AC 2007-3042: VISUAL DATA'S EFFECT ON QUALITY AND PRODUCTIVITY AT A TIER ONE AUTOMOTIVE COMPONENTS MANUFACTURER

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Visual Data's Effect on Quality and Productivity at a Tier One Automotive Components Manufacturer

Abstract

To remain competitive in their market, manufacturers must employ timely measurement of performance such as productivity and quality. A solution to this problem is the implementation of visual data-based information systems that can provide a manufacturer with productivity and quality performance information quickly. These systems will help the manufacturer make quick decisions related to scrap, re-work, and poor performance, thus reducing the production costs.

For this project, a single production assembly line was chosen at a tier-one automotive components manufacturing plant. A visual data system was implemented on a high-volume production line and thus provided the manufacturer with productivity and quality performance information quickly. After the implementation, the quality and productivity of the production line were observed to be significantly higher. The average number of defects was reduced by 30%, and the average number of parts produced per person per hour was increased by 5% for the production line.

Sharing the project with undergraduate/graduate students in the manufacturing field will help students understand the application of manufacturing methods/technology and see the relevancy of their learning as connected to the industry. Therefore, the students in manufacturing will appreciate the immediate applicability of their classroom learning in improving productivity and quality.

Introduction

In the manufacturing sector, automotive manufacturers are experiencing increased competitiveness as the market becomes increasingly global. This increased competition has made the automotive manufacturing environment more information driven and has increased the need to measure manufacturing performance on a timely basis. If timely measures of performance such as productivity and quality are not taken and evaluated, manufacturers will have difficulty remaining competitive in their market. Visual data-based information systems can provide manufacturers productivity and quality performance information quickly so that decisions concerning scrap, rework, and poor performance can be evaluated quickly.

This project deals with a production line (for automotive components) where visual performance measures were implemented and the resulting impact on quality and productivity. Implementation of the visual system in this production line has never been implemented before so there was no historical data to support a cost savings in similar high volume automotive components cases. The motivation for such implementation was to see if a visual data system would result in a cost savings through increased quality of the automotive components, or increased productivity.

Manufacturing Education and Applied Technical Projects

This project was completed as the directed project to meet the partial requirement for a master's degree in Technology through the Weekend Master's Degree (WMP) program. The objective of the WMP program is, "enhancement of analytical and problem-solving skills in applications of technology"[1]. Such enhancement of the students analytical and problem-solving skills is demonstrated through the completion of an industry-based project, thus solving a real-life problem. Examples of these projects can be used as case studies for graduate/undergraduate instruction in the manufacturing field. Sharing these projects with the students in the manufacturing field will help them understand the application of methods/technology and appreciate the immediate applicability of their classroom learning. Therefore, students in the manufacturing field will see the relevancy of their learning as connected to the industry.

To create an innovative model of advanced professional engineering education to ensure U.S. technological leadership for competitiveness will require (among others), "educational process that enables growth and engagement in creative practice", which includes the experiential learning[2]. The industry-based project for WMP directed projects provides such experiential learning from which both graduate/undergraduate students will learn.

Visual Data and Performance Management

Performance is defined as the process of quantifying the effectiveness and efficiency of action[1]. Performance management is key to improving continuously and knowing where to apply resources. Performance management can be many different things such as an operational control tool, a strategic planning tool, a management reporting tool, and a change management facilitation tool[2]. Performance management can be used to control the operations of a production line and at the same time can be used as a managing tool. Therefore, performance management requires performance measurement.

From the operations viewpoint of performance management, a production line's employees can use performance measures to know how production is progressing throughout the day. A production line may need to address an issue if the operation of the production line is abnormal. For example, a high rate of scrap generation could be due to a raw components condition being out of specification. If the production line is using a scrap performance measure such as a scrap ratio (the number of scrap parts divided by the total number of parts produced), then the problem could be identified by the production line worker and the worker can take the necessary actions to address the problem.

Organizations that use performance-based management need to use a history of performance measures[3]. Performance measures can be charted and displayed easily through spreadsheets, programs, and databases. These displays can be visual and interpreted quickly through the use of charts, symbols, and colors. For example, an organization may want to display an output performance measure at the production line. The production line worker can go to the computer, access the output performance measure chart, and possibly print out the output performance measure to be posted at the production line. This real-time performance measure data collection and presentation will assist an organization in making informed data-driven decisions.

Visual data plays an important role in performance management, and controlling the process has become one of the most important parts of the manufacturing process[4]. This is important because the performance management of a process is easier if data from that process is presented visually. Data that takes the form of shapes and lines is easier to process than data made up of numbers or text only. The human brain can identify and interpret a sheet of shapes and colors quicker than processing a sheet of numbers. Visual data representation provides a much higher degree of confidence in the findings than numerical data representation[5]. Therefore, performance management of a production line is more efficient when visual data are used.

This confidence will allow a line worker to make adjustments without question, and the worker's effectiveness in decision-making is dependent on knowledge and awareness of the process at all times[4]. This confidence will allow the entire production line to work as a team because the visual data will show the workers what is going on and what needs to be done.

It should also be mentioned that the use of visual data should allow production line workers to see if something is being skipped in the process. This is important because this could be a safety problem[4]. For example, visual data for productivity may show an abnormally high rate; and this high rate could be due to the skipping of a quality check. Skipping this quality check could make the final product unsafe or defective.

Visual data also provide several other benefits, such as providing correct information and effectively communicating the status of a production line. Effective use of visual data will result in better decision-making, safer and cost effective operation, increased productivity, and greater quality[4]. In addition, the production line can be more easily managed visually by the management of the plant. The management can use the visual data to understand the line performance quickly and make decisions in a timely manner. Management can also use the visual data to continuously improve and know where to allocate resources. Production lines that are not meeting their production goals could be allotted resources to implement the visual data at the production line.

Methods and Procedures

The project was completed at an automotive component manufacturer's plant. The manufacturer has more than 60 production lines, so one line was chosen at random for this study. The general process flow (block diagram) and the floor layout sketch of the production line are given in Figure 1 and Figure 2. The main operations are assembly, weld, melt, test, and pack. The layout is shaped like a "U", and it should be noted that the visual data was implemented at the beginning of the production line (Figure 2).

Figure 1. Block diagram of process flow

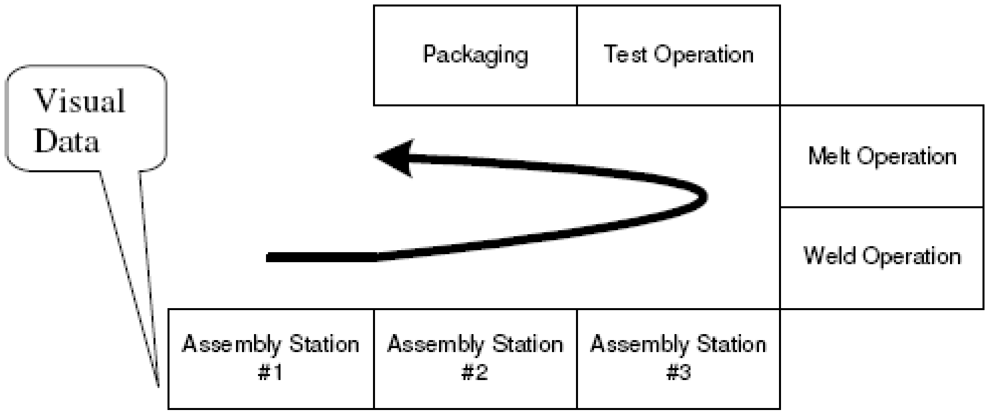


Figure 2. Process layout

To meet the objectives of this project, three steps were followed. First, quality and productivity were measured for the line. Next, visual data was implemented into this production line, and then the quality and productivity were measured again (Figure 3). Some examples of the visual data are shown in the Figure 4.

Quality was measured by the number of defective parts produced on the line per day. Productivity was measured as the total number of parts produced per day. The quality and productivity data was collected over a five month time period before and after the implementation of visual data. The data collected were entered electronically in spreadsheet format by production line workers on a daily basis.

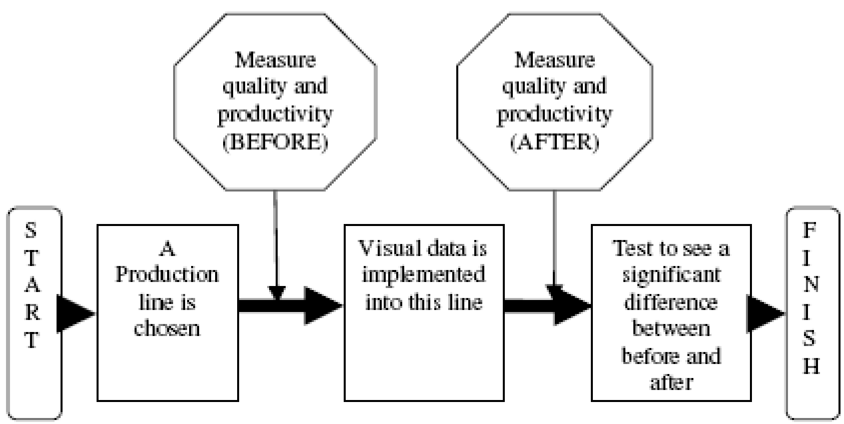
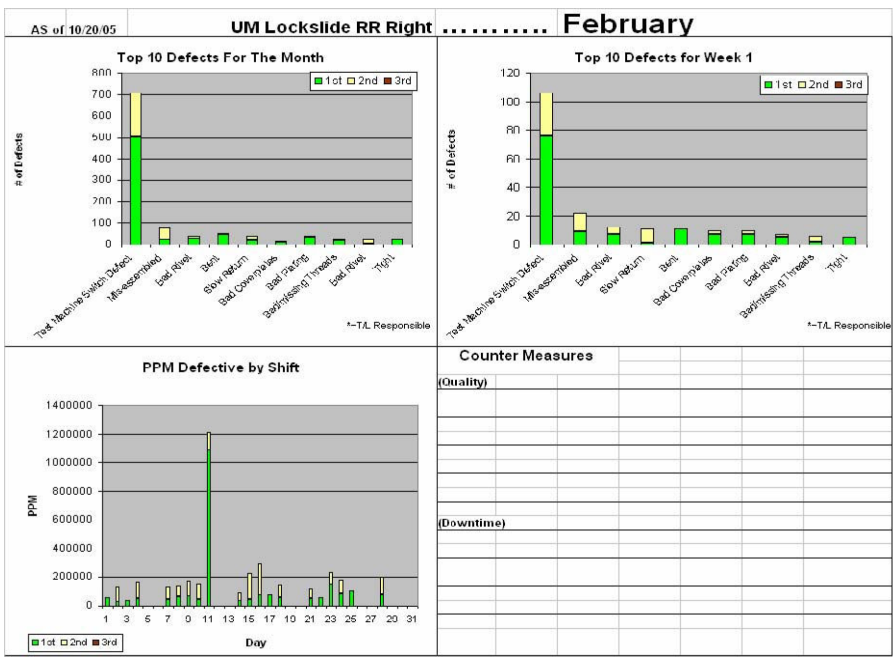


Figure 3. Block diagram showing the methods followed for the project

Two hypotheses were tested for this study. First, if visual data was used for quality (in terms of parts per million defective), then the number of defective parts would significantly *decrease*. Secondly, if visual data was used for productivity (parts produced per person per hour), then the productivity would significantly *increase*. Both of these hypotheses were tested using paired t-tests at the 95% confidence level.

(a)

(b)



(c)

Figure 4. Pictures showing manufacturing floor without visual data (a) and with visual data (b), and examples of visual data (c)

Results and Discussion

The objective of this project was to answer whether or not visual data implementation for a production line will change the quality and/or productivity. Visual data for this project was represented by two charts that display productivity (parts produced per person per hour, PPPH) and quality (parts per million defective, PPM) displayed at the beginning of the physical line. PPPH and PPM data was collected five months before and five months after visual data was implemented. The PPM data is charted in Figure 5, and the PPPH data is charted in Figure 6.

The first hypothesis was, if the visual data (Figure 4) was used to display product quality on the line, then PPM defects for the production line will significantly decrease. The data yielded a mean PPM of 20102 and a mean PPM of 14131, before and after the visual data implementation, respectively.

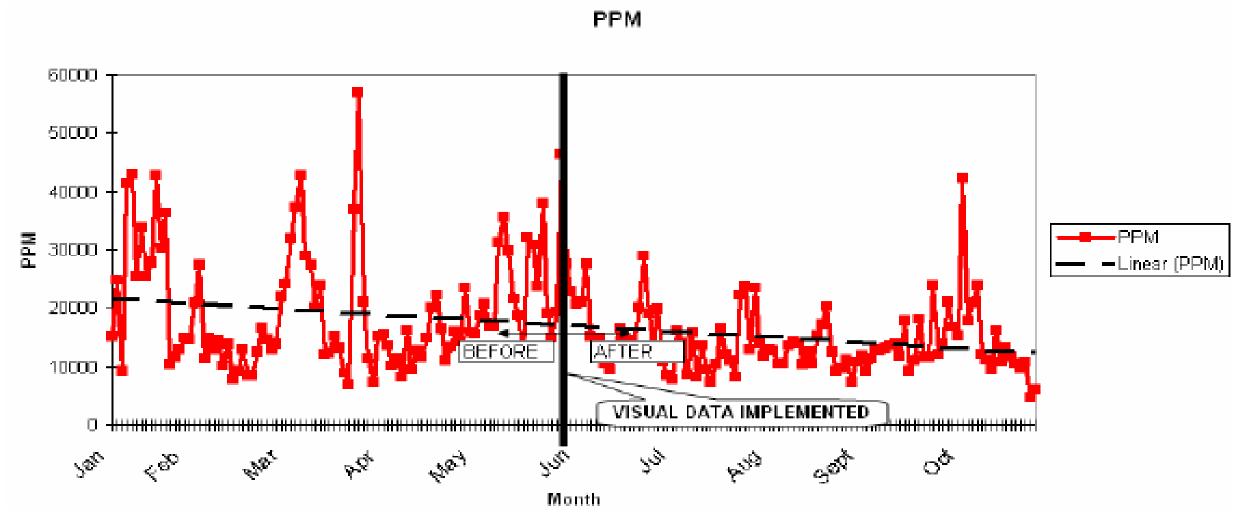


Figure 5. Line graph of PPM over ten months

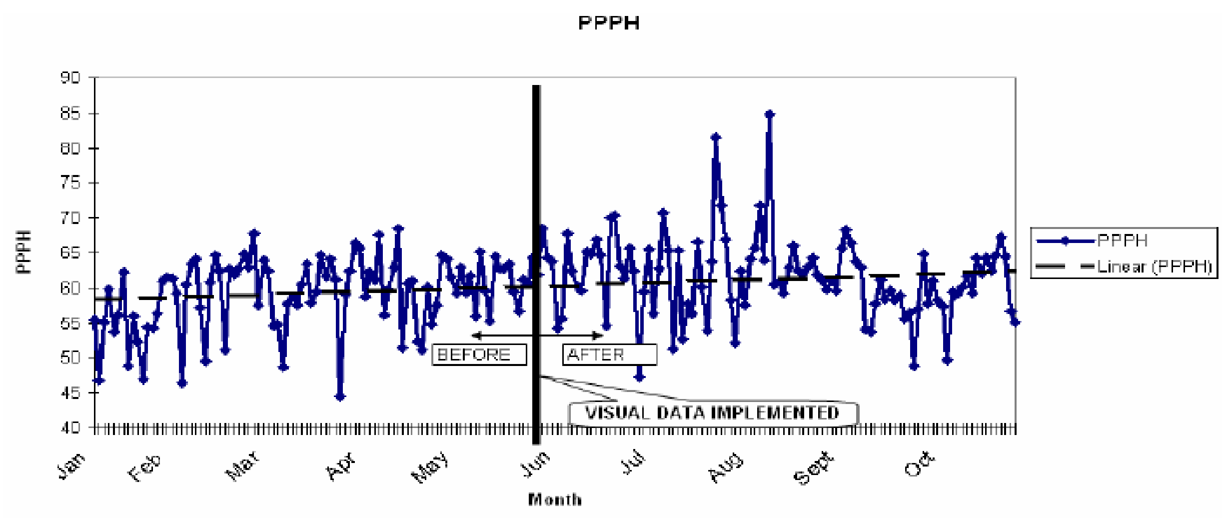


Figure 6. Line graph of PPPH over 10 months

The t-test resulted in a p-value of .0000, so the null hypothesis was rejected at the 95% alpha level. For the second hypothesis, if visual data (PPPH chart) was used for productivity, then the productivity would significantly increase (parts produced per person per hour will increase). The data yielded a mean PPPH of 59 and a mean PPPH of 62 before and after the visual data implementation, respectively. The t-test resulted in a p-value of .003, so the null hypothesis was rejected at the 95% alpha level (Figure 7).

For this production line, the average PPM was reduced by 30% and the average PPPH was increased by 5% through the use of visual data. The use of visual data has increased quality and productivity for this high-volume automotive components production line. Having the data posted visually by the line has also helped the production line workers understand the production status in terms of production goal. Having this understanding, the production line workers can make adjustments to their work as necessary. The visual data also served as a reminder to the production line workers of what the goals were. For line workers, valuable time is usually wasted looking up data manually[4]. Visual data that are presented correctly requires less time to interpret by the line workers.

Paired T for Before PPM - After PPM

	N	Mean	StDev	SE Mean
Before PPM	*96*	*20102.3*	*10330.9*	*1054.4*
After PPM	*96*	*14131.3*	*5494.7*	*560.8*
Difference	*96*	*5971.01*	*10889.54*	*1111.41*

95% lower bound for mean difference: 4124.90
T-Test of mean difference = 0 (vs > 0): T-Value = 5.37 P-Value = 0.000

Paired T for Before PPPH - After PPPH

	N	Mean	StDev	SE Mean
Before PPPH	*96*	*59.3646*	*5.2035*	*0.5311*
After PPPH	*96*	*61.5313*	*5.9435*	*0.6066*
Difference	*96*	*-2.16667*	*7.46736*	*0.76213*

95% upper bound for mean difference: -0.90072
T-Test of mean difference = 0 (vs < 0): T-Value = -2.84 P-Value = 0.003

Figure 7. Statistical analysis of data

Cost Analysis

The cost savings was calculated as follows. The average PPPH (parts produced per person per hour) was increased by 5%, which results in approximately 500 more parts produced per day by each person. Each part has approximately $.25 of labor cost, so in one day $125 is saved. Assuming 251 working days per year, the estimated annual cost savings of $31,375 for each worker is $ 31,375 (Figure 8).

Cost Analysis

A	D	C-AXD	D-25' XC
Increase in parts produced per day	**Labor dollars per piece**	**Dollars saved per day**	**Dollars saved per year***
500	$ 0.25	$ 125	$ 31,375

*Assume 251 working days per year

Figure 8. Cost Analysis

Summary and Conclusion

This project took place at a high volume automotive manufacturer and may not necessarily be generalized to low-volume and/or non-automotive manufacturers. The production line involves mostly manual work, and this project may not necessarily be generalized to highly-automated production lines. The following assumptions were made for the study. The knowledge and skills of the production line workers did not change during the study period. The data was valid and entered correctly by the production line workers. Also, the component shortages, machine downtime, and external part quality issues are consistent during the period of the study.

The average PPM was reduced by 30%, and the average PPPH was increased by 5% for the production line. Through the use of visual data, these are encouraging results for the production line and the automotive components manufacturer. The use of visual data has increased quality and productivity for this high-volume automotive components production line.

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