



Illustration 1 – University of Wales Trinity Saint David Logo (UWTSD, 2024)

University of Wales Trinity Saint David

School of Engineering

Failure Mode and Effect Analysis of Jaguar Land Rover Sub-Assemblies

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Material Sciences

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Engineering Application and Study Skills ACMA4007

1. Literature Review	4
2. Discussion	5
3. Conclusion.....	9
4. References	10
5. Appendices.....	11

Introduction

The aim of this report is to show how the use of Process Failure and effect analysis (PFMEA) can be effective in identifying quality concerns that may arise in a manufacturing environment. Through the use of PFMEA and knowledge of management systems introduced by Toyota in the 1940s, a reduction in customer complaints can be achieved in a cost-effective manner.

This report will show how engineers at GESTAMP reduced customer complaints from Jaguar Land Rover by understanding the risks associated with the standard operating procedures being used at the time. Using an PFMEA, engineers were able to detect which high risk practices needed to be addressed at the highest priority.

1. Literature Review

The PFMEA carried out was a group project. In his academic journal, Hector H. Guerrero (2013) explains the advantages of using a group of various stakeholders with differing backgrounds in PFMEA as opposed to an individual. Group projects were found to have improved results in both cost efficiency and a reduction in failures.

One of the aims of the PFMEA carried out was to achieve continuous flow in the manufacturing process as recommended by Jeffrey K. Liker (2004). Liker explains that there are fourteen principles in The Toyota Way which need to be adhered to for a process that reduces waste through factors like unnecessary actions, quality defects and levelling out of the workload.

2. Discussion

After repeated customer complaints from Jaguar Land Rover (JLR) about failures on the HTML bracket it was decided that a PFMEA was to be conducted at Gestamp. It was established that an FMEA should have been used during the design process which could have had a significant reduction in customer complaints.

Senior Process engineer Alan Kovacs would oversee the PFMEA that was to be carried out by Stewart Newson. A team was put together consisting of Alan Kovacs from engineering, Stewart Newson from the quality department, John North the maintenance manager and John Miles the assembly shop manager from production.

After the conclusion of the PFMEA it was established that the priorities needed to be addressed were the issues with parts being sent to JLR without the correct sized nuts attached (RPN 108) or without the correct number of nuts attached (RPN 81). The HTML bracket built in Gestamp is used to connect two parts of the chassis for the Land Rover Evoque. Failures on these parts not discovered during quality checks at JLR could result in vehicles being unsafe to drive. For this reason, all weld failures and problems with M8 nuts were scored a 9 for severity.

To reduce the frequency of the wrong sized nuts being sent to the customer (RPN 108) it was decided that an M8 specific nut feeder would be added to the assembly line. The previous process was for the operator to pick up two nuts from a box and place them on a jig before using a foot pedal to engage the pedestal welder. Boxes of nuts were segregated on site, but cross contamination still occurred. It is a possibility that nuts were mixed from the supplier. The improved process would be for an M8 nut feeder to be added to the pedestal welder which would stop the welder from working if the wrong sized nut was detected. With the nut feeder added the occurrence of failure score improved from 4 to 1 and the detection of failure score improved from 3 to 2 as shown in Figure 1.

Figure 1

108	Add nut feeder to assembly line	J North by 18/10/21	M8 nut feeder added to assembly line	9	1	2	18
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The potential failure with the second highest score (RPN 81) was the parts being sent to the customer with one or both nuts missing. To improve this process a poke-yoke was added to the assembly line. A Poka-Yoke is a mechanism that is added to a process to that helps an operator avoid (yokeru) mistakes (poka). The concept was introduced by Shigeo Shingo (1988) as part of the Toyota Production System.

The Poka-Yoke added to the process requires the machine operator to place the finished part on to a jig with two sensors to detect the presence of both nuts. After the pedestal welder completes two welds a red light flashes on the Poka-Yoke which prevents the welder from activating again. When both sensors on the jig are engaged the red light turns green and the welder becomes active again. If the sensor picks up that one or both nuts are missing, an alarm sounds which can only be switched off by a maintenance engineer. Adding a Poka-Yoke to the line reduced the RPN from 81 to 9 as shown in Figure 2.

Figure 2

81	Add Poka-Yoke	J North by 18/10/21	Poka-Yoke added	9	1	1	9
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The process issue with weld failures was shown to be the third most likely process failure. Parts from the press shop would sometimes come in with excess oil on the parts which would spark when heat was applied by the welder. It was established that removing oil from the parts would be difficult due to the age and condition of die tools in the press shop. Replacing them would not be cost effective when another solution could also reduce the likelihood of failures without the company purchasing new and expensive dies. The solution implemented was so introduce non-destruct weld testing on every 250 parts. Quality technicians remove parts from the line during assembly and use a torque wrench to apply pressure to the M8 nut to ensure weld integrity. This is the same process used at JLR to check parts supplied to them before they are built into their cars. This change in the process resulted in a reduction of RPN from 54 to 9 as shown in Figure 3.

Figure 3

54	Non destruct weld test in process every 250 parts	A Kovacs to arrange with quality dept to check weld integrity by 18/10/21	Quality tech removes part from the line and torque tests the weld	9	1	1	9
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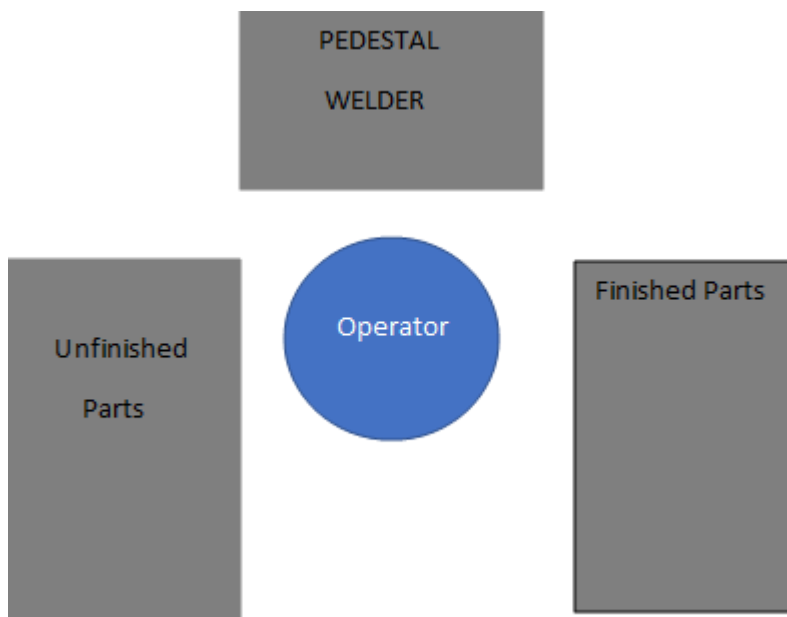
Another issue with the process identified during the PFMEA was the failure to pick up form defects during the assembly process. The severity of this failure was scored as a 7. The justification for this lower score was due to the efficiency with this fault being noticed at JLR before the part being built on to the car. Splits in the parts should be easily noticed during the assembly build so the detection score of 2 was given. To reduce the risk of this failure occurring it was decided that operator training would take place to recognise form errors on the part both in the press shop and in the assembly shop during the build process. Operators are now required to tick the face of the part where the form error occurs with a permanent marker to show the face has been checked. When the finished parts are checked in the fire wall before packing, they are ticked again with a different colour marker. These amendments to the process reduced the RPN from 28 to 14 as shown in Figure 4.

Figure 4.

28	Operator training. Finished parts to be ticked with marker	J Miles to arrange operator training with team leaders by 18/10/21	Operators trained to spot form errors during inspection.	7	2	1	14
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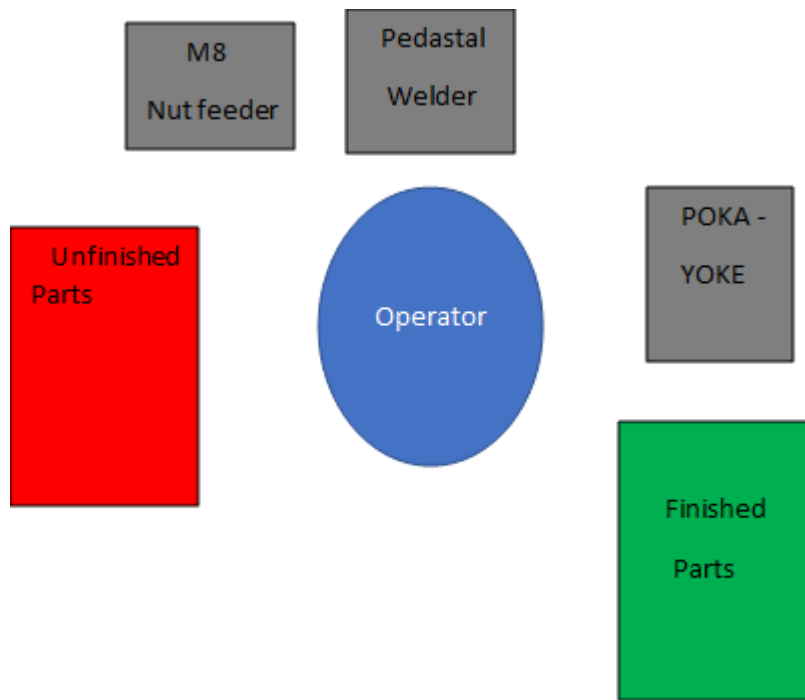
The issue with the lowest risk identified with the PFMEA was the potential for unfinished parts to be sent to packing before being built. Process for assembly before PFMEA is shown in illustration 2.

Illustration 2



Process for assembly build after PFMEA as shown in illustration 3

Illustration 3



Unfinished parts brought to the line from press shop are now only to be moved in a red pallet and finished parts are now only to be moved to packing in a green pallet. This improvement in the process resulted in RPN being reduced from 12 to 4 as shown in Figure 5.

Figure 5

12	Process redesigned. Segregate goods in and goods out. Unfinished parts put in red pallets	A Kovacs and S Newson to redesign process flow by 18/10/22	Process redesigned	2	1	2	4
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3. Conclusion

The use of PFMEA at Gestamp was deemed a success due to the reduction in quality concerns reported from JLR. The PFMEA was to be used as a live document which would be updated after every customer complaint. The PFMEA would now also be used as a tool in the design stage of future assembly lines introduced in Gestamp.

4. References

Guerrero, H.H. and Bradley, J.R., 2013. Failure modes and effects analysis: An evaluation of group versus individual performance. *Production and Operations Management*, 22(6), pp.1524-1539.

Liker, J.K., 2004. The Toyota Way 14 Management Principles from the World's Greatest Manufacturer.

Shingo, S., 1988. *Non-stock production: the Shingo system of continuous improvement*. CRC Press.

Shimbun, N.K., 1989. *Poka-yoke: improving product quality by preventing defects*. Crc Press.

5. Appendices

Personal Development Plan				
Name – <u>Stewart Newson</u>				
Degree – <u>BEng (Hons) Material Science</u>				
Previous Qualifications –				
Previous Experience – <u>Manufacturing, Quality/Lab Technician</u>				
Goal	Objective	Resources Required	Measurement	Target Date
Engineering Degree	Complete 4 year course at university to achieve a degree in Material Sciences	Attendance at lectures on a Friday afternoon	Passing Modules	Review progress every term
Higher salary	Promotion and/or progression at work	Apply for training courses provided by work through Bright HR	Higher pay, more responsibility at work	01/01/25
Improve use of ICP at work	Make myself invaluable at work by learning to use machines and processes where we have a skills gap	Approach HR and Lab manager to explain the benefits to the company of helping me become multiskilled	Trained or starting to be trained how to use ICP	01/06/24
Quit Smoking	Save money and improve health	Follow up with NHS Wales about getting help to quit	Go a month without smoking, then two months	01/06/24

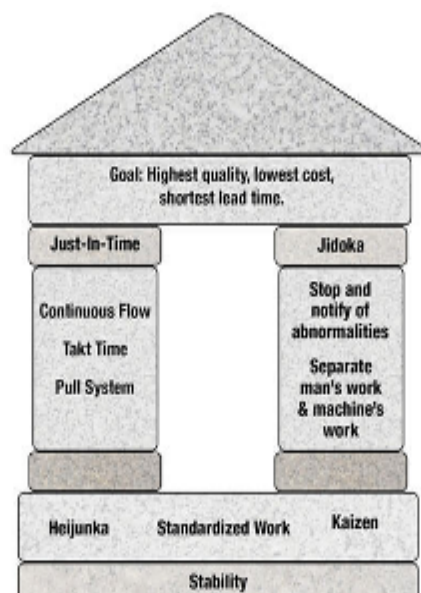
How PFMEA can ensure efficiency based on the Toyota Production System

Stewart Newson

Bhng (Hons) Material Science

Introduction

The motivation for this poster is to give a summary of the benefits of using FMEA to identify the risks for process failures in a manufacturing environment.



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THE TOYOTA W & BOOK SUMMARY BY JEFFREY A. LIKER

The use of PFMEA at Gestamp was deemed a success due to the reduction in quality concerns reported from JLR. The PFMEA was to be used as a live document which would be updated after every customer complaint. The PFMEA would now also be used as a tool in the design stage of future assembly lines introduced in Gestamp.

Influences

The Toyota Production System - A production system based on the philosophy of achieving the complete elimination of all waste in the pursuit of the most efficient methods

Poka-Yoke – Improving product quality by preventing defects. Book by Nikkan K. Shimizu

PFMEA IMPROVEMENTS

RPN BEFORE PFMEA	RPN AFTER PFMEA
108	18
84	9
28	14
54	9
12	4



FMEA LOGO FROM VECTOR IMAGES

Summary of Key Findings

The FMEA showed how the introduction of systems popularised by Toyota could reduce waste in production lines in Gestamp. These systems included;

- The use of Poke-Yoke
- The use of pull systems
- Kaizen (continuous improvement)
- Hansei (relentless reflection)

References

- Shimizu, N.K., 1989. Poka-yoke, improving product quality by preventing defects. Car Press.
- Olson, A.P., 2019. A study of the Toyota production system: From an Industrial Engineering Viewpoint. Routledge.
- Srinivas, R., Subramanian, K., Ramdas, C., Reddy, S., Subramanian, R., and Chen, C., 2010. A modified FMEA Approach to enhance reliability of team systems. International Journal of Quality & Reliability Management, 27(7), pp.832-845.

