Minimizing the seven wastes at Betts Spring Manufacturing

Lisa M. Houts
California State University, Fresno

ABSTRACT

This case study profiles the history of Betts Company and its recent efforts to minimize "muda," a Japanese term for waste, in the hot wound coil spring process in its Spring Manufacturing division in Fresno, California.

Keywords: muda, seven wastes, lean manufacturing, operations management

INTRODUCTION

Betts Company has been "Improving the Way Things Move" (http://www.betts1868.com, 2015) since it began in San Francisco in 1868 under the name of "Betts Spring Company." Founder William Michael Betts travelled from England to the United States to use his background as a steel craftsman to found a new business. Originally, Betts made springs for carriages, streetcars, and wagons. By focusing on quality and service, the company prospered, living up to its motto of "Building Well and Serving Better" (http://www.betts1868.com, 2015). Later, in response to new opportunities, Betts manufactured springs for the growing railroad system and eventually for heavy duty trailers (Industrial Machinery Digest, 2015).

The company name changed from "Betts Spring Company" to "Betts Company" in 2013 as part of a rebranding project, but the company's commitment to quality and service remains the same (Devany, 2013). Now in its sixth generation of family ownership, it is the oldest spring manufacturing company west of the Mississippi. Betts Company brings in sales of roughly $70 million a year, employs about 300 people, and is headquartered in Fresno, California. Betts Company is comprised of three main divisions (Devany and Marr, 2015).

- Betts Spring Manufacturing continues the tradition of making high quality springs, using both hot and cold wound processes to create wire, coil, and leaf springs of all sizes for a variety of different industries including the automotive aftermarket. Everything is made to order to meet the exact specifications of each individual customer. The manufacturing facility was moved from San Leandro, where it had been since 1973, to Fresno, California in 2008 (Devany, 2013).
- Betts Truck Parts and Services began by providing suspension parts for medium and heavy-duty trucks. It now provides a wide line of parts and services for under the frame rail, operating from six distribution centers in California, one in Arizona, and one in Oregon (Industrial Machinery Digest, 2015).
- Betts HD makes fenders and mud flap hangers for Class A commercial trucks. William Michael Betts III designed and patented the first mud flap hanger used in trucking in 1954. He was grandfather to both Bill Betts, the current Betts Company president, and Joe Devany, the current director of operations of Betts Company Manufacturing Business Units (Devany and Marr, 2015).

Now approaching nearly a century and a half in business, Betts has relied on its culture which focuses on

- Outstanding service to customers.
- Resilience and innovation (which included recovering from complete destruction of the original manufacturing facility in San Francisco's 1906 earthquake as well as changes in the transportation industry).
- Continuous improvement (encouraging management and employees to embrace a philosophy of lean operations and undertaking many projects to improve the quality of products and manufacturing processes) (Devany, 2013).

BETTS SPRING MANUFACTURING

The spring manufacturing division uses hot and cold wound processes to make wire, coil, and leaf springs. Because all springs are custom made for specific applications, they are typically made based on purchase orders from large customers. Sometimes springs are made in front of a purchase order if Betts knows it will be forthcoming, but the company does not make-to-stock. Wire and bars of spring steel are the two main raw materials needed to make coils. Wire, purchased from Korea, is used for the cold-wound process. Bars of spring steel, purchased directly from U.S. mills, are used for the hot-wound process. Even with Betts' focus on lean operations, considerable amounts of money are wrapped up in inventory. Typically, Betts holds over $800,000 in raw materials inventory and over half a million dollars in finished goods. The remainder of this case focuses specifically on the hot wound coil process and the lean principles that have been applied to these operations (Devany and Marr, 2015).

OVERVIEW OF THE HOT WOUND COIL LINE

Hot wound coils account for about forty-five percent of sales for the Betts Spring Manufacturing division and about fifteen percent of sales for Betts Company as a whole. The hot wound coiling line has a single piece flow of parts through a line. A worker places a bundle of precut bars on a bar feeder that then feeds one precut bar at a time into the furnace for heating. The bars are coiled one at a time and then quenched and tempered one part at a time, but all are part of a continuous flow process. After that, the coils go into a batch-in-queue type of process for grinding (if required), shot peening, presetting, and testing. Once completed, the finished coils are sent out to a subcontractor for powder coating and then returned to Betts for packaging before being sent out to the customer (Devany and Marr, 2015).

The layout of equipment is arranged to reduce transportation and materials handling time and cost, thus improving flow time and efficiency. Betts would like to bring these steps into a continuous flow line, eliminating work-in-process bottlenecks so less cash is tied up in work-in-process inventory that is sitting on the manufacturing floor. It used to have boxes of coils sitting out at various steps in the process, because some work areas could not keep up with the pace of upstream operations. However, substantial improvements have been made as a result of lean processes that were implemented. One bottleneck that still remains is in front of the presetting and testing area, and steps are being taken to eliminate this (Devany and Marr, 2015).

Many steps have been taken to organize the manufacturing facility to standardize processes and to keep things organized and orderly. Throughout the factory, point of use racks keep workers' tools nearby the equipment and neatly organized. For example, point of use racks for grinding wheels are located near each grinder to minimize transportation time, instead of having all wheels at a central location. Shadow boards have outlines of each particular tool drawn on the pegboard, making it quick and easy to store tools where they belong, increasing efficiency by reducing time spent looking for the right one. Areas are marked out on the factory floor to indicate where scrap bins go for optimal placement and efficiency (Devany and Marr, 2015).

SPECIFIC WORK FLOW OF THE HOT WOUND COIL LINE

The flow of the hot wound production process begins with the raw materials, located in a storage area just outside the doors of the facility. In order to purchase directly from U.S. steel mills and get the best pricing, Betts must order a full truckload of spring steel, so sometimes it orders more than what it needs at a given time. The advantage, however, is about a twenty percent savings over what it would have to pay if it purchased from a distributor. Currently, the spring division is turning its raw materials inventory six times a year. In a lean system, it is desirable to increase inventory turns by ordering in smaller quantities, to minimize the amount of cash tied up in materials. Betts would like to increase its inventory turns to seven per year (Devany and Marr, 2015).

Two years ago, Betts found a way to greatly reduce round bar spring steel scrap. Forty foot lengths were being purchased for all coil types, but often significant amounts were leftover as scrap during the cutting process. Betts realized that by purchasing varying lengths for each bar diameter, such as 38-, 40-, and 42- foot bar for a particular bar diameter, it could select a bar length that best matched the size coils it was planning to make. This minimized scrap and resulted in an annual savings of about $150,000 (Devany and Marr, 2015).

As part of a process to reorganize the raw materials area and get the spring steel off the ground, racks were built for storing the bars and are numbered for inventory purposes by bar type and length. To minimize transportation time and cost, the bars are arranged in the outdoor storage area so that the sizes used most often are stored closest to the cut-off saw and the entryway to the fabrication area Those bars used less frequently are stored further away. Outside, a worker uses a cut-off saw to cut the bars to the proper length for the size coils to be made. Any scrap is sold to a scrapper as part of Betts efforts to recycle unused materials (Devany and Marr, 2015).

Once the round bar is cut to the appropriate lengths, the pieces are placed on metal racks and staged inside the building near the coiling area. To make a coil, a bar loader feeds a length of spring steel into the furnace in a single piece flow. The process is controlled and monitored by a computer, which adjusts the amount of time spent in the furnace based on the diameter of the bar. In the furnace, the steel bar is heated to a red-hot 1750 degrees and then wound around a mandrel, in an automated process, into the shape of a coil. Next, the hot coil goes through an oil quench and tempering process which changes the metallurgical properties of the spring to bring it to the proper operating hardness for the application. A hardness reading is again taken to make sure the springs are within specifications (Devany and Marr, 2015).

In the past, one problem with this process was that defects could occur if the time the bars spent in the furnace or quench tank varied from what was optimal. Sometimes workers allowed the bars to stay in the furnace too long, because they were not sure what was best. Too much time in the furnace resulted in decarburization of the coils, breaking down the material. Visually, one could see “alligator skin/scale” on parts, or the coils could break if overheated. In addition, too little time in the quench tank would negatively impact quality, while extra time spent there unnecessarily increased flow time (Devany and Marr, 2015).

The main reason for these problems was cultural. No specific studies had been done to determine the exact amounts of time needed. When only 300-500 coils needed to be produced in a day, time was not much of a constraint and the inefficiencies persisted. As demand increased and Betts adopted a lean approach, wasted time and too many defectives came to be seen as undesirable. The goal was to optimize product quality and decrease throughput time. Betts needed to change and adapt cycle times to meet growing demand, now at 1500-2000 coils per day, and ensure timely deliveries to customers. In addition, cutting unnecessary time in the quench process would improve flow time and further help increase daily capacity and on-time deliveries. Another important benefit was that accurate times and furnace temperatures would mean improved quality (Devany and Marr, 2015).

Metallurgical analysis was performed to determine the ideal number of minutes for each bar diameter to spend in the furnace. Now, the line is completely automated. Furnace time is automatically determined by a computer, controlled by an operator who simply inputs the diameter of the bar. The computer monitors the entire process and identifies any problems that occur. Steps and motion are saved, since a worker can oversee everything from one computer screen and no longer has to walk around to change or monitor the various pieces of equipment. With more precise timing for the furnace and quench process, scrap was reduced by three percent and cycle time by fifty percent, increasing the number of coils that can be made each day and helping achieve on-time deliveries in the midst of growing demand. In addition, energy use was reduced as was the standard cost per part (Devany and Marr, 2015) .

A special tooling rack was constructed near the hot wound coiler to make it more ergonomic for workers to change parts. Heavy mandrels, weighing in excess of 250 pounds, are used to wind the heated coils around. Different mandrels are needed for different size coils. Shelves on the tooling rack have ball bearings to facilitate the movement of the mandrels to the coiler in a safe and efficient manner. Thus, moving the mandrels on and off the shelves involves rolling them instead of having to lift them, making it easier for workers and reducing the likelihood of injury or strain (Devany and Marr, 2015).

From the coiling department, all coils are sent in batches to downstream operations. Some springs go to the grinding area. At this point, the coil still has the round shape and diameter of the original bar. In order for a coil to make a flush connection with a surface, one or both ends can be ground flat. The need for this process depends on the end use of the particular spring being made. In order to increase the rate of downstream processing, another grinder was recently purchased. Also, the previous manual operation became more automated, and tooling and fixtures were adjusted to get more springs on the table at a time. Together, these changes resulted in decreased cycle times and increased the number of parts per hour from twenty-five to 100, using both the old and new pieces of equipment. After coiling parts are ground on one or both ends as required by application, they move to the shot peening process which enhances their strength and durability. Small "shot" or spherical media hit the spring in a tumble blast process, which creates an effect similar to hitting a piece of metal with a ballpeen hammer. Tiny indentations are made on the spring, which makes the spring less susceptible to cracking and increases its life (Devany and Marr, 2015).

In the next step, all springs move to the "preset/testing" area. A worker takes a spring and places it into a machine which compresses it until it all the coils touch each other. When the pressure is removed, the stress in the spring is released. If a spring is 20 inches before being preset, it may be only 19 ½ inches afterwards. It is important to do this before a customer tries to use the product, otherwise the size of the spring could change with usage and not function properly. An analogy might be that it is important to wash fabric before cutting and sewing it, since waiting to wash it until after a garment is made may mean that the item shrinks and ends up smaller than intended (Devany and Marr, 2015).

The preset/testing step is slow, however, resulting in a large bottleneck of springs sitting in crates waiting their turn to be processed. This is because until recently there was only one machine available, a $250,000 high-precision piece of equipment designed to both preset the spring and test its quality. Thus, every single coil was being tested. However, 100 percent inspection was not always required, and it put undo wear and tear on a very costly piece of equipment. Now, at a cost of $20,000, Betts has built a special machine which will only preset the springs, eliminating the excess wear and tear on the high-precision machine. A sampling (ten to fifteen percent) of those springs preset on the new machine will then be tested. This will help relieve some, but not all, of the bottleneck by increasing the number of units that can be preset each hour. Any remaining bottleneck should be alleviated once Betts builds two more preset machines and brings them out to the production floor (Devany and Marr, 2015).

EMPLOYEE INVOLVEMENT AND INCENTIVES

These last three departments, grinding, shot peening, and presetting/testing, are arranged in close proximity in a cellular environment. When Betts moved from San Leandro to Fresno in 2008, many employees needed to learn new skills. Cross-trained employees can now move back and forth between these three departments as needed, adding flexibility in scheduling production and giving workers opportunities to increase the variety of work they perform. For instance, a worker can load springs into the grinding machine. Then, rather than standing idle while that process takes place, the worker can move to a different area and complete another type of task. Thus, better use is made of the worker's time, increasing his efficiency (Devany and Marr, 2015).

Additionally, all employees are trained in lean production and 5S techniques, so that they understand and support this important aspect of Betts corporate culture. In the spring division, employees are divided up into five teams of three to six employees each based on geographic area of the facility. Each quarter, employees can earn up to three and a half percent of gross income as a bonus for devising new techniques for lean production and 5S as well as meeting goals for things like on-time delivery, quality, and safety. They are audited with a twenty-point audit sheet using yes/no criteria and need earn "yesses" on at least eighty percent to achieve goals and earn their bonuses. This plan has proved popular with employees, increasing their commitment and morale (Devany and Marr, 2015).

MUDA

The seven types of waste (muda) are unproductive manufacturing practices which are essential to address in a lean production system such as the one found at Betts Company. The seven wastes are overproduction, waiting, transport, non-value added processing, excess inventory, motion, and defect. In addition to these seven wastes in the traditional model, sometimes an eighth waste of "underutilized people" is added to the list. Underutilized people are a resource whose time is wasted with inefficient processes or unnecessary waiting time. Also, workers may be capable of contributing more than they currently have the opportunity to do (Devany and Marr, 2015).

There is often overlap between the various types of waste. Signs posted throughout the spring manufacturing facility remind workers of these types of waste, and workers participate in generating new ideas for lean production as well as implementing existing ones.

Seven Types of Waste (Muda)
Overproduction -- more products are being made than are required or products are being made unnecessarily early
Waiting -- periods of inactivity such as employees or equipment sitting idle due to production bottlenecks, inventory shortages, machine breakdowns, and quality problems; customers waiting on the phone for assistance; or trucks waiting to be loaded for shipment.
Transport -- unnecessary movement of materials, such as moving raw materials from delivery trucks to warehouses and finally to staging, or moving work-in-process (WIP) from one work area to another.
Non-value added processing -- extra operations, such as rework, extra handling, or extra storage that occur because of problems such as overproduction, extra inventory, or defectives.
Excess inventory -- any materials (i.e., raw materials, work-in-process, finished goods, supplies) which are not needed to fill current customer orders.
Motion -- extra steps or movements made by employees or equipment because of inefficiencies in work design, facilities layout, inventory handling, or any other activities which do not add value to the process.
Defects -- products which do not meet the organization's internal quality standards or which do not adequately meet customer expectations.

GLOSSARY OF TERMS

Bar loader – an automated piece of loading equipment which a worker fills with a bundle of precut round spring steel bars. The bar loader moves the steel bars one by one into a furnace where they will be heated until they are red hot.

Cut-off saw – an abrasive saw used to cut hard materials such as round spring steel bars.

Decarburization – a reduction in the carbon content of metals, often steel, which can be harmful to steel-heated parts such as the round bar used to make coils.

Mandrel – a mandrel is a heavy cylinder around which the red hot spring steel bar is wound into the shape of a coil.

Metallurgical -- properties related to the production and purification of metals.

Presetting -- a process whereby a worker takes a spring and places it into a machine which compresses it until it all the coils touch each other. When the pressure is removed, the stress in the spring is released, changing the length of the spring.

Shot peening -- a process which enhances the strength and durability of the coils. Small "shot" or spherical media hit the spring in a tumble blast process, which creates an effect similar to hitting a piece of metal with a ballpeen hammer. Tiny indentations are made on the spring, which makes the spring less susceptible to cracking and increases its life (Devany and Marr, 2015).

DISCUSSION QUESTIONS

1. Give examples of how the various types of muda have been reduced at Betts Spring Manufacturing. How have these changes impacted the company?

2. How does the emphasis on lean production relate to Betts Company's strategy and culture?

REFERENCES

(2015). The Science & Art of Making Springs. *Industrial Machinery Digest* 47-49. Online at http://www.indmacdig.com.

(2015) Vision, Mission, and Value and Company History. Online at http://www.Betts1868.com

Devany, Joe (2013). Lean Training Development and Implementation, Betts Company, M.B.A. Final Project,

Devany, Joe and Marr, John (2015). Personal Interview on May 13, Fresno, California.