr>
<td>W-R</td>
<td>4.17</td>
<td>3.22</td>
</tr>
<tr>
<td>W-B</td>
<td>6.03</td>
<td>5.01</td>
</tr>
<tr>
<td>W-G</td>
<td>5.31</td>
<td>4.58</td>
</tr>
<tr>
<td>P-R</td>
<td>5.03</td>
<td>4.20</td>
</tr>
<tr>
<td>P-B</td>
<td>6.17</td>
<td>5.11</td>
</tr>
<tr>
<td>P-G</td>
<td>5.74</td>
<td>4.76</td>
</tr>
</tbody>
</table>

A new type of high speed bender was also purchased. By working with the manufacturer of the bender, the setup time of this machine was cut by a factor of 3 from its earlier design to the point where the setup time is negligible. Furthermore the run time required to bend a piece is approximately equal to 2/3’s of the time needed to machine the part. In order to insure that there would be no queuing in front of the bender, which would inhibit the realization of the one-piece flow concept, Velocity purchased 2 of the improved benders at a cost of $75,000 each.

Third, to produce defect free components, Jackson realized he needed not only capable equipment and processes, but also raw materials that had the desired physical attributes. After a year of negotiation and technical exchanges, Velocity established long-term supplier agreements with Vendor C to provide machining blanks. The result was a material that was cheaper for Vendor C to manufacture, that was easier to machine, and that produced virtually no defects anywhere in the manufacturing and assembly processes.

Velocity also made important changes to the physical design of the assembly portion of its operation. The physical flow of material was changed as follows. The 18 machined one piece fittings were held in a decoupling stock area prior to the assembly cell. Once the daily production plan was established, the needed machined fittings were withdrawn from stock and placed at the beginning of the assembly cell. The production plan indicated the sequence in which assemblies were to be created. Upon completion of an assembly, partially completed products were moved to the customization operation. No inspection or testing step was performed, except by the operator, until the final proof test. Thus there was a one-piece flow throughout the assembly process. The total flow time, including the time in decoupling stock between successive operations, averages 46 minutes.
The assembly operation was simplified and made more reliable by using new fixtures. These fixtures made it impossible to mis-align the components thereby eliminating another source of defects. Their use also resulted in reducing the assembly time for each part. Another change to the process was the direct delivery of materials -- base plates and adhesives -- to the assembly work station. Furthermore, the vendors providing these materials were responsible for managing the inventory. Each day the vendors delivered inventories so that there was no need to carry more than a few day’s worth of stock on hand for these components.

The customization was similarly simplified. Using new fixtures helped speed this process and eliminated virtually all errors. As in the assembly stage, vendors were now responsible for managing component stocks. These stocks were resupplied daily.

Finally, the new proof-test stations were installed. Since they were very accurate, neither type I nor type II errors were made. Most importantly to King was the fact that no defective products would be shipped to their customers.

To meet capacity needs and flow time requirements, Velocity installed two assembly stations, two customization stations, and two of the new proof-testers. In combination, this equipment gave Velocity the capacity to assemble, customize and test 47 units each day.

The complex production and inventory control system that had been central to Velocity’s operations was also redesigned. The one piece flow concept put into place in the assembly cell made scheduling of production releases for customization and proof testing unnecessary. Production planning was now accomplished by the team leader in the machining cell and by the team leader in the assembly cell.

The manufacturing facility still operated only one shift a day. At the end of a work day, the team leader in the machining cell observed what machined fittings had been withdrawn from stock during the day. His objective was to replenish these stocks on the following day. A simple KANBAN card system was used to insure that this team leader knew which components had been withdrawn from stock by the assembly cell’s team leader. This is how the system worked.

Velocity’s production planner had created an appropriate quantity of cards for each machined component. This quantity corresponded to the components target inventory level. When a blank was machined, a card was attached to the completed component which identified the component type. The component along with its card were placed in the decoupling stock following the bending operation. When the component was withdrawn from this decoupling stock by the team leader of the assembly cell, the card was separated from it and placed in a bin. At the end of the day the cards in the bin indicated what components had been withdrawn from stock during the day and therefore had to be replaced on the following day.

At the end of a day, the machining cell’s team leader obtained the appropriate machining blanks from stock, prepared a simple work release, which indicated the quantity and sequence of component production on the next day, and placed the KANBAN cards, blanks and materials in front of the lathe. At the end of the day, the team leader also sent a fax of the next day’s production release to supplier for blanks. The supplier, Vendor C, was required to replenish these stocks on the following day.
The day's production requirements for the assembly cell were determined at the beginning of the production day. Customer orders that were received the previous day or early in the morning of the current day, plus any backlogged orders, were scheduled for production on the current day, subject to the availability of machined components and assembly capacity. The team leader determined the actual assembly sequence based on the following rules. First, he would schedule the production of backlogged orders. Second, production of non-stocked finished products for which there were outstanding customer orders was scheduled. Third, production of stocked items was scheduled. In the latter category, products for which there would be a shortage at the end of a day were scheduled for assembly before stock replenishments were scheduled. If there was insufficient capacity to meet all delivery requirements, capacity was allocated so that the most important customers had their orders produced first.

Target inventory levels for only 6 finished products were set at a positive value. The range of items which have positive target inventory levels along with the values of these targets were set by the production planner based on his analysis of the demand data.

THE MARKET'S RESPONSE

Tom King looked at the sales data for the past 6 months and observed that demand for product continued to grow. The total average daily shipments now averaged just over 38 units, a doubling of its sales volume. Table II shows the current average daily forecast of sales volume for each of the 68 finished goods part numbers. By this doubling of the sales volume, by reducing of waste throughout the manufacturing process, by changing of the product design, by raising of prices, by reducing of inventories, and by improving the equipment and flow times, profitability had risen sharply, too.

Although the situation was good, there were signs of problems. Demand had grown considerably during the first year. In fact, it went up by about 67%. Growth in the second year was only about 21%. About the same growth rate was expected in the coming year. In the first year, when most of the changes were made to the system, fill rates were consistently at 98% or above. As demand increased, the fill rate began to drop. They presently usually ranged from 90% to 100%. King was beginning to get phone calls from irate customers who were asking why service was deteriorating and telling him to fix the problem or else they would be looking elsewhere for their supply. Thus the expected growth in demand depended on being able to supply the product reliably.

King called his management team together to discuss the situation. The Marketing and Sales V.P., Nate Coleman, argued that the inventory levels for finished goods should be raised dramatically. He argued strongly that manufacturing was not delivering product and therefore the only rational solution was to increase stock levels.

Jerry Jackson pointed out that he reviewed the monthly sales data for the past few months, and that he clearly had enough capacity to meet the demand. On days when he was unable to meet the demand, there was always an unusually large order placed by one or more customers. He argued that in order to keep manufacturing costs in line, he could not consider adding more capacity. He recommended that Coleman talk with the customers causing the problem and that he get them to change their ordering patterns. If that failed, he would support raising the inventory levels of finished goods.
Julia Anderson, the Chief Information Officer, had been working to create a system, called the Demand Analysis System. This system would allow all of the management team to analyze customer and product demand patterns. While testing this system, she stated that she observed that there seemed to be a very large amount of variability in the demand patterns. Furthermore, the demand often exceeded the average daily rates reported in the monthly management reports by a very large amount. Thus, in her view, raising the inventory levels seemed like a reasonable thing to do.

As usual, Larry Judge waited until he heard all the arguments before expressing his opinion. He agreed that something was wrong and that unless fill rates were increased quickly, Velocity’s recent success could turn into a disaster. While he understood the argument for increasing stock levels, his gut feeling was that the on time service levels could be virtually 100% with even less inventory.
ASSIGNMENT 1

As we have discussed, demand for Velocity’s products has increased over the past 2 years. To understand the characteristics of the demand process, analyze the demand data for the past 6 months. Specifically, perform Pareto analyses by customer and part; analyze time series patterns for each finished product; analyze time series for key customers; finally, analyze the demand data for each machined component.

a) Prepare a report summarizing your conclusions from these analyses. Include graphs and tables only as necessary to substantiate your findings.

b) Now that you have analyzed the data, set the target inventory levels for both machined components and finished goods. These values establish the number of KANBAN cards that will be used to control production in the pull system used by Velocity. Justify your answers.
ASSIGNMENT 2

Now that you have played the Velocity Factory Simulator, you have an opportunity to critique and change the production and inventory control system.

a) Explain how effectively the current KANBAN system operates. What are its strengths and weaknesses? What impact does this system’s use have on Velocity’s delivery performance and why?

b) Suppose the team leaders from the machining and assembly cells worked together to create a daily production schedule. That is, suppose the output of production from the machining cell is immediately available to the assembly cell. Then the sequence in which components are machined could be determined so that it better matches the sequence in which the assembly cell would need them.

Julia Anderson has also created an improved demand forecasting tool. By carefully examining the ordering patterns, she recognized that different customers must follow some sort of ordering policies. She contacted these key customers and persuaded them to share their rules with her. Although she doesn’t have access to the actual inventory levels and daily demand data, she has used historical data and policy information to infer when orders will be placed and how much will be ordered. She suggested that by using this tool we could improve on-time delivery.

Create a strategy that takes advantage of the communication opportunity between cells and the forecasting system produced by Julia Anderson. Furthermore, determine a detailed production and inventory control policy to implement your strategy.
ASSIGNMENT 3

During the weekly management committee meeting, Julia Anderson reported that she had completed both the technical development of and customer agreements for a true EDI order system. Each of the top 10 customers agreed to use this system. Anderson also stated that this EDI system reduced the customer order entry and receipt time. Previously customers typically required one day to enter their orders; it took another day for Velocity to receive and process the orders. By using the new system, orders could be processed instantaneously, thereby reducing the ordering cycle by 2 days.

The customers were at first skeptical. They did not see the advantage to introducing this new order processing system. However, once they saw that it was possible for them to have two days removed from the ordering cycle, they were delighted and embraced the new system with great enthusiasm.

Some of the customers took advantage of the new system by delaying the placement of their orders by two days. However, customers numbered 1, 4 and 5 were willing to electronically place an order on a day and expect the shipment to occur two days later. Thus Velocity could receive an order at the end of day \( n \) for these 3 customers and ship it on day \( n+2 \). The inventory shipped on day \( n+2 \) could be produced on either day \( n+1 \) or \( n+2 \) or could be withdrawn from stock on-hand at the end of day \( n \).

Your assignment is to analyze the impact of this change to the information system. How do the requirements for inventories change? How does the production planning methodology change? Describe your approach to managing in this new environment in detail.