

Will a poka-yoke system be the answer to customer concerns?

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Gestamp

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Abstract

Jaguar Land Rover reported a mix up of parts at their production line. It was the responsibility of the New Product Introduction team to react to the issue. The quality engineer conducted an 8D investigation as part of a team. The aim was to establish the root cause and implement corrective actions. The time frame of the project was recorded by the project manager initially before the manager's departure. The quality engineer took charge of the situation to ensure the completion of the project. The corrective action was to implement a poka-yoke bar with the help of an external company. The purpose of this corrective action is to prevent the loading of wrong parts. The bars have been trialled, tested and approved by the customer and since implementing the bars, Gestamp have not received any concerns from Jaguar Land Rover (JLR).

Non-disclosure agreement

By signing this non-disclosure agreement, I hereby agree to keep the contents of this report confidential between Coleg Sir Gar and Gestamp.

Lecturer: John Williams (on behalf of Coleg Sir Gar)

_____ Date: _____

&

Author: Marcus Thomas (on behalf of Gestamp)

_____ Date: _____

Company background information

Gestamp are an automotive Body in White and chassis manufacturer who supply parts to Original Equipment Manufacturer (OEM) brands such as Jaguar Land Rover (JLR), Aston Martin and Bentley.

Gestamp's vision statement is "Working for a safer and lighter car" (Gestamp, 2020) which they support by investing in the latest manufacturing processes such as hot stamping. This process improves the hardening of the metal. Gestamp is the largest global supplier of hot stamping parts (Gestamp, 2020).

Gestamp helps make a safer and lighter car by introducing safe zone technology into panels. This allows controlled crumpling of parts if there was to be a collision, henceforth making the car safer. Improvements in the weight of the car occurred via the introduction of boron steel in the production process.

Gestamp employees are responsible for maintaining high standards of quality assurance and aim to improve our reputation as a tier one supplier. Factors that can improve the company's reputation include:

- ❖ High quality products,
- ❖ Rapid response to customer concerns,
- ❖ State of the art facility,
- ❖ Trained workers.

To ensure high standards of quality, Gestamp offers all their workers the necessary training to be competent in their job role. They also have a system that encourages employees to follow a "stop-call-wait" procedure. This means that the worker who spots a potential fault should stop what they are doing, call a team leader and wait for their response.

One of the company's high standards is their zero defects policy. This means that the customer should not have any concerns with the finished good. As it stands, we are receiving customer concerns daily. Some concerns can be eliminated without substantial investment e.g. by designing a preventative process rather than a reactive process.

An example of a prevention process is a poka-yoke. This is a fool-proofing process that tries to minimise the likelihood of errors occurring. This project aims to assess the importance of introducing poka-yoke systems in the workplace.

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Introduction

In this report, I am going to be discussing common problems within the Gestamp business from a quality perspective. The focus will be on the packaging of finished goods. With a specific emphasis on preventing the mix of left and right hand parts in a pallet.

Early 2019, Gestamp received a complaint from JLR that the parts had been sent to them in the opposite pallets. This meant that the parts on the assembly were on the wrong side of the conveyor in production. Therefore putting the line on stop and delaying the production of their cars. The result of this was an immediate visit from engineers of JLR. Meanwhile, Gestamp conducted an 8D investigation to find a method to prevent a recurring issue.

Kaizen is a famous approach to problem solving that strives for continuous improvement. Ultimately, the manufacturer aims for zero defects with a Kaizen methodology. Simply, Kaizen could be interpreted as a “learn-by-doing” model. The manufacturer performs regular process audits to maintain high standards sustainably. As part of the continuous improvement, the manufacturer would record learning outcomes from a fault and reflect on how to improve the process. A poka-yoke system fits in a Kaizen methodological approach.

A poka-yoke is the result of continuous improvement to try and foolproof the manufacturing process. To evaluate the cost of faults, one might consider that problems at the production line of the manufacturer will incur unexpected expenses through downtime and corrective labour cost for the customer. Therefore, it is in the manufacturer’s best interests to prevent any delays to the OEM’s production process.

The number of concerns before and after the implementation of the poka-yoke is of interest. This will give an indication of the effectiveness of implementing poka-yokes. Beyond being effective, implementing poka-yokes might not be worth it financially. Therefore, there will be a comparison of the cost of introducing a poka-yoke against the cost of the customer concerns. It might not be in the interest of the manufacturer if implementing poka-yokes is not cost-effective, depending on their attitudes to maximising profits.

The methods used in this study will consist of qualitative data from case studies, as well as quantitative data to evaluate concerns, efficiency and costs. In this research, there will also be a focus on lean manufacturing techniques such as “Five Why’s” and the 8D investigation.

The purpose of researching the issue is to find out the scale of the problem. This means finding how many parts are affected, has this happened before and have the learning outcomes been recorded as part of the lessons learned policy. If the problem has not happened before then the issue must be isolated to a single root cause by working backwards through the process from the customer

concern to Gestamp delivering the parts, back to the operators assembling the parts on the line. Once each process has been monitored and researched, the data collected should be shared in the 8D meeting to identify changes in the process and aspects that need improving.

Objective

To critically analyse information from a range of sources, and demonstrate an understanding of different types of research methods, and the applicability of them to propose a solution to engineering issue in the workplace.

The objective of this report is to investigate the effectiveness of a poka-yoke in the workplace and to orchestrate the installation of poka-yokes to improve customer satisfaction and confidence. Also, a literature review will need to be carried out to show the stages undertaken to complete the project and the range of techniques and sources used to come to an overall conclusion to prove whether it was a success.

Importance

The importance of adopting a poka-yoke system is that it increases the efficiency of quality checks (Shingo, 1986) and requires minimum training as an operator. By error proofing the process, the customer can rest assured that there will be zero concerns with their order.

Sources of information

Primary and secondary sources

Primary and secondary sources are two sources of information that are instrumental in proving the validity of research in a report:

- ❖ Primary sources include the raw data gathered from my own research or investigation i.e. surveys, results of experiments in the form of statistical data or a written report, and the secondary sources include the data gathered by other people i.e. journals, customer feedback, articles.
- ❖ The secondary sources of information include customer feedback reports and case studies. The customer feedback will help delve directly into the areas that they deem high and low priority. By tackling issues when they arise, Gestamp can strengthen their relationship with the customer. In the long-term, this should nurture more investment.

The problem

Jaguar Land Rover (JLR) reported a mix up of parts in dedicated left and right hand pallets. The result was that their production line was on stop whilst the issue was resolved. The production line at JLR is timed so that the parts are supplied to the line-side as soon as the corresponding car is ready. The issue for JLR was that they did not know the scale of the issue, so any incurring expenses concerning sort and rework billed to Gestamp.

JLR sorted and used all the stock that they needed and any remaining shipped back to Gestamp Llanelli for sorting. The process at the time of the issue was that the parts get loaded into the corresponding pallets with the part variant identified by writing on the pallet. The issue with this is that it does not prevent the operators loading the wrong parts. To help the operators in times of uncertainty the process needed to be improved to protect the company from further concerns.

The standard procedure for responding to a customer concern at Gestamp is to follow the 8D investigation method. An 8D is a reactive process that helps identify a problem, find the root cause, establish potential solutions and implement the corrective actions (Riesenberger & Sousa, 2010).

Literature review

Methods

The purpose of a literature review is to explore different avenues to make the study as comprehensive as possible with comparative data from various sources to confirm or deny initial assumptions as facts.

The research in this report will be supported by information gathered from credible sources such as journals and professional websites.

The research carried out will not be exaggerated, the author will be given full credit for their intellectual property, and the author of this report will remain unbiased throughout to identify the facts.

The main focus of this literature review is to focus on customer satisfaction. This will be done by investigating the use of poka-yokes and how they reduce the number of concerns.

There are numerous principles within the lean manufacturing methodology that would aim to identify the root cause of the problem and propose solutions, such as Ishikawa, Pareto, Kaizen, and Mistake Proofing.

Ishikawa uses what is known as a fishbone diagram to illustrate the categories of potential causes i.e. tooling, machinery, work force, finance, quality, etc. This method is effective for identifying causes and providing reasons.

The Pareto principle states that 80% of the problems are caused by 20% of causes. Knowing this the qualitative data collected can be used to help focus the attention to the causes rather than the effects for long-term gain rather than short-term gain.

Kaizen is also known as continuous improvement, which encourages small changes to improve the business to benefit the business massively. This system can be applied to the production line by communicating with the worker to find common faults or obstacles.

Mistake proofing which is also known as a poka-yoke system is used as a preventative measure to eliminate mistakes by installing a process that physically will not allow the wrong product to be passed onto the next station.

The process flow for implementing a poka-yoke for the problem discussed above can be seen in Figure 1.

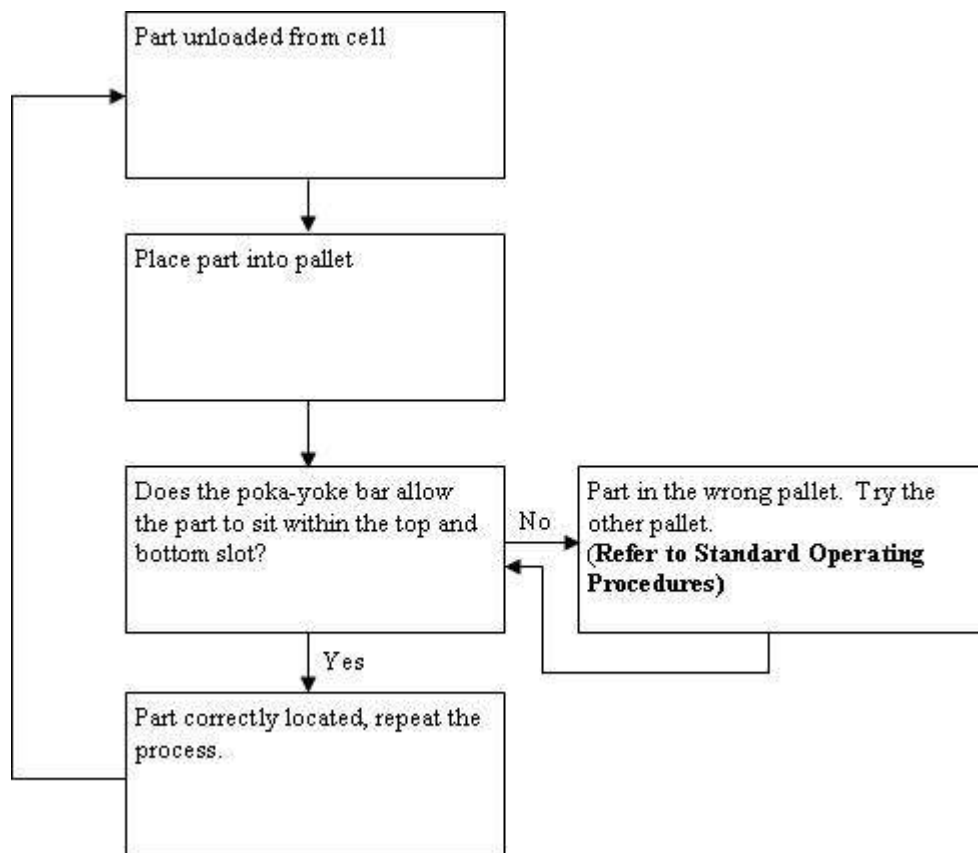


Figure 1 – Poka-yoke process flow diagram

Case studies

A case study shows the development of a person or group conducting an investigation **Invalid source specified..** They are available online through education portals and company websites.

Case studies are beneficial to the author and to people who seek to find answers without any cost. Collecting many case studies will allow the reader to analyse and interpret their own understanding of the investigation. Thus, driving their investigation forward and reducing risk of failure **Invalid source specified..**

Observations

Observations allow true vision of how a process is run in its natural environment without interference **Invalid source specified..**

A couple of benefits of conducting an observational study is that it provides live feedback without bias, and allows the person conducting the research to engage with the people involved to seek answers afterwards **Invalid source specified..**

Case studies

Objective

To critically analyse three original case studies, and investigate whether a poka-yoke can reduce, or eliminate, the number of concerns received from customer, thus improving quality management.

Method

Search criteria

The case studies in this literature review were found using online resources. The main search criteria typed into the search engine was 'Poka-Yoke'. Additional keywords were added to narrow the search to relevant documents:

Keywords: Case study, PDF, Automotive, Industry, Customer, Investigation, Examples, Advantages, Disadvantages.

Exclusion criteria

- Unoriginal versions of a published document
- Documents that have not been published
- Studies not relevant to the use of poka-yokes

Articles

Included articles

The full citations for each case study used can be found below:

- Patil, P. D. S. A. & Pingle, A. S., 2017. *Poka Yoke for Filter Pin Detection in Nozzle Holder Body Using PLC*, Maharashtra: K. K. Wagh Institute of Engineering.
- Lazarevic, M. et al., 2017. *A Systematic Literature Review of Poka-Yoke and Novel Approach to Theoretical Aspects*, Aškerčeva : Strojniški vestnik.
- Diego, B. et al., 2018. *Implementation of Poka-Yoke System in an Automotive Company*, Delaware: SRYAHWA.

Results

Case study 1 – (Patil & Pingle, 2017)

Summary

Patil and Pingle discuss the importance of high quality and defect free product. They assume the mentality of each operator, and their interest in work, play a key role in eliminating a “silly mistake” or “errors by operator” (Patil & Pingle, 2017). The aim of the study is to implement a poka-yoke mechanism to detect the presence of a filter pin in a nozzle holder. The consequence of not detecting the filter pin is “wastage of time, [and] money which affects total production” (Patil & Pingle, 2017).

Methods used

This case study uses a poka-yoke system to correct the already existing problem in the mechanism. Patil and Pingle (2017) used a Programmable Logic Controller (PLC) to correct the entire system. The input devices that feed the Central Processing Unit (CPU) consist of sensors and switches. The output devices include an LED unit and a buzzer. When the filter pin is not present the proximity sensor will feedback to the CPU and stop the process and alert the operator.

Patil and Pingle designed a flowchart to represent the flow of conforming and non-conforming products, which can be seen in Figure 2.

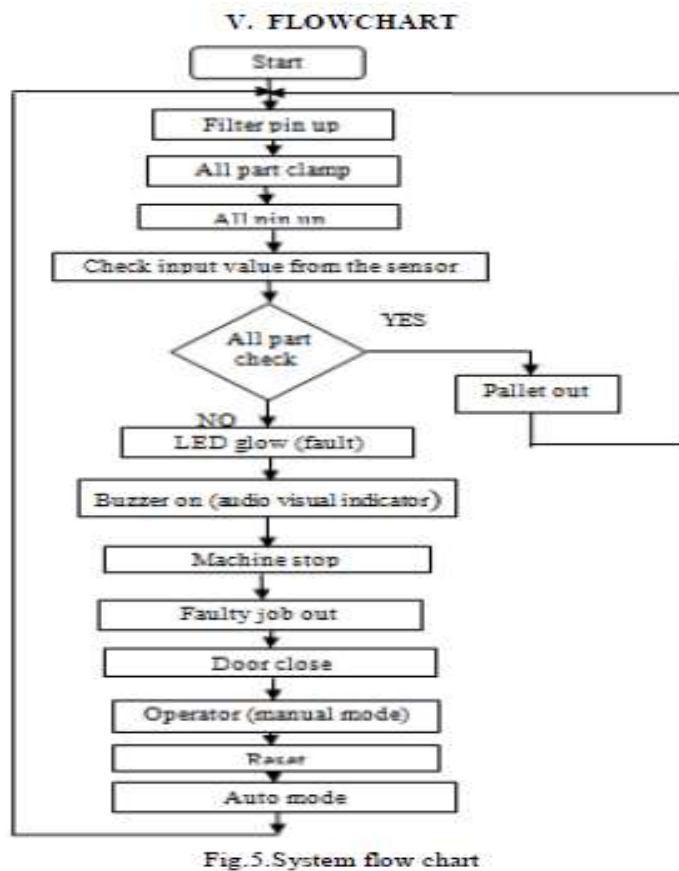


Figure 2 – Poka-yoke process flow

Results

In approximately seven weeks there were 54 defects found from the process before implementing the poka-yoke. The results show that once the poka-yoke had been installed there were zero defects, as shown in Figure 3. The author used quantitative data to support their study.

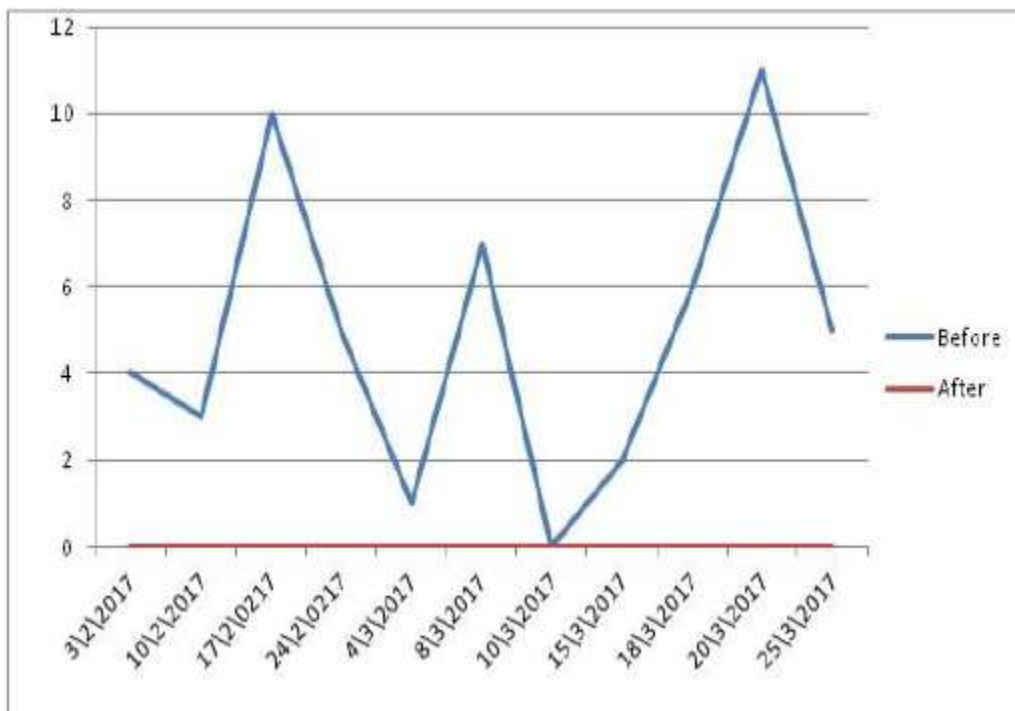


Figure 3 – Poka-yoke results (before and after)

Conclusion

This study shows that the installation of a poka-yoke was effective and eliminated the risk of operator error. The benefits of using a poka-yoke are that it enhances productivity, reduces quality cost (e.g. sort and rework), and improves customer satisfaction (Patil & Pingle, 2017).

Case study 2 – (Diego, et al., 2018)

Summary

The purpose of this case study was to prevent one stage in the process moving onto the next without being released first. The problem was that the product did not arrive on time as agreed with the customer, due to production time exceeding estimated timing. A two way switch was installed to control each batch and prevent one person from controlling the station. In the poka-yoke system, it required an 'ok' from three control panels that feed into control panel 1 ready for release.

Methods used

As quoted by the author, the research conducted in this case study is “bibliographic research followed by a case study” (Diego, et al., 2018). The reason for conducting the investigation was a series of operational failures within a seven-day period. The purpose is the “fixation of the front stabilizer bar in the suspension” (Diego, et al., 2018).

A five why study helps understand the reason why the product didn't arrive on time as agreed with the customer. The five why root cause analysis method is useful because “by repeating “why” five times, the nature of the problem as well as its solution becomes clear.” (Serrat, 2017).

Results

The authors conclude their study by saying “preventative action prevents major problems occurring, such as recall, [and] field action” (Diego, et al., 2018). By introducing a poka-yoke sequence to the process 100% of the operational failures had been eliminated. The cost of implementing the poka-yoke was very low because it used current facilities; so the only cost was wiring, a 2-position switch, and labour. The alternative cost is long-term sort-rework, which consumes time and money.

Conclusion

The author provided relevant and clear examples and definitions at the start of the study, but lacks clarity when explaining the production line process. The five why's root-cause analysis technique appears to be useful for establishing what went wrong and why. It gives the person responsible of the investigation the opportunity to establish more reasons why each 'why' could be a root-cause.

Case study 3 – (Lazarevic, Mandic, Sremcev, Vukelic, & Debevec, 2017)

Summary

The purpose of this case study was to carry out a literature review and to “summarise the latest studies and definitions of poka-yoke applications” and propose a generally acceptable definition of poka-yoke. The author did not carry out an investigation. The authors collected data from investigations carried out by others and used it to support their definition of poka-yoke.

Methods used

The investigation was focused on the review of studies conducted by other people. The study shows ethical value by giving credit to the rightful owner of quoted literature, many of which was by the author Shigeo Shingo who was a decorated engineer who pioneered the Toyota Production System (TPS) (Rampersad & ElHomsy, 2007).

The study discusses the use of Statistical Process Control (SPC) and its influence on quality control, however that method traces trends and variation, it does not look to prevent a problem from happening. There are two types of poka-yoke that can be used: control and warning (Shingo, 1986). The control type locks the components in place i.e. jigs and fixtures, and the warning type only alerts the operator by light or alarm that something is wrong.

Results

The study provides plenty of qualitative data but no quantitative data. The aim of the study was to research and evaluate, then propose an acceptable general definition.

The authors have included many examples of poka-yokes used in different industries such as: manufacturing, construction, automotive, and the software and service sector.

One example, which was of particular interest, was the implementation of customized pallets with pins to prevent mis-locating parts. The reason that this example is interesting is because it is a strategy that could be adopted in Gestamp to prevent left and right hand parts being mixed up.

Conclusion

This case study provides a comprehensive review of the types of poka-yokes, why they are used and their definitions. The author believes that the addition of a poka-yoke system will help “prevent execution of bad actions by the workers, or the detection of bad products which are the results of errors” (Lazarevic, Mandic, Sremcev, Vukelic, & Debevec, 2017).

The benefit of using this case study is that it provides a broad overview of the meaning of 'poka-yoke'. The problem with the case study is that as an Engineer in the automotive sector it would be more relevant to research and apply methods in the same working environment.

Collective summary of case studies

Case study 1 – poka-yokes eliminate risk, increase productivity and reduce quality costs.

Case study 2 – used the Five Why's technique to establish potential root-causes. The poka-yoke should be considered during the design stage of a project.

Case study 3 – supports the need to implement a poka-yoke system as a preventative measure. The case study also provides a broad overview of what a poka-yoke is and numerous scenarios of how they are used.

What is a poka-yoke?

It is a Japanese term that means to prevent mistakes electrically, or mechanically (Diego, et al., 2018). A poka-yoke helps workers spot inefficiencies, errors, or potential defects, which empowers them to follow the “stop-call-wait” procedure. By doing this the amount of waste can be reduced, costs can be reduced and increases efficiency (Nair & Krishna, 2018).

For a pedestal welder that welds nuts onto a steel plate, it is important that before it gets packaged it has a nut present. Therefore, a jig can be used in combination with various sensors to detect the presence of critical parts. If all sensors detect the presence of a part, it is acceptable. If a sensor cannot detect a part, it is unacceptable. This is an example of how the welding process can be improved with a poka-yoke.

Poka-yokes should error-proof the issue at hand and minimise the number of customer concerns. It is often the case that companies are looking for cost-effective ways to reduce waste in the production process. If a poka-yoke is successful in error proofing a problem, the manufacturer will benefit from reduced costs, and penalties, and therefore more profits.

However, a poka-yoke could be expensive to implement due to disruptions in production while installing the new system. The disruptions could lead to an increased lead time which means the customer spends longer waiting for parts. Moreover, it could be costly due to the difficulty of innovating a new way to improve the system. The engineer must conduct a cost-benefit analysis before undertaking a new project, which can also be a timely process. Effectively, issues of production should be considered extensively during the planning stage to reduce costs in the future. It is plausible that the implementation of simpler working procedures should have a positive impact on the worker. This is because once a poka-yoke system is in place, the systems require very little training to use. The parts will also be less difficult to manufacture in the future due to simplification of the manufacturing process.

Project

Immediate reaction to customer concern

The standard company procedure for reacting to customer concerns is to:

1. Contain the suspect stock,
2. Create a team to resolve issue,
3. Identify the problem,
4. Report problem to customer,
5. Continue to investigate the root cause.

The suspect stock is controlled using software called SAP (Systems, Applications & products in Data Processing) and must be put on S-Hold which prevents it being shipped to customer, within 24 hours stage D2 of an 8D investigation must be reported to the customer, and within 48 hours the customer should have an update to explain why it happened (stage D3).

For any company associated with Gestamp, a quality alert or quality concern is raised using the online Fullstep portal. Fullstep allows Gestamp to raise a concern and track the progress of the supplier's investigation. To help collect more information on the issue JLR provided details which included the SAP and Odette label. These two labels help track the status of a part through production and transit. By narrowing down the search to the day of production we can better estimate the reason for the issue, for example, a lack of dedicated pallets, lack of documents and training at line/cell, and trained operators not in work or unofficial customer requests. There is also the possibility that the error occurred through human error.

In this case Gestamp is the supplier and JLR are the customer. At the time which JLR raised the concern I was a Project Engineer but since then I have been moved to the Quality department which changes my role in this project. The 8D that was conducted did not include myself but I was there to generate ideas to overcome the issue, to arrange the manufacture of the poka-yoke bars, and coordinate the tasks needed to successfully implement the bars with the customers approval.

Timing plan

Initial timing plan

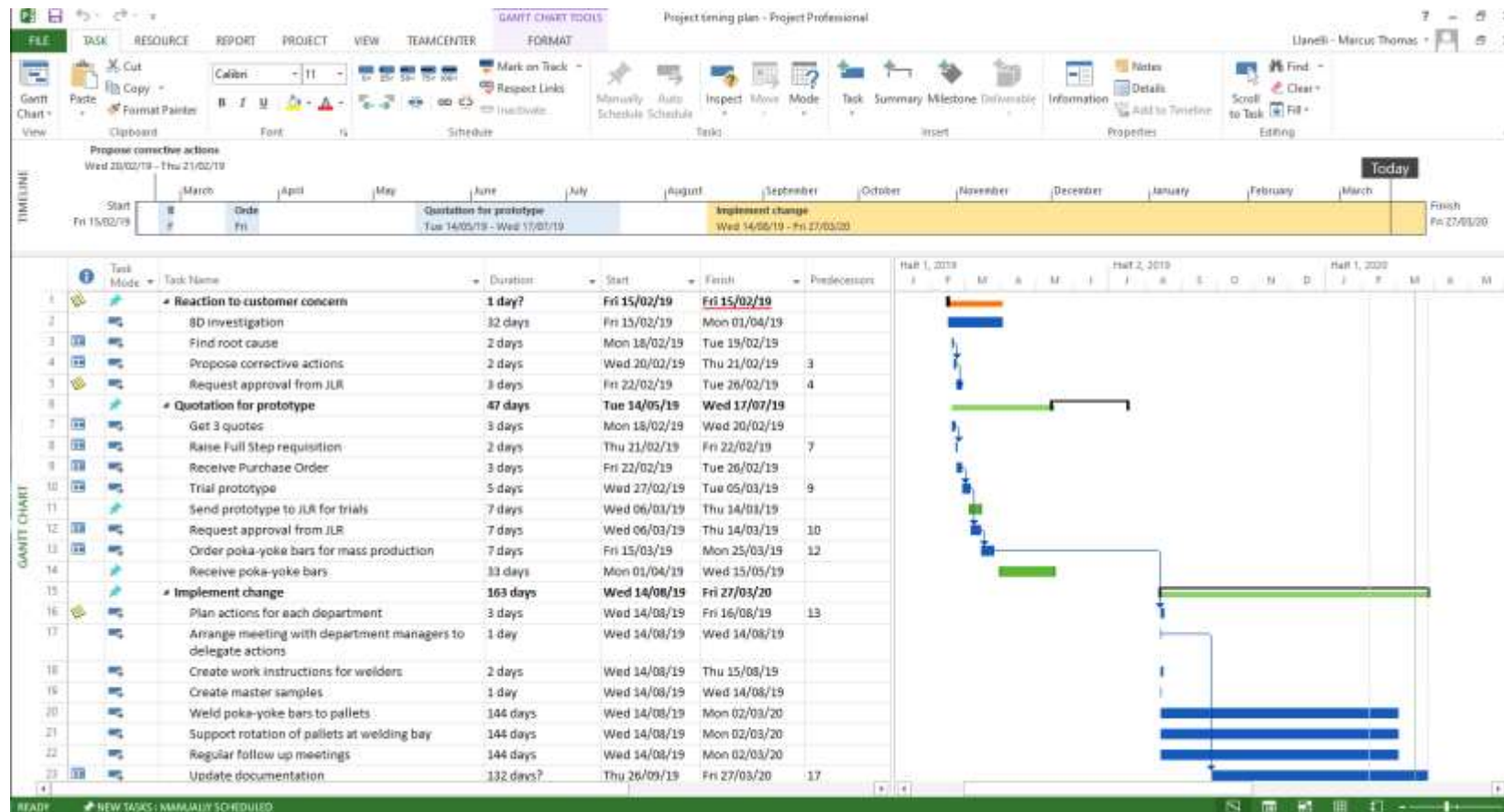


Figure 4 – Initial timing plan

The Gantt chart above shows the predicted timeframe for the completion of this task. The initial estimated completion date was the 23rd March 2020, however due to a lack of manpower the project has been delayed to prioritise production so the forklift drivers are no longer available at the moment.

Updated timing plan based on current progression

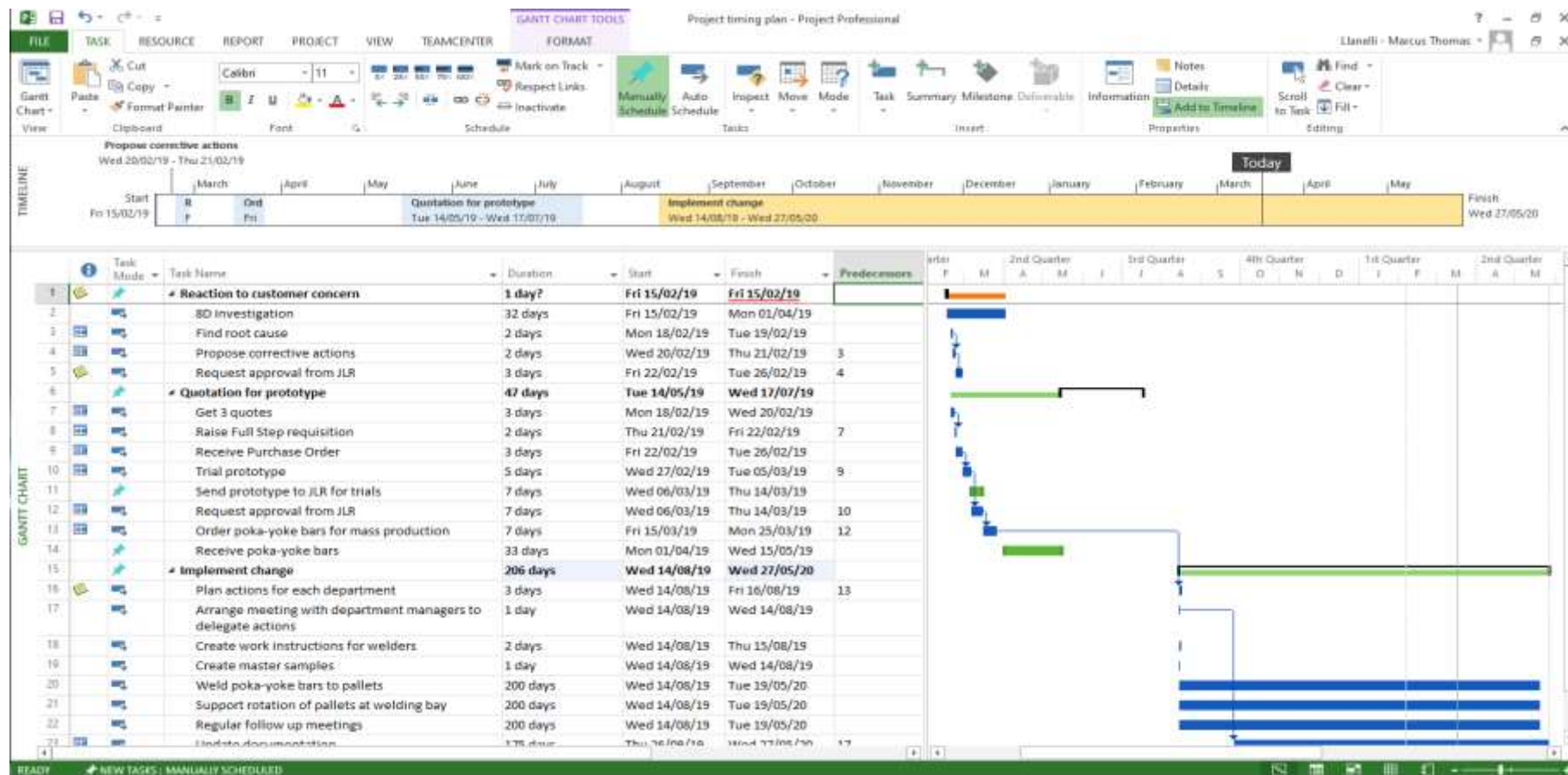


Figure 5 – updated timing plan

The completion date has been extended from March 23rd to May 27th. This is because of the variables affecting the availability of workers such as a fall in customer demand, Gestamp reducing the workforce to the essentials and the recent outbreak of COVID-19, , which has resulted in everyone being sent home and all production and projects to be put on hold.

8D investigation

8D is a problem-solving tool used to identify the root causes of a problem and implement corrective actions to prevent them from happening again. The customer with a problem statement initiates the process known as stage D0.

There are eight elements to an 8D as the supplier:

- D1 – create a team of relevant people
- D2 – define the problem
- D3 – contain the issue
- D4 – establish the root causes
- D5 – identify potential corrective actions
- D6 – implement and validate corrective actions
- D7 – outline the preventative steps
- D8 – congratulate the team

The document used to record the findings of the 8D investigation is in Appendix 22. The Quality Engineer led the 8D at the time, Steffan Nicholas. As a Project Engineer, I arranged a meeting with various departments to help identify the problem, determine the scale of the problem by the number of pallets on-site, establish a reason why it happened and propose potential solutions.

D1 – create a team of relevant people

Table 1 – 8D Team

Name	Job Role
Steffan Nicholas	Quality Engineer
Huw Davies	Senior Quality Engineer
Alan Lewis	Assembly Manager
Peter Streefland	Assembly Manager
Matthew Edgington	Assembly Manager
Jason Barker	NPI Project Manager
Marcus Thomas	NPI Project Engineer
Jamie Fitzgerald	Shift Manager
Jon Richards	Deputy Quality Manager

D2 – define the problem

Jaguar Land Rover (JLR) reported an issue at their production line. They reported mixed parts in the wrong pallets (Appendix 11) according to the EU1121 agreement (Appendix 6 & 7). The disruption cost JLR time and money to sort the stock.

D3 – contain the issue

All pallets on site were contained and put on S-Hold. This prevents the label from moving from one work centre to another on the SAP system. All stock at despatch needed to be called back to Firewall ready for inspection and sorting.

D4 – establish the root causes

As part of the root-cause analysis, the five whys process was used to generate ideas. The method began by asking, “How did it happen?” and from that keep asking “why?” to get to the root cause in its simplest form. We found the root cause of the issue to be because of an operating error due to the lack of training. The training competency sheet was signed at the start of the project by the Standard Operating Procedures (SOP) coaches and Team Leaders after the operators have proven their competency.

The SOP team is responsible for generating the paperwork at the cell for the operators to follow sequentially (Appendix 1). The instruction sheets also include the packaging details i.e. pallet type, packing factor and orientation. The correct orientation can be seen in Appendix 12.

D5 – identify potential corrective actions

The first corrective action was to update the current SOP documents and ensure the operators at the assembly cell understand the correct operating procedure (Appendix 1). This meant checking the pallet identification number, quantity and images showing the orientation were all present. Once this was completed, all pallets on-site needed to be moved to the Firewall. This allowed quality to check the compliance of the parts. With all stock onsite in the correct orientation, there was no risk of sending mixed parts. The next stage was for the response team to implement the corrective action. This would prevent the error from happening again. The team agreed that a poka-yoke would error-proof the operating procedure.

Using the Control (DMAIC) method, we moved onto the design stage by inviting external companies on-site to share their ideas.

D6 – implement and validate corrective actions

The email shows JLR's approval of the initial pallet design (Appendix 4). Despite the failure of Gestamp to anticipate the mixing of parts between pallets, JLR also made the same error and failed to correct or foresee the issue during the design and approval stage.

Before implementing the corrective actions, we first needed to propose an idea and a plan to JLR for their approval.

Trident is a local fabrication company. They are on the register of Gestamp's approved suppliers. They were invited to Gestamp to share their thoughts and ideas on the issue. After discussing the problem, it was suggested a poka-yoke would be beneficial. After a demonstration of how it would work we were interested in the idea. The design would prevent a part going in the wrong pallet.

Trident began by fabricating a prototype to test its effectiveness and functionality (Appendix 8).

There were two designs:

where the poka-yoke bar fitted through a hole on the child part at the bottom of the assembly (Appendix 4),

where the bar was located through the centre of the hot stamped part.

The prototype was welded to a left and right hand pallet. Pallets containing assembled parts were sent to the assembly plant for JLR to test the practicality of the design.

Appendix 3 is evidence of a trial conducted at Gestamp with dedicated pallets from JLR. The trial was performed with a mix of old and current model year parts. The result of the trial was the parts were held securely and no issues were anticipated at the time. The risk of mixed parts should have been identified in pre-production. The issue could have been prevented if the pallet design had been critically analysed.

JLR responded to the project manager and expressed their satisfaction with the design. The prototype pallets would be used as the master reference samples for the welders to replicate for the remaining pallets.

D7 – outline the preventative steps

This stage should be completed within 30 days of the problem being raised.

The Product Failure Mode and Effect Analysis (PFMEA) document was reviewed but no changes were made. The control plan and SOP documents were updated to give better instructions of how to package the parts correctly.

D8 – congratulate the team

The team were congratulated for their contribution to the investigation. This is an important stage of the investigation for many reasons. Congratulating the team for their efforts gives each of them a sense of accomplishment and a morale boost. By reviewing the process at the end and sharing each other's praise it helps build a stronger working relationship with peers.

Management of project

The decision to error-proof the pallets came after the project had been handed over to production. At this stage, the original project manager had left the business. As the quality engineer it was my responsibility to close the project. The importance of this task needed to be explained to each department representative, which was to prevent mixed parts.

The original proposal was for the poka-yoke to locate through the first and last part of each row (Appendix 13 & 14). The issue with this idea was the parts were difficult to locate in the grooves due to the bar being too low down and going through too many parts.

Due to a lack of facility space and employees, the project manager requested a quote from Trident to provide the resources to complete the project (Appendix 10). Appendix 16 shows the workspace which the welder has to weld the pallets. There are 180 pallets in total and the welder is only able to store four pallets at a time near the bay. The pallets are welded on top of steel flooring which earth's the pallet. There is not enough space for the welder to process any more than four at a time due to the lack of space, which delays the completion of the project.

However, they offered one worker and no contribution to consumable material. They also wanted Gestamp to provide the forklift drivers to move pallets. Their quote was deemed unfeasible and therefore saved as a backup in case of no better alternatives. The plan was to proceed with completing the project internally. The disadvantage of this is that it would take longer.

There were delays to the project because production took higher priority and due to a lack of staff to oversee the project. Without forklift drivers, there was nobody to retrieve the finished and unfinished pallets and unfortunately, that has been the case throughout this project. The production team has been unable to spare drivers to get the pallets and take them where they need to go because it would take too long.

The logistics team are unable to spare a driver because their drivers are predominately agency and not always called in to work because of the uncertain climate in the automotive market (Appendix 19). The logistics and production team have been finding it difficult rotating the complete and incomplete pallets and when this happens the welder has been asking for the pallets to be stacked out of the way so that they do not block the entrance to the welding bay (Appendix 19).

Once complete the pallets are to be stored outside between the welding bay and the steel stores (Appendix 20). It is the responsibility of the assembly production team and logistics to collect the pallets as and when needed.

The primary form of communication was through emails. The reason for this is that many of the people I needed to speak to were managers and spent most of their time in meetings. The benefit

of sending emails was that it was that the conversation is recorded which keeps each person accountable.

As part of the verbal instructions given to each welder, the advice given was that when viewed from the rear, the poka-yoke bar should be on the left hand side for the left hand pallet (Appendix 17).

Also, for the right hand the poka-yoke bar should be on the right hand side (Appendix 18).

The preliminary stages of the project

Quality documentation is created during the pre-production stage of a project. The documents represent preparation for foreseeable errors and can be updated any time an unforeseen circumstance is brought to attention. If there is a change in the process, or part, the documents will need updating accordingly. Examples of quality documentation adhered to are:

- ❖ Control Plan,
- ❖ PFMEA,
- ❖ SOP,
- ❖ Record Cards
- ❖ Gauge Instructions.

The X260 project is a carryover part from the previous model year part. A wax reinforced version, which consists of a wax support braced onto the inside of the B-Pillar secured by adhesive, then baked in a dedicated oven. The parts were stored in cardboard boxes without a poka-yoke to prevent the mixing of parts. The current cell has poka-yokes in place to control the location of nuts, the orientation of sub-assemblies, and the sequential order of applying the clamps (Appendix 15). The correct sequence to apply the clamps is top-bottom-middle. If this sequence is broken, the cell will sound an alarm. The importance of applying the clamps in the correct order is that it prevents distortion to the part.

At some point, the potential failure mode for the pallet design was overlooked. The part has dedicated pallets with indication of the orientation of the part, left or right hand. However, it still allows the opposite hand to be located in its nesting. In retrospect, a poka-yoke during the design stage could have reduced the error of mixing parts.

Mixed parts concerns between 2018 & 2020

Gestamp uses an internal database to record the number of quality concerns and alerts raised internally or externally. The record shows details outlining the problem and the resultant costs (Appendix 21).

The tables below show the figures extracted from the database with filtered results of mixed parts between 2018 and 2020. The system is work-in-progress and not yet fully utilised. The actual number of concerns may be higher, but the information below has been recorded on the official database.

Table 2 – Number of mixed part concerns at Llanelli (2018-2020)

LLA	Count of Fault	Column Labels				
	Row Labels	Gestamp	JLR	Unipress	Volvo	Grand Total
	Assembly and Paint		6		1	7
	Cold Pressing	1	15			16
	Hot Stamping and Laser		4			4
	Laser 10			1		1
	Laser 6			1		1
	Laser 9			7		7
	Grand Total	1	25	9	1	36

Table 2 shows that at the Llanelli plant most concerns are raised through JLR and predominantly from the Cold Stamping process. The use of poka-yokes in cold stamping is less frequent compared to assembly and the reason for this is there is less opportunity during the stamping stage to incorporate an error-proofing system. The system is able to detect the presence of a part or nut using proximity sensors but operators without poka-yoked pallets package the parts.

During the assembly stage, a jig can be set up with sensors to detect critical areas of a component for presence of child parts or Bought out Parts (BOP's). The presence of parts may allow the part to be loaded into the corresponding pallet through a light curtain that detects whether the sequence is being followed or not. If not, an alarm sounds and the system locks until supervision has given the OK to proceed. Quality assigns the authorisation to supervisors and Maintenance. By not giving the operator permission to bypass the alarm we can control the level of decision making by making someone accountable of the actions carried out.

Table 3 – Number of mixed part concerns at GWM (2018-2020)

GWM	Count of Fault
	15

Due to a lack of detail recorded on the database Gestamp West Midlands (GWM) only provides the number of instances. There have been fifteen instances in the last two years (Table 3). There were no costs reported during this time.

Table 4 – Number of mixed part concerns at Cannock plant (2018-2020)

CAN	Column Labels							Grand Total
		BMW	JLR	Nissan	Renault	Toyota	VDL	
	Count of Fault	2	4	6	1	2	2	17
	Column Labels							Grand Total
		BMW	JLR	Nissan	Renault	Toyota	VDL	
	Sum of Sorting Cost (£)	0	0	2700	500	0	770	3970

At Gestamp Cannock and Gestamp West Midlands (GWM), the number of faults in the last two years was seventeen with a total expenditure cost of £3,970. This includes the cost of sort and rework labour and materials. The average cost per concern is £233.53.

Table 5 – Number of mixed part concerns at Aycliffe (2018-2020)

	Row Labels	Count of Fault
AYC	BMW	10
	Continental	1
	Ford	6
	JLR	8
	London Taxi	1
	Nissan	3
	ThyssenKrupp	1
	Volvo	14
	VW	3
	ZF Lemforder	3
	Grand Total	50

Table 6 – Cost of mixed part concerns at Aycliffe (2018-2020)

	Row Labels	Sum of Sorting Cost (£)	Sum of Other Cost (£)	Sum of Customer Penalty (£)
AYC	Continental			500
	Ford	1000		1118
	JLR	4322		3560
	London Taxi			
	Nissan			
	ThyssenKrupp			
	Volvo	1000	1000	4810.82
	VW			
	ZF Lemforder			
	Grand Total	7322	1000	11294.67

Table 5 and Table 6 show the number of customers who have experienced concerns as a result of Gestamp supplying mixed parts. The total number of concerns was fifty with a total cost of £19,616.67. Some of the costs were not recorded on the database at the time. With these figures, it averages a cost of £392.33 per concern. Appendix 9a shows the cost of purchasing poka-yoke bars for approximately forty-five pallets. The cost is £90 per pallet and a total cost of £4050. The benefit

of having the poka-yokes in place is that it prevents repeat concern costs. The disadvantage is that if the customer concern costs £1,000 and happens once every two years, by the time the cost equals that of the poka-yoke bars the part will be producing service spares and therefore not feasible. A few reasons to justify the cost are:

Maintaining a good customer-supplier relationship,

To prevent stopping the production line at the customer.

There are alternative methods that would spread the cost and make the investment more feasible.

Methods include the vast selection of sensors, jigs & integrated computer systems to detect process patterns and specifications.

Table 7 – Number of mixed part concerns at Gestamp UK (2018-2020)

Gestamp	Count of Faults
UK0.2	118

The total number of concerns can be improved as part of the Gestamp's ambition for continuous improvement. Each fault has its own reason for resulting in mixed parts, but the process of resolving the issue is the same. The use of problem solving techniques such as 8D and Five Why's to identify root causes and establish corrective actions. The corrective actions can be used towards a lessons learned activity for future projects or designs. Another useful technique to collect information is the 'Five W's and One H' method. This quickly establishes who? What? When? Where? Why? How?

Corrective actions

Updating and reviewing documents

As part of the investigation recorded in D7 each document was reviewed to check the failure mode has been recorded. The control plan and SOP document needed to be updated to state the corrective action and highlight areas of particular interest.

Process Failure Modes and Effects Analysis (PFMEA)

The PFMEA is a live document that to predicts and records potential failure modes. Each failure mode is a combination of severity, occurrence and detection score. The sum value is a Risk Priority Number (RPN) value. A high RPN value (typically over 100), a severity equal to, or greater than eight automatically requires immediate reaction for corrective actions.

Control Plan

The Control Plan is a document that outlines the control measures in each step of the process (Appendix 5). In this case it needed to be updated to state the orientations of the parts are controlled by the location of the poka-yoke bars and dedicated grooves. The change has also been recorded on the SOP documentation to help the operators understand where the parts go (Appendix 1).

In the Control Plan under 'Op 800 Robotic spot welding using 2 x spot welders' the packaging process specification is "As Per Customer Packing Instructions". The measurement specification states the parts and pallets should be checked "100%". The control method for the packaging of parts is the Standard Operating Procedure (SOP).

Standard Operating Procedures (SOP)

In reaction to the customer concern, there needed to be a change of procedure to ensure the operators are fully trained and competent. To reinforce their training in the event of them being in doubt there are SOP documents at the assembly cell which instruct the operators what to do in the correct sequence with the aid of pictures (Appendix 1).

The SOP shows an image of a pallet with the corresponding part nesting in the dedicated grooves with the pallet factor and pallet type as shown in Figure 6.

Refer to Appendix 1 for the complete SOP document.



Figure 6 –Updated SOP to show poka-yoke (Appendix 1)

The poka-yoke bar in Figure 6 has been highlighted in a yellow circle and demonstrates the functionality. The poka-yoke bar only goes through the hole of the first part; the remaining parts in

each row will only be able to fit the same way. This acts as a visual and a physical reminder to the operator to ensure the parts are packaged correctly.

Since implementing the poka-yoke, there has not been a repeat concern raised for mixed parts at the X260 cell.

Conclusion

The purpose of this project was to evaluate whether poka-yokes are the answer to customer concerns or not. This is a research project reactively trying to rectify recurring customer complaints of mixed parts upon receipt.

The immediate reaction to the customer concern was to understand the problem statement. From there an 8D investigation was carried out to find the root cause and evaluate the corrective actions.

The findings from the investigation were sent to the customer daily.

The customer concern was addressed immediately in agreement to the standard response procedure, an 8D investigation. An 8D investigation was conducted and the findings were sent to JLR. JLR gave their feedback on the trial they performed and gave consent to install poka-yoke bars to their dedicated pallets.

Trident was invited on-site to share their ideas with overcoming the issue. The team agreed that a poka-yoke was the best solution. Trident manufactured a prototype poka-yoke that was initially rejected due to operator difficulty. The second poka-yoke bar design is located through the first loaded part. JLR conducted trials and approved the design. Their approval gave consent to apply the poka-yoke bars to all X260 pallets. Trident manufactured ninety extra pairs of poka-yoke bars for the completion of this task.

There have been many obstacles delays to the completion of the project. These delays include:

- ❖ Not enough free labour - the company has made cutbacks by reducing the number of agency staff. The majority of forklift driver's onsite are agency workers. This delays the completion of the project because the available forklift drivers are used for production.
- ❖ Not enough workspace - the welding bay does not have enough space to store all the pallets that need welding. Additionally, the lack of availability of forklift drivers means the welding bay is cluttered with finished pallets.
- ❖ Departure of project managers - for the last seven months there has not been a project manager to lead the project. During this project three project managers have come and gone. Each arrival meant a delay, a result of picking up where the previous manager left off.
- ❖ Priority of projects - this project has been in production for two years and only encountered one customer concern. Compared to some other projects this is not a common problem and regarded as a medium-low priority. Recently, there has been a high priority given to new projects which delays the completion of this task.

Each time that I have encountered an issue I have escalated it to my manager. The response from the escalation is always positive; everybody gets onboard with the idea. The problem is people forget and do not commit to fixing the problem. Currently, everybody is off work because of COVID-19.

Upon my return, I am going to arrange a face-to-face meeting with all necessary managers and have everybody commit to a date. I will follow up each action and record the status.

As a project engineer and quality engineer, directly involved in this project from the start. The project has grown and this has given more opportunity for extra responsibility. When the concern was raised, I was a project engineer arranging the meetings, calling customers and suppliers, and setting a timescale. Now, as a quality engineer, I am responsible for the completion of this task and the quality compliance.

From this project, I have learned that there are advantages and disadvantages to the introduction of a poka-yoke. The advantages of a poka-yoke are:

- ❖ Easy to use,
- ❖ Easy to train,
- ❖ They error-proof the process,
- ❖ Reduce customer concerns
- ❖ Improve quality assurance

However, the disadvantages are:

- ❖ Time consuming - to investigate, trial, prototype, receive approval and install the poka-yokes.
- ❖ Cost-effectiveness - If the cost of a customer concern is less over the remaining lifespan of the project than the cost of a full poka-yoke installation, it might be worth considering the feasibility of the system.
- ❖ Difficulty of fool proofing - some systems may already have a poka-yoke in place or perhaps the process is shared and the differences in parts prevent freely modifying the design.

The definition of a poka-yoke is to “error-proof” which is to prevent the occurrence of defects. The prevention of an error should be considered during the design stage. This can be done by reviewing lessons learned and taking time to think about what could go wrong. The cost of installing a poka-yoke would be saved by including it in the pallet design from the start.

Recommendations

I recommend that corrective actions must be trialled, approved and implemented as soon as possible. This is to prevent unnecessary delays. Delays may include higher priority tasks, staff members leaving the business or other unforeseen circumstances.

The biggest issue implementing the change was that everybody gave up when the project manager left. There always needs to be a hand-over process to keep everyone focussed on what needs doing. Poka-yokes are a preventative measure and should be implemented before they are needed and not when they are needed.

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Appendix

Appendix 1 – Standard Operating Procedure (SOP) document

Appendix 2 –Engineering Change Request form

Appendix 3 – X260 Packaging Review presentation

Appendix 4 – X260 original pallet agreement with JLR

Appendix 5 – Control Plan

Appendix 6 – X260 JLR EU1121 packaging document (Right Hand)

Appendix 7 –X260 JLR EU1121 packaging document (Left Hand)

Appendix 8a – Prototype quote

Appendix 8b – Prototype delivery note

Appendix 9a – Trident mass delivery of 90 pairs

Appendix 9b – Poka-yoke delivery note

Appendix 10 – Trident quote to weld poka-yoke bars to pallets

Appendix 11 – Mixing wrong hand in pallet

Appendix 12 - Correct orientation of parts in pallet

Appendix 13 – Poka-yoke proposal

Appendix 14 – Initial poka-yoke idea

Appendix 15 – List of poka-yokes at cell

Appendix 16 – Welding bay layout 4x2

Appendix 17 – Left hand welded to pallet

Appendix 18 – Right hand welded to pallet

Appendix 19 – Stacking of finished pallets

Appendix 20 – Welded pallets to go back into production

Appendix 21 – Mixed parts concerns at Gestamp

Appendix 22 – X260 8D