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SIMULATION OF A PLANT-WIDE INVENTORY PULL SYSTEM

Brian L. Slobodow

Electronic Data Systems
Delco Chassis Division
2509 Hayes Avenue
Sandusky, Ohio 44870, U.S.A.

ABSTRACT

Successful implementation of inventory pull (kanban) systems has become a widely discussed topic in recent years. This paper examines one such effort which uses simulation modeling as a means to quantitatively design such a system.

The Normalize area is responsible for heat treating raw material for Delco Chassis wheel spindle bearing products. Within the area, product travels in containers that eventually are delivered to various machining lines. Since its inception, the area has been scheduled with a traditional "push system." The result has been high inventory, long lead times, floorspace organization problems, and a lack of employee involvement.

A Normalize pull system was proposed to provide for better control of product flow through the area. Furthermore, the pull system maintains a maximum inventory level of approximately two days for all part sizes at the machining lines. The simulation uses historical production data to replicate demand for Normalized product. By using actual production data, the Normalize environment is simulated as if the pull system had been in place for ten months in 1992 and 1993.

The simulation's results confirmed the feasibility of the pull system. The pull system would have caused an acceptably low amount of starvation in the machining lines. With the pull system, plant-wide Normalized inventory can be reduce by approximately 48%. Furthermore, plant Industrial Engineers will be able to dedicate floorspace to properly store Normalized inventory.

1 INTRODUCTION

The Normalize area is a part of Delco Chassis' wheel spindle bearing plant in Sandusky, Ohio. The bearings produced in Sandusky have two major forged components: spindle and hub. Spindle and hub forgings are shipped to Sandusky by three major suppliers. At the time of the project, Sandusky was producing fifteen different kinds of bearings. Twenty eight unique spindle and hub forgings were being stored in the receiving area's "pad," to supply the plant. Pad inventory is always contained in large wire baskets. The baskets can store 600 to 2000 forgings, depending on the part size.

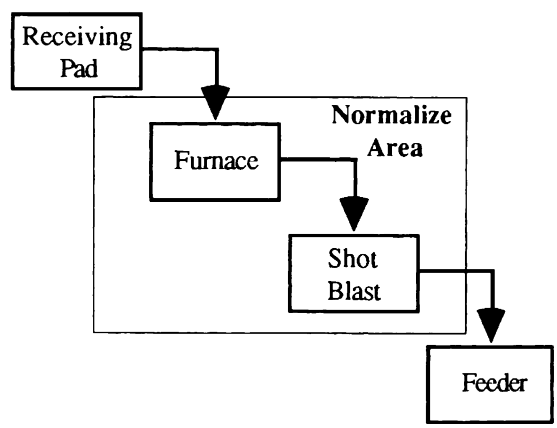

Figure 1: Product Flow

The Normalize area physically consists of eight furnaces and three shot blast machines. All forgings are first heat treated in one of the eight furnaces. Truck drivers are given a schedule at the beginning of each shift. The drivers are then responsible for transporting baskets between the pad and the furnace entrance. A furnace operator monitors several ovens at a time. The operator runs product through the furnace into gondolas. Gondolas are smaller than baskets and can hold approximately 75% of a basket. The forgings must cool for at least four hours after the furnace operation. After the cooling period is complete, gondolas of forgings are processed through one of three shot blasters. The shot blast operator returns product to the gondola once the operation is complete. After the shot blast operation, the forgings are ready to enter a machining line.

A second group of truck drivers is responsible for delivering finished Normalized product to the machining lines. They periodically make deliveries throughout the plant. All Sandusky machining lines begin with a feeder machine that loads forgings into the line's material handling. The truck drivers attempt to deliver the gondolas in proximity to the feeders so the material can be quickly loaded into the line. This is often a difficult proposition since floorspace for gondolas is not dedicated and can be hard to find. The drivers are also responsible for returning empty gondolas to the Normalize area.

The Normalize schedule is developed daily by a production controller. This person begins the process by completing a physical inventory at all the feeders. Then he forecasts the demand for product over the next 24 hours. The schedule is based on a combination of inventory, demand, experience, and best guess.

2 PROPOSED PULL SYSTEM

The pull system was developed in response to plant-wide inventory problems. Because the Normalize area is scheduled on anticipated demand and is run without restrictions, it can substantially overload a machining line. This can result in large amounts of gondolas to accumulate at and around a feeder, causing many subsequent problems. If a quality concern should arise, often the gondolas can be difficult to locate. The truck drivers can get frustrated because the large inventory of gondolas can block aisles, restricting their ability to maneuver. When engineers completed a leadtime analysis for the plant in 1992, they discovered 90% of a forging's time in the plant was spent waiting behind a feeder. Furthermore, when machining lines do run well, the twenty four hour scheduling cycle might not be able to anticipate demand fast enough. This can cause starvation in the lines, therefore idling machinery and people. In summary, the scheduling or push system is erratic, problematic, and in need of a feasible replacement.

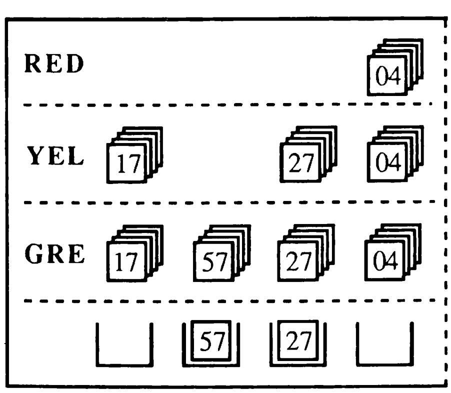

Figure 2: A Portion of the Pull Board

The key to the proposed pull system is a visual control board located in the Normalize area. This board consists of twenty eight columns (one for each forging type). The columns are divided into three sections: green, yellow, and red. Each section has one peg which can hold several pull cards together. When an operator has an open furnace in his area, he uses the pull board to determine the next type of part to run. The operator first attempts to select a group of pull cards in the red section, if none are available he selects from the yellow. If no pull cards are in the yellow section, he selects from the green. When the pull board is empty, the operator and his furnace is idled.

After the operator pulls a group of cards from the proper pull board section, he requests forging baskets from the pad truck driver. Each pull card explicitly details the amount of baskets the truck driver should deliver to the furnace. Higher volume parts have larger basket delivery quantities than low volume parts. The furnace operator processes baskets of parts into the gondolas. Each gondola is tagged with one pull card. The gondolas make their way to the feeders in the same manner as in the scheduling system.

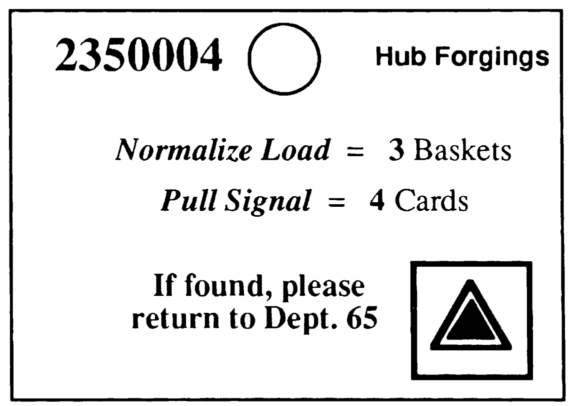

Figure 3: Sample Pull Card

As the feeder operators load gondolas of forgings into the machines, they must remove the pull card. The removed pull cards are placed in one of several holding boxes throughout the plant. Periodically throughout the shift, truck drivers pick up the pull cards from the holding areas. They return the cards to the pull board and if they have a sufficient amount of cards to make one signal (pull signal quantities are on the cards) they place the cards in a green, yellow, or red section peg. If they do not have enough cards to make a pull signal, the cards are temporarily placed on an accumulating peg.

The maximum amount of gondolas in the system is controlled by the amount of pull cards created. Because of floorspace limitations, a two day maximum inventory was attempted for most part sizes. This was impossible for some low volume sizes. In these cases, enough gondolas were allowed to maintain a minimum batch size through the Normalize furnace.

3 SIMULATION METHODOLOGY

Only one simulation model was created for the project. The model was constructed using the WITNESS simulation software. Some basic assumptions were made to reduce the model's complexity. The forging vendors were generally able to keep up with any fluctuations in Sandusky's production. Therefore, the model assumes that raw forgings were always available for the Normalize area. Furthermore, since baskets were shipped by weight and individual forging weight was constant, standard piece baskets were assumed. One of the model's criteria was to use historical data for feeder production rates. Data files were created containing historical daily production totals for a ten month period (May 1992 to March 1993). The daily rates of production were used to run the feeders at uniform rates. At the end of each simulated day, new data was read from the data files. Production fluctuations within each day were ignored by using a uniform depletion rate at the feeders.

Downtime and part changeover data was collected for the Normalize ovens and was included in the simulation logic. The pull board, with twenty eight columns, controlled decision making at the furnaces. Baskets were run through the furnace into gondolas, as in the current environment. The gondolas and pull cards traveled throughout the plant according to the pull system logic. While constructing the model, special consideration was given to limit the amount of elements and transactions. For example, gondolas traveled through the model as single parts with an attribute that contained the number of pieces in the gondola. When the gondola began to be depleted by a feeder, its attribute was incrementally changed. This limited the amount of parts active in the model at any one time. Through efficient construction, the model's run speed was excellent. This speed was especially noticeable since, traditionally, simulator-created models tend to run slowly. The ten month replication length was completed in twenty minutes of computer time. This allowed for rapid experimentation and shortened the overall simulation construction time.

4 SIMULATION RESULTS

The results of the model quantitatively analyze the validity of the proposed pull system. If the pull system had been in place for the ten month period in 1992 and 1993, there would have been extremely few occurrences of starvation at the feeders. Feeder starvation is defined as any moment when production is scheduled for a machining line, yet no gondolas are available for the feeder. The simulated pull system caused .02% cumulative starvation at the feeders. This amount of starvation is noticeably lower than with the push system.

The inventory statistical results were just as impressive. The pull system would have allowed Sandusky to carry approximately 48% less total inventory for the ten month period. This translates into a substantial carrying cost savings. The leadtime reduction is proportional to the inventory reduction. With the pull system in place, there will be a defined maximum amount of gondolas in the system at any time. This will enable Industrial Engineers to dedicate proper amounts of floorspace to the storage of gondolas.

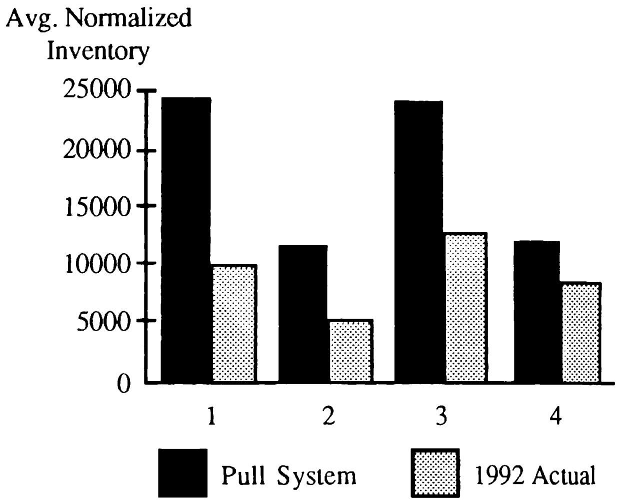

Figure 4: Inventory Reduction on Four Part Sizes

Inventory savings and starvation prevention are not the only benefits, though. With the pull system, the Normalize area's response time to machining line demand will be almost immediate. No longer will the area be anticipating demand. Furthermore, the production controller who schedules the area will no longer be required. Since coverage for this person has been a major problem for Sandusky in the past, this could be an important gain. The pull board enables management to permanently change customer part volumes quickly. For example, if a spindle bearing customer decides to increase production volume, pull cards can be added or redefined. With the push system, it might take months for a volume change to get down to the Normalize area.

The Sandusky employees have much to gain from the pull system. With the pull system, there will be fewer baskets in the system because of standardization. This should improve plant safety because of less over-crowding. In addition, with a reduction of inventory, there will be a noticeable decrease in work for truck drivers. Overall, the pull system will be Sandusky's first effort of its type to empower its workforce in a synchronous environment. The potential benefits from this manufacturing technique have been well documented by others, most notably Toyota. The simulation was constructed with limited animation so that the entire plant can be viewed using the pull system. This potentially can be used to train hourly employees who will be affected by the pull system.

5 IMPLEMENTATION

The Sandusky facility is currently exploring the implementation of the pull system. The task is not a simple one as there are many implementation issues. The truck drivers traditionally read the shift schedule and prefer to deliver most of the baskets in the first few hours of the shift. With the pull system, they will need to make a cultural change. They must only deliver baskets explicitly requested by the furnace operator. Operators, both furnace and feeder, must be trained to handle the pull cards. Furthermore, the truck drivers delivering gondolas will have to be trained to return cards from the holding areas to the pull board.

Further complicating implementation is the method by which the foreman of the Normalize area is evaluated. He is currently judged by the amount of product he can process through the area. With the pull system, this will need to change. There will be instances when the pull board is empty and the furnaces are idled through no fault of his own. Furthermore, the basket quantities defined on the proposed pull cards are about 50% less than current scheduled runs. Therefore, the pull system will increase the changeovers at the furnaces. There is some concern that increased changeovers affect forging quality. This issue will need to be examined closely before implementation.

This is by no means a complete discussion of implementation issues. Throughout the development process, concerns were documented. These items, along with others that will arise, will need to be addressed by an implementation team.

6 CONCLUSIONS

This project is not yet complete. The simulation and animation are being used in several presentations to a variety of audiences to demonstrate the potential benefits. The model's results have been able to assure people that the pull system is feasible and can have a documented impact on the facility. Some may point out that the pull system proposal could have been developed without simulation. Yet, the model accomplished something no one person, or group of people could do: completely validate the concept by using historical production data. Implementation may begin in late 1993.

In the future, the model created for this project could be used to make modifications to the pull system. Instead of adjusting pull card quantities and definitions on the factory floor, experimentation could be done with the model. This will facilitate the continuous improvement process that is a part of any synchronous system.

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AUTHOR BIOGRAPHY

BRIAN L. SLOBODOW is a Systems Engineer for Electronic Data Systems. Brian received his B.S. in Industrial and Manufacturing Engineering from The University of Rhode Island in 1990. His interests include synchronous manufacturing, line balancing, design for manufacturing, and simulation modeling. He is a member of IIE and SME.