Application for VCC Quality Award

Improvement project:

Process control of sheet metal material in deep draw operations

Unit: Volvo Cars Body Components, Volvo Car Corporation

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Team members:

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Martin Carlsson	Operator, Line 51 Uniside
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Tommy Berntsson	Operator, Line 54 Roof
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Purpose of the improvement project:

1. To reduce rework of Uniside panels by determining optimum values for process control variables in the deep draw operation in Line 51.
2. To establish the optimum values for process control variables in the deep draw operation for Roof panels in Line 54 by applying the results of our work with Line 51, since Line 54 and Line 51 have similar processes.

Description of the improvement project:

In 2006 the variation in the quality of the Uniside panels produced in Line 51 sometimes made it necessary to send up to 70% of the panels to rework. Dents, press lines and cracks were a constant reality and it could take hours to adjust the deep draw operation. A cross-function Team headed by a 6-Sigma Black Belt was created to study the problem. The Team soon realized that the blank washing process step prior to the deep drawing operation was not under control and that the process control variables were not correctly identified. Working with the existing process in a methodical manner, using small, low-budget changes and gathering information from rejection reports and equipment suppliers, the Team identified the relevant process control variables and determined the optimum values for these variables. A new Data Logging System has also been created by the Team to enable constant fine adjustment of the process and to ensure continuous follow-up.

Today the process consistently produces panels in the correct quality. Rework is almost eliminated. The knowledge gained in the study of Line 51 has now been applied to controlling the process variables in the deep draw operation of Roof panels in Line 54, and will soon be applied to the process control of the deep draw operation of Front Fender panels in Line 52. Similar tremendous savings as achieved in Line 51 are expected.

1. Choice of improvement project

The deep draw process is the most critical step in the stamping process. The deep draw operation is a complex process since it is dependent on several factors, including:

1. Surface quality and function of the deep draw dies
2. Function of the press
3. Quality of the sheet metal material
4. "Hygiene" of the sheet metal material, in other words how clean and free from pollutants the sheet metal blank is when it enters the die
5. Amount of lubricant present on surface of the sheet metal blank when it enters the die
6. Distribution of the lubricant over the surface of the sheet metal blank as it enters the deep draw die

It can be seen from factors 4,5,6 that the success of the deep draw operation is extremely sensitive to the function of the washing unit that cleans and lubricates each sheet metal blank before the blank is loaded into the die. Thus, the variables that govern the washing process must be correctly identified in order to control the deep draw process. Once they are identified, the correct values must also be established for these variables.

This project was chosen because extensive and unstable variation in the quality of the Uniside panels produced in the deep draw operation in Line 51 could result in press runs where up to 70% of the panels had to be reworked. Downtime was high and productivity poor. Human resources both on the line and in the rework department were being utilized in an inefficient manner. The situation was precarious and completely unacceptable.

Line 51 is an XL press line (156 inch) with a weekly production of approximately 25,000 parts manly Uniside panels. It runs on a 5 day shift basis and is the mail line for producing large complex parts. It is the most critical line in that if there is a breakdown the panels cannot be stamped in any other line and external resources must be purchased. Correct quality in these complex exterior car body panels is also extremely important from the standpoint of rust protection since rework reduces rust protection. If the process variables can be controlled so that the produced panels meet the quality specifications with no or only little rework, very substantial savings can be obtained. Line 51 also contains equipment, especially the washing unit, which is expensive to repair or replace. If this equipment can be used more efficiently to reduce wear and replacement, additional substantial savings can be gained here also. For the above reasons, Line 51 was considered as the most valuable choice for an improvement project.

How the improvement project is oriented to customer needs

Internal customers:

- Decreased costs for extra material to replace scrapped panels.
- Quality assured with little or no rework.
- Improved delivery precision.

External customers:

- Reliable rust protection and high surface quality.

2. How we have worked as a Team:

The cross-function approach to deciding the members of the Team has resulted in very successful cooperation and stimulating exchanges of different types of expertise. Having a 6-Sigma Black Belt as the Team Leader has also been very positive and has provided several key opportunities for all the members to test 6-Sigma strategies. Team members learned hands-on about 6-Sigma systematization, which has been utilized to verify and sustain each achieved improvement.

Even though the initial emphasis was on Line 51, it was important to have Team members from Line 54 so that Team activities could also be directed toward implementation of the results in Line 54 (and further in Line 52) to achieve sustained improvements in these Lines.

How the Team used Innovative Thinking

The Team put strong emphasis on finding the root cause of the extensive quality variations in the stamped Unisides, instead of simply continuing to work with the mechanical adjustment of the dies*. Innovative Team thinking in looking for root causes resulted in:*

- *The Team began to focus on understanding the washing/lubricating process step prior to the deep draw operation.*
- *The Team created a Data Logging System to collect and manage process data as well as to follow up and verify process trends.*

The Team studied more closely both the washing equipment and process variables in the washing/lubricating step. Benchmarking was tried but was found to be a poor alternative with no results, since there is no other car manufacturer that uses hot-dipped galvanized steel for Uniside or Roof panels. Trade fairs were checked and the Team contacted several suppliers of washing/lubricating equipment. Finally one equipment supplier was found who was interested in working in a 6-Sigma environment to develop the equipment for washing/lubricating. After a period of tests and evaluations of oil-cleaning filters and centrifuges, the Team came to several surprising conclusions, leading to more innovative tests, solutions, and applications, as described in Section 4 below.

How the work has been divided among the Team

In our Team we have used a follow-up action plan. For each item a responsible person was assigned depending on competence, profession, and experience. This resulted in that our Team became a strong, enthusiastic group with an enormous drive to improve.

How Team members have supported each other

Via our Team Meeting Report all actions are followed up, when extra help has been needed the tasks are divided among the Team, or extra resources are approached. In the meantime an excellent continuous communication based on accurate facts and figures has been established. All this has resulted in that the Team has developed both an inspiring team spirit and a resolute will to improve.

Team competencies and empowerment

The Team has a range of diverse competencies:	**D**	**M**	**A**	**I**	**C**
Engineering Manager	X				X
Die engineering / Quality Support (Customer contact)	X	X	X	X	X
Maintenance Supervisor	X		X	X	X
Six Sigma Black Belt.	X	X	X	X	X
Production Personnel.	X	X	X	X	X

Team responsibility for the improvement project

The Team has had full responsibility in this improvement project. All Team members have participated with commitment and creativity. Not only have we together defined the

problems and tasks but also contributed different ideas, initiated improvements and tested different solutions.

One of the innovative results of our Team responsibility and commitment is that as a Team we have created the Data Logging System that assures continuous follow-up and fine adjustment of the optimum values for the process control variables established and verified by the Team.

3. Use of Problem Solving / Quality Tools

DMAIC	Tools	Purpose
Define	Process maps	Process visualization.
	Brainstorming	Determine all possible causes
	Cause and Effect Matrix	Scope the project
Measure	Feedback from customers via Rejection Reports	Determine costs
	Data collection	Determine amount of rework
	Data collection	Determine costs
	Data collection	Determine amount of oil on panel (g/m^2)
	Data collection	Determine oil consumption
	Data collection	Determine oil distribution
	Data collection	Determine line downtime
Analyse	Pareto	Define priorities
		Identify causes
		Identify checkpoints
Improve	Brainstorming	Gather ideas
	Process maps	Visualise Improvements
Control	Control plan	Check oil amount on blanks
	Control plan	Follow up Rejection Reports
	Control plan	Follow up on rework

A new **Data Logging System** was created by the Team as an integral part of the Control Plan, to provide continuous direct input for controlling the process. The Data Logging System ensures objectivity in determining optimum values for the process control variables.

4. How the Primary Cause of the Problem has been solved

The majority of the Volvo Unisides are stamped in Line 51. The sheet metal blanks for the Uniside are normally hot-dipped galvanized steel. Car body parts that are stamped in hot-dip galvanized steel provide several advantages over the electro-galvanized steel used by other car makers. Using hot-dipped galvanized steel to produce car body parts:

1. Provides better profitability since hot-dipped galvanized steel is cheaper to purchase
2. Results in higher process reliability since hot-dipped galvanized steel has better stamping properties
3. Gives Volvo customers a much better product regarding rust protection since hot-dipped galvanized steel has better inherent rust protection properties
4. Provides produced parts with better adhesive properties.

However, one disadvantage of using hot-dipped galvanized steel is that some zinc from the galvanization can contaminate the stamping process. This contamination places great demands on the washing step prior to the deep draw operation. The washing unit for cleaning and lubricating the sheet metal blanks uses special, relatively viscous oil (23 centistokes). Both cleaning and lubricating are carried out in the same machine. This means

that the machine components must be maintained to assure both the cleanliness of the blank and the purity of the lubricating oil since these are critical factors in the success of the subsequent deep draw operation.

Up until the present Improvement Project, the method to ensure the cleanliness of the blank and the purity of the lubricating oil has been inefficient and misunderstood and even resulted in completely unnecessary costs. The Team formulated a solution that inexpensively and efficiently cleans the zinc from the washing process so that it does not contaminate the subsequent deep draw operation, see the table below. **Note:** Each result in the table is not always the final result but may have had to be studied and tested again to achieve the final successful result. See under the proposed *Next step*.

Solutions implemented by the Team and the Results

	Before Improvement Project	**Solution formulated and implemented by Team**	**Result / *Next step***
1.	Relatively viscous oil (23 centistokes) used for lubricating the blanks.	Use same oil. Change oil filter density.	Difficult to purify the oil. Provides better stamping properties. *Improve cleaning solution.*
2.	Oil flow at 0.1 rotations of the faucet.	Installation of return pump and oil flow at full strength at 4.8 rotations.	Cleaner blanks but too much oil, resulting in friction too low in deep draw operation = dents and overdraws in panel. *Adjust oil flow to provide better friction.*
3.	Two drying rollers (textile type 3M) changed every 3-4 months at a re-coating cost of SEK 100,000 per roll because pores on rollers are contaminated by zinc and pollutant particles. First filter is 60µ steel net filter. Second filter is 25µ PAL filter.	First filter of 60µ steel net is retained. Second filter is changed to 10µ PAL filter.	Filter change frequency increased from 3 per year to unacceptable 26 per year (SEK 1086 per filter and 15 are needed). *Find new solution to support use of 10µ PAL filter (see Point 4 and Point 5).*
4.	Poor efficiency of washing/lubricating unit	Install centrifuge borrowed from Triple R Europe (originally for hydraulic fluid in closed system)	800 grams of dry sludge extracted consisting of over 80% zinc. *Put centrifuge in service. Decrease the change frequency of PAL filters.*
5.	*Extra solution to support use of 10µ PAL filter*	Change first 60µ steel net filter to 25µ steel net filter. (Test from W736)	Decreased change frequency of PAL filter.

6.	Continued improvement	Install additional by-pass system with a *1µ filter and a flow of 1.8 L/minute*	200-300 gram zinc extracted each week.

5. Description of the Achieved Results

Summary of Savings for LINE 51

	During Improvement Project	Achieved Results (SEK)	Savings for Line 51 (SEK)
1.	Centrifuge installed. Extra by-pass system installed.	Rollers in washing unit - change frequency decreased from 3 times/year (3 x 400,000) to 1 time per18 months (current rollers still in use)	933,336 / year
2.	Filter densities adjusted	Decrease change frequency for PAL filters from every 14 days to 2 times per year (SEK 16,290 x 2)	373,020 / year
3.	More efficient washing process	Oil consumption reduced from 9 oil changes a year (1000 L/time) to one time per year	216,600 / year
4.	Improved cleaning and re-use of lubricant	Recycled oil: 7000 L X SEK 163,800 (yr 2007)	1,379,556 / year
5.	Time required to change dies for new press run (Line downtime) decreased from average 3-4 hours down to 20 minutes	Line downtime = 20,000/hour 3 hrs x 20,000 = 60,000 60,000 x 8 Unisides = 480,000 480,000 x 44 weeks (1 year) = 21,120,000	21,120,000 / year
6.	**SUB-TOTAL for LINE 51**		**SEK 24,022,512 / year**
7.	Used oil that has been waiting for disposal has instead been cleaned and is ready for re-use	Environmental savings (once only year 2007)	+ 63,800
8.	Purchase of centrifuge in 2007 from Triple R Europe	Process stability	- 328,000
9.	**GRAND TOTAL for LINE 51**		**SEK 23,758,312 first year SEK 24,022,512 year ongoing**
10.	Washing process control variables identified and optimum values determined	**Process stability/reliability** = consistent, superior quality of Uniside panels in Line 51	Hundreds of hours freed up in human resources at Rework Dep't

- The savings stated above will be only slightly lower in Line 54 (Roof) and Line 52 (Front Fender), *thereby significantly increasing the overall savings*.
- As of W816, Line 54 has reduced its rework % from 80% to 5%. Implementation of the improvements in Line 52 is scheduled for W817.

Impact on Volvo Cars Common Agenda

CS#1: (High+)
- External customer receives the specified quality
- Customer receives rust protection that is superior to competitors
- Internal customer receives specified quality with no delays.

Profitable Growth: (High)
- Low-budget improvement project proven as being able to result in outstanding savings.

Next Generation of Cars: (High+)
- Use of hot-dipped galvanized steel material is assured for future car models (cheaper + better stamping properties than electro-galvanized material)
- Large panels with complex surfaces (e.g. Uniside, Roof, Fender) can be planned in hot-dipped materials with no concern for major rework %.

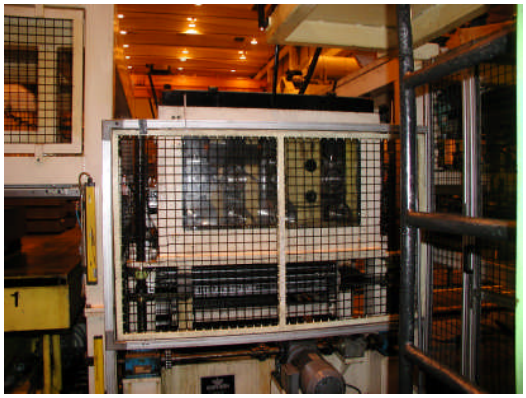
Next Generation of Managers and Employees: (High)
- Increased bank of knowledge of process control in deep draw operations
- Sophisticated use of 6-Sigma strategies spread throughout all levels of company

6. How the Results are Sustained

The results of the Improvement Project are sustained by the following:

1. The Control Plan created by the Team for a) measuring oil on the blanks, b) following up Rejection Reports, and c) following up rework %.
2. The new Data Logging System created by the Team for documentation of the collected data and the different fine adjustments to the process.
3. The new knowledge gained in the Improvement Project regarding process control of deep draw operations is now shared at several different levels in the company.

LINE 51



Washing unit for washing and lubricating blanks in Line 51

Centrifuge installed in Line 51