

MODULE: GREEN BELT SIX SIGMA
MODULE CODE: ACMA 5005
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ASSIGNMENT TITLE: UNDERTAKING A
GREEN BELT PROJECT

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Executive Summary

One of the most pressing issues within the company for several years now is the inability to control the 'Hose Over-Connector' operation and ensure all final assemblies that are shipped to the customer are within the 0 - 2mm tolerance and never exceeds the specified tolerance. Over the last few months, the business has received several customer complaints due to the inability to protect the customer from faulty parts. This gap has resulted in Hose being pushed off of the Connector when the Clear Vision System is operated. This has occurred due to the fact that the hose was over the 2mm top tolerance and was under-inserted over the connector barb. The result of this production failure was when the driver of the car operated the system, the hose was pushed off the connector under water pressure and the system then failed.

This is a major failure mode within the CVS Systems and corrective action is required ASAP. This improvement project was presented to the Manufacturing Engineering team, with the intention of them being able to design, produce and implement an effective control measure that will protect the customer from any failures due to this manufacturing operation. William Davies (Manufacturing Engineer) was nominated to be the owner/champion for this project due to his heavy involvement with the hose assembly production line and good understanding of it. In order to successfully deliver the Six Sigma project the DMAIC approach was followed, which included the following steps; Defining the overall problem at hand; Measuring/quantifying the scale of the problem; Analysing the data collected from the measurement phase; Improving the problem with the proposed solution; and putting in place controls to ensure the gains are withheld.

The Six Sigma green belt project delivered a robust countermeasure that pays back in under a year. It has been rolled out across multiple assemblies within the business and now set as a global standard for all new fixtures in future projects.

Introduction

William Davies' within Kautex Textron CVS LTD is a Manufacturing Engineer. Kautex Textron CVS LTD is a multinational company which specialise in clear vision systems. These are windscreen wash systems, camera cleaning systems and headlamp wash systems for the automotive industry. As a Manufacturing Engineer within the company some my job roles include system maintenance of all manufacturing processes, implementation of new tooling for customer projects and most importantly for this project providing engineering solutions to problems within the manufacturing process brought about by customer complaints and QDR's.

Define

Problem Overview

In previous years there has been several customer related issues with the Hose-Over –Connector operation and the hose being under inserted over the various connector barbs. This flaw in manufacturing resulted in the hose being forced off the connector barb losing adhesion when the CVS system was operated, thus resulting in a failure of the system and it then having to be replaced. This is a huge part of our production line at Kautex due to the fact that every single hose assembly fixture contains a Hose-Over-Connector operation and if initial checks aren't thorough, lots of assembled parts are slipping through the net and causing financial and reputational problems from the company. The main problems faced by the company are:

1. A huge amount of costs are being incurred due to the company having to deal with wrong or incorrect parts being supplied to the customer.
2. Massive financial implications due to extra inspection processes having to be undertaken.
3. Financial implications due to the training of inspection contractors when dealing with faulty parts.

Customer Related Issues

Some examples of the problems that have been found at the customers end are:

Internal Inspection Issues

The Firewall Inspection area have also seen several parts displaying the defective characteristic over the last few months, these findings were:

Part Number	Number of Parts	Date of findings
4000013961	1	20/01/18
4000013491	3	20/08/18
4000010040	2	23/03/18
4000013961	1	08/02/18

Cost Incurred Whilst Dealing With The Issue

The costs incurred when dealing with this problem have impacted the business greatly, these have been:

Cost Per Technician Per Week = 2848.54

Customer related costs from the last year = > £1000 (cannot release exact figure)

Quality department dealing with issues = > £600 per issue

Possible Reasons for this issue

When initially discussed and thought about, a range of factors could be contributors to the problem at hand, these include:

1. Hose Stretching/Shrinkage – EPDM hose is prone to stretching. Especially when operators are not taking care when laying the hose into the fixture they will stretch it and if left to sit in the fixture it will shrink and be forced off the connector.
2. SOP Documentation – if the documentation provided to the operators is not correct and does not specifically specify that the hose needs to be fully inserted up to the shoulder of the connector, the operators will not do so.

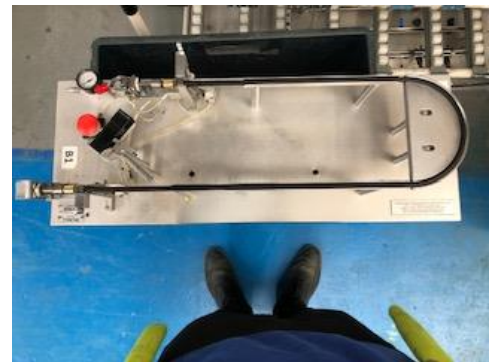
3. Training – even though the SOP documentation is provided for the operators to read at all times, they are all firstly trained by a qualified trainer within the business. If the standard of training provided isn't up to scratch then problems like this could be easily brought about.
4. Operator Negligence – with all manual tasks there is a margin for human error. If the operators are not concentrating or have a lot of pressure on them to hit production targets, the chance of them not completing operations is very high.

Actual Reason for the issue

The reason why this issue was occurring could be all of the above variables or more. But the main issue is that before now these failure modes haven't been taken into account. With these not being taken into account no countermeasures have been implemented to protect the customers and Kautex from this failure mode.

Defined Trial problem part

It was decided that the initial idea developed by the ME team would be trialled on a problem fixture that has a very simple assembly operation, which is the Leoni fixture, this produces the Tailgate Wash Hose Assembly for the Volvo V316 Project and is produced under the Part number 1052333. This part incorporates 2 X Voloplast Quick Fit connectors (1032471) and 1 length of EPDM Hose (1018503). When the idea is finalised and has the buy in from the company it is planned to be rolled out onto all new project fixtures and also retrofitted on all current problem fixtures.



The team and I thought that this fixture was the most suitable fixture to trial due to many positive attributes it has in giving a good representation of the Poke Yokes ability. These include:

1. It is one of the fixtures/parts where the problem has originally occurred.
2. It has the most recent customer QDR against it and the company needs to implement a control measure for it quickly in order to maintain good customer relations.
3. It is a very simplistic design which poses no real challenge to the modification process.
4. It has a very high demand for parts against it for the foreseeable future (83570 for this year), this will allow the ME team to gain a realistic idea of the design's capability and test its durability.
5. It already incorporates the leak test operation and the pneumatic system pre-installed onto the fixture which can easily be tapped into in order to include the Poke Yoke into the system.
6. There is also lots of free space available on the fixture for the Poke Yoke to be included without interfering with the operation at all.

Goal

With this being the fixture selected for trial, my goal was to implement a robust control measure that will ensure that 100% of parts produced will be within the correct Hose-Over-Connector insertion tolerance of 1 mm + or – 1.

It must also meet all specification points which I have outlined.

I would ensure that I remained on target for planned completion by regularly reviewing my Project Plan very regularly and ensuring that all milestones set out were hit on time. If they were not alternatives recovery steps would then need to be put into place to gain the lost time back.

Process Map

It is essential that before going any further in the project that I understand the process. To do this I created a current state process map, which highlights each operation step by step, as well as all aspects that feed into the operation that need to be correct in order for good parts to be produced.

Customer Requirements Of The Control Measure

In order to gauge the needs and wants of Kautex and the External customers it was essential to complete a 2 stage Characteristics matrix.

This matrix allowed me to prioritise certain aspects of the design over other in order to meet all customer requirements and achieve overall satisfaction with all parties concerned.

Measure

Before even thinking about implementing any process improvements/Poke Yokes it was essential to firstly gain an understanding of the current state of the process. To do this, the process and outcomes of the process needs to be measured in order to highlight/pin point the problem being faced.

In order to do this it was decided that the process would be measured twice a week over the duration of 4 weeks. With these results, an average from each set of data would be collected in order to give an overall picture of how repeatable and reliable this specific assembly process is.

The results from this table were then put into graphical form in order to give a visual representation of what was going on.

The way in which this data was measured was the first 30 hose assemblies were taken off the line every Monday and Friday from a different operator every day to show if the process was reliable. Before being measured, the hoses were left for 30 minutes in order for them to relax. If it was reliable then the results would be very similar with every operator.

The measurement device used in measuring the problem at hand was the QuickScope. This allows very accurate and precise measurements to be taken by utilising the precision camera.

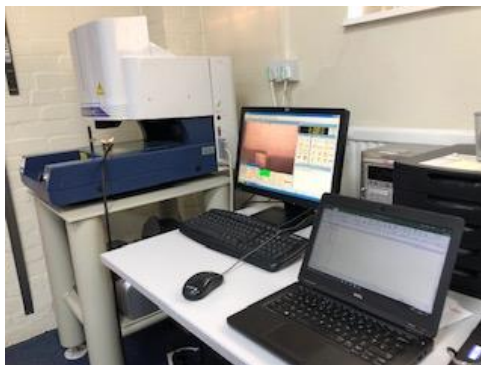
The factors that needed to be taken into account when undertaking this exercise were:

- Operators Gender (Men usually Stronger than Women).
- Age of hose used.
- Relaxation time of the assembly.

With all of these factors taken into consideration the process should still be able to produce good parts at the nominal lengths to the tolerance.

The measurements process used was as follows:

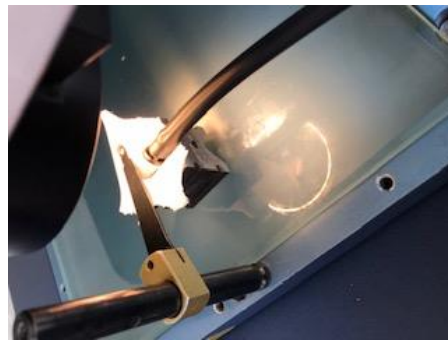
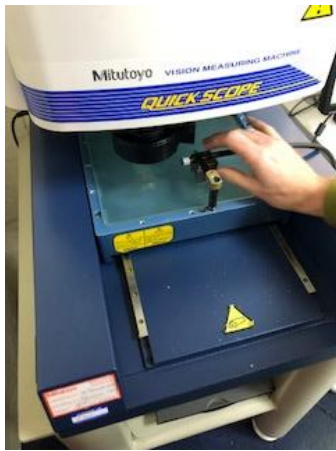
1. The QuickScope Measuring Device:



2. Set up clamp:



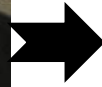
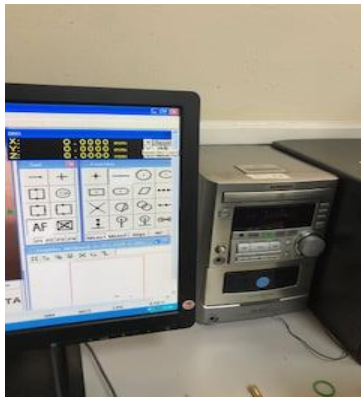
3. Clamp hose assembly to bed:



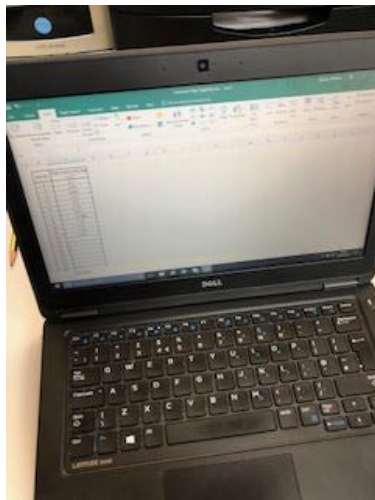
4. Set the camera axis to the connector edge:



5. Set to zero and measure to the cut end of hose:



6. Note result in chart:



Analyse

The results from the data collection exercise were:

Day Of measurement	Average length Calculated
Week 1 – Monday	1.346
Week 1 – Friday	1.174
Week 2 – Monday	0.554
Week 2 – Friday	1.099
Week 3 – Monday	0.666
Week 3 – Friday	0
Week 4 – Monday	0
Week 4 – Friday	1.647

As seen in both Graphical data collected and the table of average results, the process clearly showed that the process cannot produce repeatable and reliable results. The averages should be showing at least a nominal result of 1mm but would've been even better if it was closer to the bottom tolerance to enable the assembly to withstand the greatest amount of water pressure when the CVS system is operated.

There are many variables which can influence the results from this process and produce the problem at hand, these include:

- The operator – could've been poorly trained/new and getting used to the process.
- Stretched hose – if the hose is stretched then when given time to relax the hose can shrink and force the hose off of the connector slightly if left in the fixture.
- Cycle Times - being too short, so operators are rushed and cut corners.

These results clearly prove that the process is not repeatable and there are many variable factors which have no control measure in place to counteract the problems being faced.

This showed that a control device/Poke Yoke needed to be implemented to ensure that 100% of assemblies produced are at least within the tolerance parameters, more preferably right down towards the bottom end to give the best resistance to the water pressure.

Improve

3 Solutions

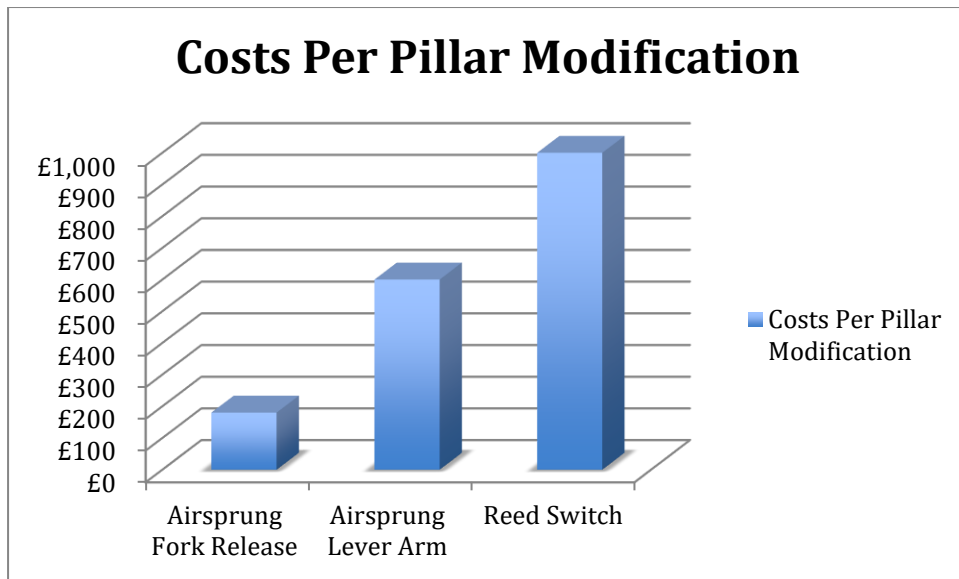
From all evidence gained and when consulting the process map and my senior members within the ME team I came up with three concepts which I believed would solve the problem faced (all three ideas can be found through page 29 to 34 of Logbook).

The first of these solutions was an air-sprung fork release which is retrofitted onto the existing pillars of the assembly fixture. The Poke Yoke feature would act in such a way that if the hose was not fully push over the connector (to within the specified tolerance) then the pneumatic circuit would not be complete, due to the fact that the air switch would not be triggered, which would then mean that the signal to release the assembly on the locking connector slide would remain closed until the operation was fully and correctly complete. When realising the assembly cannot be released the operator is then triggered to check the hose over connector joints and readjust until correct which will then mean that the assembly can be released once correct and within tolerance.

The second of these solutions is an interpretation of an existing pump and hose assembly technique that is currently used in the factory but retrofitted across to this hose over connector operation, with a large impact on the footprint of the tool, due to the lever arm and slide needing to be fitted. This Poke Yoke feature works off of a lever arm system which forces the operator to push the hose fully over the connector barb to trigger the pneumatic switch. This will mean that the signal to release the assembly on the locking connector slide would remain closed until the operation was fully and correctly complete. When realising the assembly cannot be released the operator is then triggered to check the hose over connector joints and readjust until correct which will then mean that the assembly can be released once correct and within tolerance.

The third and final solution was reed switch Poke Yoke system. This system would be retrofitted to the existing pillars of the tool. It is a more complex system in comparison to the others in the way in which it would work. This system would work in such a way that there would be a reed switch mounted to the top of the tool post which would be connected to a circuit with a green and red light (pass/fail) the lights will remain red until the hose comes into direct contact with the reed switch which is set so that the hose will be over the connector barb and within the required tolerance. Once triggered the light will show green giving the operator an indication that the part is within tolerance and a signal will be sent to the locking connector slide to release the assembly from the fixture.

Once all of the ideas were finalised in their generation phase I then approached the companies subcontracted tool maker in order to gain quotations on what the cost would be for each modification, per pillar. He then came back with estimated quotations as shown below:



Evaluation of Solutions

When all three solutions were finalised with all of the data collected for each I found it was then time to evaluate them against my specification in order to come to the conclusion as to which was the best fit in order to solve the problem at hand. The first evaluation method I chose was 'Pros and Cons.' This was due to the fact that I found it very effective previously in the project and it is a well known and highly supported evaluation method. When undertaking this I followed the exact same format as previously, but this time I chose to include all of the specification points being met by each solutions and positives and each specification point being missed as a negative. This process was done for each possible solution and then tallied up at the end to show the best and most high-ranking solution in accordance with the specification points (All 3 Pros & Cons Evaluation tables can be found 36 & 37 of the Logbook).

I then went onto my second evaluation method, which was a Characteristic matrix for each possible solution. In this characteristics matrix I set the output variables to the specification points with a ranking of most important to least and the input variables to each aspect contained within the specification points. I then set a scoring system of:

- 1- Being Good
- 2- Being Satisfactory
- 3- Being Bad

This then allowed me to score each solution again in accordance to the specification but allowed me to delve deeper into what was required and whether or not the solution incorporated all of the most important points. This process was carried out for each possible solution and then closely deliberated by myself to come to the conclusion of which was the best and met all of the necessary requirements for the project to be a success (all 3 Characteristics tables can be found on pages 38, 39 & 40 of the Logbook).

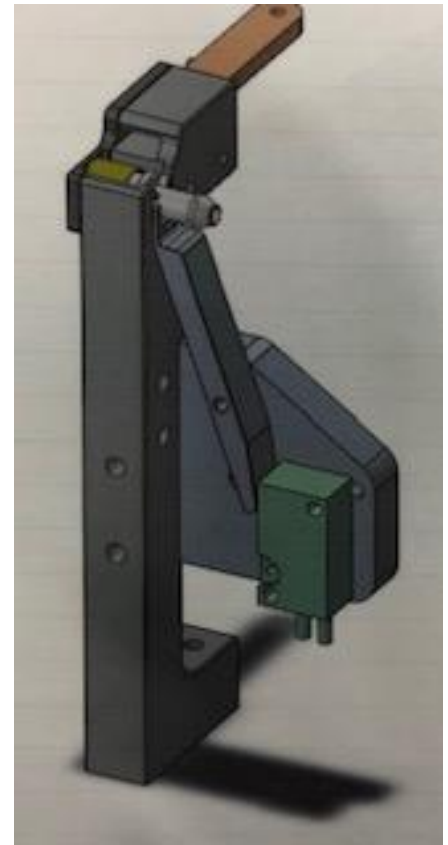
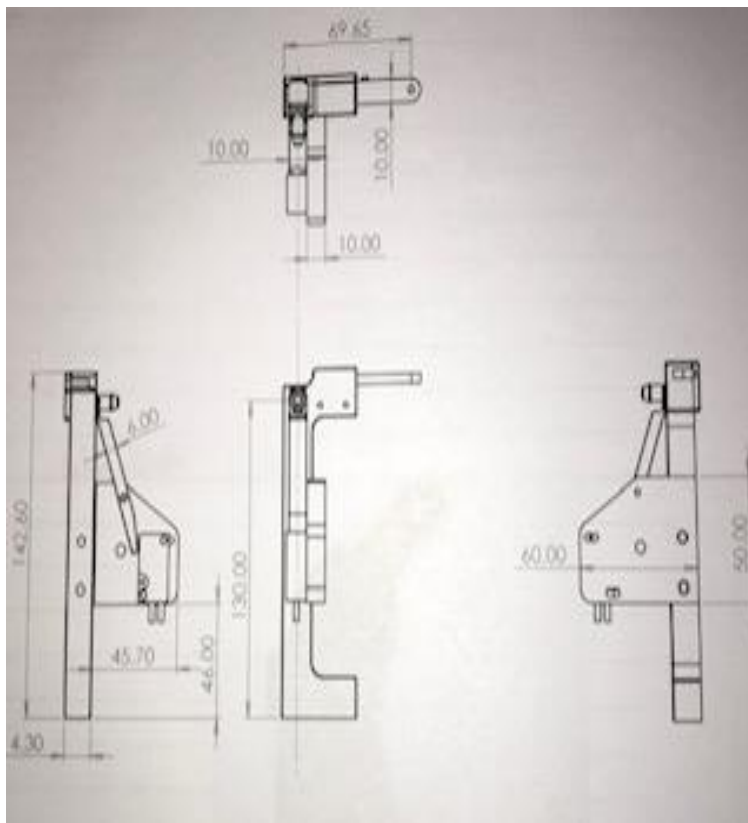
The third and final evaluation method I chose to use was Payback. This method allowed me to exactly calculate the amount of money being lost on a yearly basis due to this problem and how long it would take for the chosen solutions to pay for themselves by solving this problem and cutting out all additional unnecessary costs. From this calculation it then gave me the amount of months it would take for the modifications to pay for themselves and compare these figures to each other (All 3 payback evaluations can be found on pages 41 & 42 of the Logbook).

Finalising the Design of the Modification

Packham Engineering Services had previously been made aware of the design concept due to the fact that William Davies had previously reached out to him in his project selection phase for initial estimates of cost for the Tooling modification. Alan Packham (Director of Packham Engineering Services) came into KHE to finalise the Poke Yoke design with William. They firstly went out onto the shop floor and surveyed the Hose assembly Fixtures that had the possibility of being selected for the modification and dimensioned them.

Once Alan was happy with the overall fixture layout and shown the prototype which was developed by William the manufacturing team sat down with him in a meeting and discussed all of my requirements and provided him with the project specification. Everyone then agreed on what was required and Alan went away with the exact idea of what was required.

He then was given a 4 day period where drafted the design on the SolidWorks Application. He firstly produced the 3D model in order to give the team a visual representation of what he had in his head and everyone was very happy with it and agreed that it was exactly what was required to counteract the problem at hand. From the dimensioned that he has gained, he then went on to convert the 3D CAD into a 2D engineering drawing and provided this to William in order to archive as a reference and to set the standard for the modification. As shown below:



The design was then emailed to William Davies and it was circulated around the team for approval. The whole ME and Management Team were happy with the modification and approved this with Alan. Once approved Alan then confirmed he was happy to get involved with the project and produce and fit the required modification.

Gaining Quotation & Budget Code

Alan was then approached by William and sent the fixture details and was requested to quote for a single initial trial Poke Yoke device. With him already having all of the CAD data and also the Specified material he was very quick in turning around the quote, which was received.

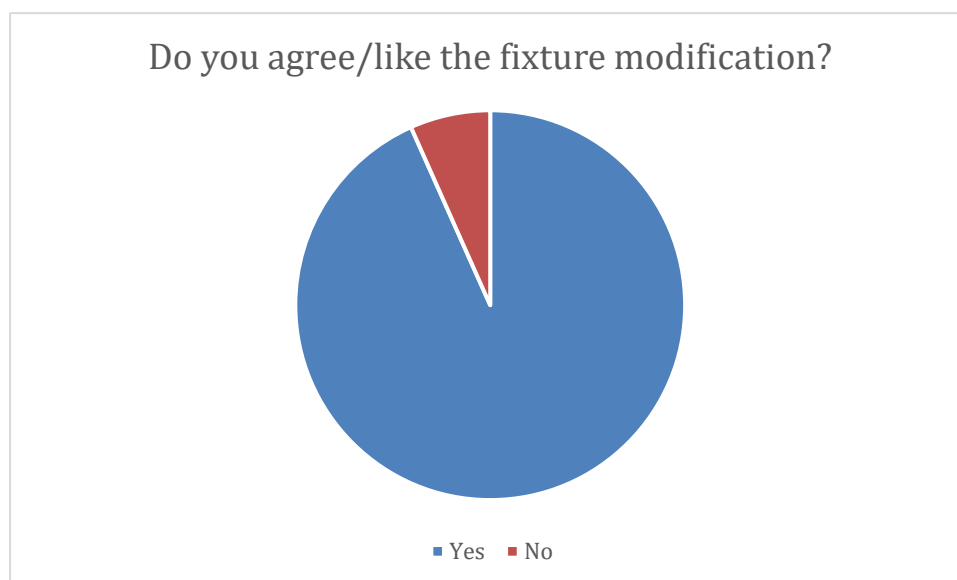
This quotation was then forwarded to Stephen Mills for approval and the Budget Code was requested from him.

He was very happy with the cost of the Poke Yoke including fitment to the fixture. He approved the cost and gave William the approval to use the Maintenance Budget code and instructed him to raise the order on that day. William then raised the order through the Sourcing system used in Kautex called Ariba.

For the trail fixture this cost centre allocation was suitable but if when the Poke Yoke is fully approved and set as a standard, the cost will be absorbed by initial project start-up cost by the customer.

Production Surveys

It was necessary to gain feedback from the production team, so a survey was undertaken on the Volvo production line. In this survey 30 operators from the line and the team leader of these operators were asked “do you agree/like the fixture modification?” when shown the 3D CAD and also the rough prototype. Their replies were as follows:



Reasons for the “No’s”:

1. Operator 1 said that they think it is ‘pointless’ and ‘operator’s shouldn’t have a job if they cannot complete simple operations.’
2. Operator 2 said that they think it will increase cycle times so they cannot hit their targets.

Team Leader – Overall Comment

I feel that this would be a hugely beneficial change within the process and will be a great asset to the overall Poke Yoke system of the fixture. As a whole the operators also really liked the modification and feel that the change needs to come as soon as possible. It gives the operators the piece of mind that the part is made correctly and they will have no comebacks on themselves by following the process exactly. There are always going to be a few pessimists within the bunch but I would take their feedback with a pinch of salt.

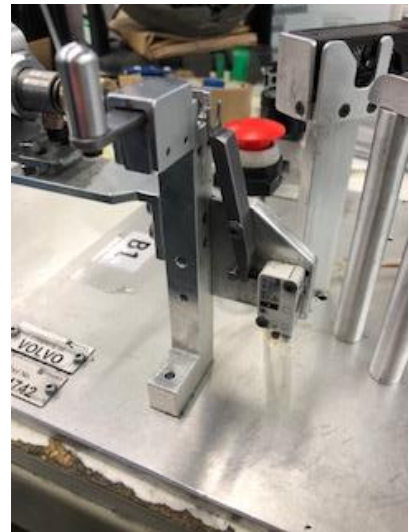
As a team we all reviewed the result of the survey and were very happy with it. This gave us the confidence in the design and spurred us on to continue as we have been in order to implement this trail modification and hopefully roll out in the future.

Poke Yoke Implementation

With the positive feedback and overall production buy in William called Packham engineering services and confirmed that he had received the purchase order. They confirmed that they would be able to start the Poke Yoke manufacture 06/02/19 and confirmed delivery date and fitment for 11/02/19.

When delivery date was confirmed William reached out to the planning department arranged a 1 hour timeslot for fitment of the modification and also production were given the heads up in advance in order for them to be able to build a months-worth of stock by running the job over 3 shifts instead of 1, due to the fact that the fixture will be out of serious production until signed off by all concerned parties. The contingency plan for this would be that the parts produced from the trail would be capable and would be suitable for production parts to make up and lost stock and to be able to meet delivery demands.

Packham Engineering were closely monitored by the team and given daily updates on the manufacturing progress to ensure that they would meet the timescale. The Poke Yoke was complete and fitted 11/02/19 by Alan Packham with the support of William. When fitting the Poke Yoke, the fixture was removed from the line and put into the Manufacturing engineering Room where it can be monitored and trialled in a controlled environment and does not pose a risk to anyone's personal safety.



1 - Trialling Modified Fixture

For the first Capability study of the modification it was decided that William would build the 30 parts required. This was so that the Modification could be tested in a controlled manner and there would be a guaranteed reliable result due to the knowledge of how to build the fixtures, no bias and also no time constraints against him. This also gave the team the ability to ensure that the modification was safe to use and did not affect the overall usability of the fixture.

The 30 parts were run off and allowed time to relax. They were then transported into the CMM room in order to be measured (previously arranged access with the Quality department). It was then decided that the best method of measuring the very small gap between the end of the hose and the connector was the quick scope machine, the measurement process was:

1. The small V-Block and Clamp were set up on the bed of the Quick Scope measurement machine.
2. The Quick Fit Connector was then clamped onto the V-Block and the camera was then positioned so that the Y-axis was flush to the end of the connector.
3. At that point it was then set to zero and the camera was moved across to the to the cut end of the hose along the X-axis.
4. When moving it from one end to the other it allowed William and the Quality Technician to precisely measure the gap left by the Poke Yoke between the cut end of the hose and the Quick Fit Connector.
5. The results were then noted into a table in preparation for the Capability test.

The results of the first measurement exercise were:

Part Number	Hose Connector Gap
	1 ± 1
1	0.500
2	0.860
3	0.285
4	0.350
5	0.560
6	0.721
7	0.477
8	0.540
9	0.790
10	0.701
11	0.655
12	0.423
13	0.829
14	0.410
15	0.650
16	0.650
17	0.830
18	0.639
19	0.669
20	1.070
21	0.540
22	0.599
23	0.466
24	0.734
25	0.410
26	1.070
27	0.455
28	0.720
29	0.700
30	0.460

The Capability test:

The same measurement method used in measurement phase of the project.

Capability Study Summary:

When looking at the capability study results, it clearly shows that the process is capable.

It shows that the CP & CPK values are leaning towards the lower limit of the tolerance, although that is what the aim was. This is due to the fact that the further the hose is pushed onto the connector barb the less chance and more resistance it will have to the water pressure forcing them apart.

Going forward, as a team the Manufacturing Engineering department felt that the modification needed a slight adjustment to bring the hose down to the lower specification limits again.

In order to push the capability results down towards the bottom tolerance of zero (has the most resistance to water pressure) it was decided that William himself could move the Pneumatic switch back a fraction so that the release tolerance is pushed closer to the bottom end. This will then fine tune the process and further include the quality of the parts produced by the fixture.



SOP Modification

With the initially successful trial results gained, it was decided that with the slight adjustment (shown above) the Poke Yoke system will be a viable counter measure for the problem being faced. With the modification being a permanent fix and now a part of the overall manufacturing process there was a need to update the Standard Operating Procedure documentation in order to incorporate the new fixture design change.

The process of updating the instructions proved to be very straight forward and the only change that had to be made to the documentation was updating the image on the Visual Aid and a small adjustment to the text instructions attached to it. This was done by one of the team going out and gaining the SOP from the production line, highlighting the required updates, pulling the digital copy off of the shared Manufacturing Documentation drive, archiving the original documentation for traceability and making the specified amendments. Once they were then made the old document was replaced on the system and the new documentation was printed off and went through the approval flow of the Health and Safety Manager, Customer Quality Engineer & the Manufacturing Focus Factory Manager.

The documentation once fully approved/signed off was scanned and PDF'd onto the shared Manufacturing Documentation drive as a back-up for the production line. Once this was done the team was able to reintroduce the documentation back onto the hose assembly line.

2 – Trialling Modified Fixture

With the slight adjustment to the Poke Yoke system it was necessary to re-trial/re-test the Poke Yokes capability.

Knowing the modification was now very close to being a perfect fit/control measure it was decided by the team that the next trial was for an experienced trainer to build the parts. This would then give a more realistic representation of what the general operator population would produce using the Poke Yoke system but with the training being very experienced, there is a lessened chance of bad parts being produced.

With the trainers being regularly available, it was very straight forward in gaining their time to come off line into the controlled Manufacturing Engineering room and run off the 30 parts required to conduct the Capability study.

Due to the effectiveness of the measurement process from the previous capability study it was decided that the same process of utilising the Quick Scope machine would give the best and most repeatable results which would ensure conclusive evidence of whether the slight tuning was beneficial.

The results from the second measurement exercise were: (Appendices 6)

Part Number	Hose Connector Gap
	1 ± 1
1	0.5
2	0.25
3	0.35
4	0.4
5	0.26
6	0.39
7	0.42
8	0.28
9	0.36
10	0.32
11	0.29
12	0.32
13	0.28
14	0.36
15	0.23
16	0.42
17	0.23
18	0.21
19	0.36
20	0.24
21	0.37
22	0.38
23	0.26
24	0.25

25	0.48
26	0.39
27	0.32
28	0.25
29	0.34
30	0.25

The Capability Test:

The same measurement method used in measurement phase of the project.

Capability Study Summary:

This capability study shows a positive decrease in the defect “Part Per Million.” The graph shows that the very minor adjustment made improved the capability in the teams opinion, due to the fact that all values/measurements have been pushed further towards the bottom limit of Zero which would produce the most reliable assembly part. This meant that there were no further adjustments required on the modification.

From these results it was concluded that the modification is Capable and safe to introduce reintroduce to the line. This approval was given by the Quality Engineering team and communicated back to the Engineering team through Daniel Phillips which is a Graduate trainee within their team.

3 – Trialling Modified Fixture

From the very positive result of the previous trial it was decided that the fixture could be reintroduced to the line. To ensure that the data collected gave a realistic representation of the Modifications effect on the Capability of the fixture, it was decided that the first 30 parts produced by the on-line operator would be Capability studied as a safe guard and final test for the Poke Yoke.

These parts were collected and measured by William Davies and Roger James using the exact same methods from previous trials.

The results from the third exercise were: (Appendices 7)

Part Number	Hose Connector Gap
	1 ± 1
1	0.42
2	0.24

3	0.31
4	0.46
5	0.30
6	0.33
7	0.38
8	0.34
9	0.31
10	0.37
11	0.32
12	0.24
13	0.26
14	0.28
15	0.32
16	0.26
17	0.34
18	0.40
19	0.32
20	0.26
21	0.34
22	0.40
23	0.32
24	0.28
25	0.39
26	0.34
27	0.42
28	0.34
29	0.21
30	0.28

The Capability Test:

The same measurement method used in measurement phase of the project.

Capability Study Summary:

These results again showed the team that the modification was completely capable and will serve as the perfect control measure for the problem at hand. All of the results collected showed repeatability

within the process and all team Manufacturing Engineering team members were in agreement that the process can be fully signed and a perfect control measure. It was then necessary to gain cost breakdowns for other fixtures in preparation for the management presentation.

Management Presentation of Project

With all of the concerned parties sign off of the Poke Yoke modification the concept was nominated as a possible standard throughout the Kautex Organisation. William Davies was nominated by Stephen Mills to present the concept to the management team at KHE along with the Global Managing Director at Kautex.

While presenting to the team William covered many areas, these included:

1. Explaining the existing problem and how it had impacted the company.
2. What control measure/ Poke Yoke had been implemented to counteract the problem.
3. A video clip showing the modification working and how effective it is.
4. The benefits of this change within Kautex's quality.
5. The potential of this Poke Yoke device and how it could help.
6. If the system was selected to be a set standard, what areas could cost potentially be driven down.

At the end of the presentation it was also informally discussed about the importance of the second pillar modification being implemented on the Leoni jig for a fully Poke Yoked assembly operation on the targeted part and to also be able to close out the QDR against it.

When this was mentioned, the management team came to the conclusion that with the presented data that the second modification must go ahead as soon as possible in order to keep the customer happy, and prevent any further issues on that jig.

Pillar 2 Poke Yoke Implementation

With the approval from the management at KHE, Alan Packham was called and given the verbal go-ahead to manufacture the second Pillar Modification whilst William Davies raised the order using the previous quotation and chased it through the external sourcing system at KHE called Ariba. When the order was fully approved and received by the tool maker, he confirmed the delivery date of 22/03/19.

With this confirmed delivery date a verbal conversation between the Manufacturing and Engineering teams occurred which would enable the jig to be released from production for an hour, so that the modification could be fitted along with the documentation being updated.

Once manufactured by the tool maker William Davies personally retrofitted the second modification to the tool post and connected it up to the pneumatic system. 3 assemblies were built and the total hose length was firstly measured to ensure that the Poke Yoke hadn't altered the length. He then went onto measure the gap between the connector and cut end of hose to ensure that it was equally as efficient as the first. The result from the initial tests were:



Hose Length	
Number	Length
1	1178
2	1162
3	1173

Connector Gap	
Number	Length
1	0.29
2	0.31
3	0.36

These results showed the team that the second fixture modification was capable and within spec, so no further tests were required.

Second SOP Modification

With the Modification completed, it was essential that the SOP was made to suit. This was very important due to the fact that all documentation provided to the production line must be up to date and communicate to the operator the exact procedure of using the tool provided to them.

This was a very straight forward change consisting of a quick swap and change of images on page fur of the Visual Aid. The reason why the written instructions did not change was due to the fact that there was no physical change to the operating procedure.

This change took a matter of minutes and the documentation was updated on the line at the same time as the fixture was being modified, resulting in very little impact to production time on the tooling.

Control

With the full implementation of the Poke Yokes the team decided that creating and implementing a control plan was essential to maintaining the standards within the project to ensure success.

It was decided that one weeks worth of forms would be provided to the production line Team Leaders and stored at the front of the SOP's and were to be filled out by each operator before the start of each run and will be reviewed each day by the team leader and representatives from the Manufacturing and Quality Engineering departments as a control measure for the implementation of the modification.

Control Plan:

Actions	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Operator Start-Up Checks												
TPM												
Design Review												

1. The operator start up check sheet must be populated on a daily basis and closely monitored by the Manufacturing Engineering team and adjustments can be made if and when necessary.
2. The TPM on the modification will consist of the modification being fully stripped down and cleaned using the provided equipment, visually assessed for any wear or sharp edges and the pneumatic triggers checked to ensure that they are still in operational condition. Then the maintenance technician will rebuild them so that they are secure and then have the operator to check that they are satisfied with the work and then the jig can be released back into production.
3. There will then be a design review 6 months into the implementation phase of the project where representatives from each departments involved will discuss any issues or slight changes are required to fine tune the modification.

Conclusion

To conclude, this has been a very large and vital project within KHE and Kautex globally. Many different techniques and people were involved within all aspects of the project in order to take it to its completion date. Overall it is felt to be a great success and milestone which the Manufacturing Team at Kautex has overcome, resulting in a very robust process being implemented and avoiding large and serious consequences from customer related faults. All aspects of the project have gone ahead to plan with very little adjustment. Within the Automotive industries often fast paced and frantic environment it is very often that full project completion isn't achieved and a quick fix is implemented, but this has not been the case. Each step of the project was completed to the highest standard achievable, with little to no points missed. This is why the result was one of the most robust process improvements implemented within the business in recent times. Not often that a project is implemented with little to no comebacks but this one most certainly has!

Evaluation

Comparison to the Specification:

Specification Points	Does it meet the Specification	Reason
Performance/Functionality	Yes	The implemented solution ensures that all operators push the hose over the connector barb and up to the shoulder of the connector with a gap less than 1mm.
Reliability	Yes	The solution ensures that 100% of parts are within tolerance by not realising them until the set pneumatic switch is triggered.
Operational Conditions	Yes	The solution has had no effect on push forces.
Scale of Operation	Yes	This solution can be retrofitted across any fixture within Kautex.
Maintenance	Yes	The implemented control plan specifies that all modified fixtures must be maintained and monitored on a monthly basis.
Cost	1/2	The cost of fixture implementation came in at a cost of £180 per fixture which is significantly under targeted costs and TPM also costs will be at its highest of £85.23 for the first year but will be decreased significantly in on going years.

Aesthetics	Yes	The solution encompasses all specified materials and components in accordance to the specification.
Ergonomics	Yes	The solution has no effect whatsoever on cycle times or the complexity of the operation.
Size/Weight	Yes	The solution attached onto original tooling posts which does not impact tooling footprint and weighs next to nothing and enables the fixtures to remain a 1 person lift.
Capacity	Yes	The solution is 100% accurate and checks every assembly which is produced to ensure it is within the specification limits.
Health & Safety	Yes	The solution runs of 2 bar pneumatic pressure with all edges/materials free from burrs and sharp edges, it also does not have any impact on the push forces which were within the specified limits before the modification, the fixture also remains a 1 person lift due to the lights modification. All hand operations have not been effected and doesn't increase the risk of injury when using the modified fixture.
Legislation	Yes	The solution is within compliance of the Rula and KIM recognised standards within the Kautex organisation.

When reviewing this evaluation, it was felt across all boards that the project has been a great success. Nearly every aspect of the specification was achieved with one slight issue around the cost of TPM on the fixture yearly. The reason why this is higher than the previously targeted amount is due to the fact that the spare piece part costs were absorbed by this and have taken a greater initial investment. In future years to come this will decrease due to having the spare parts already and only labour being the contributing factor to TPM costs.

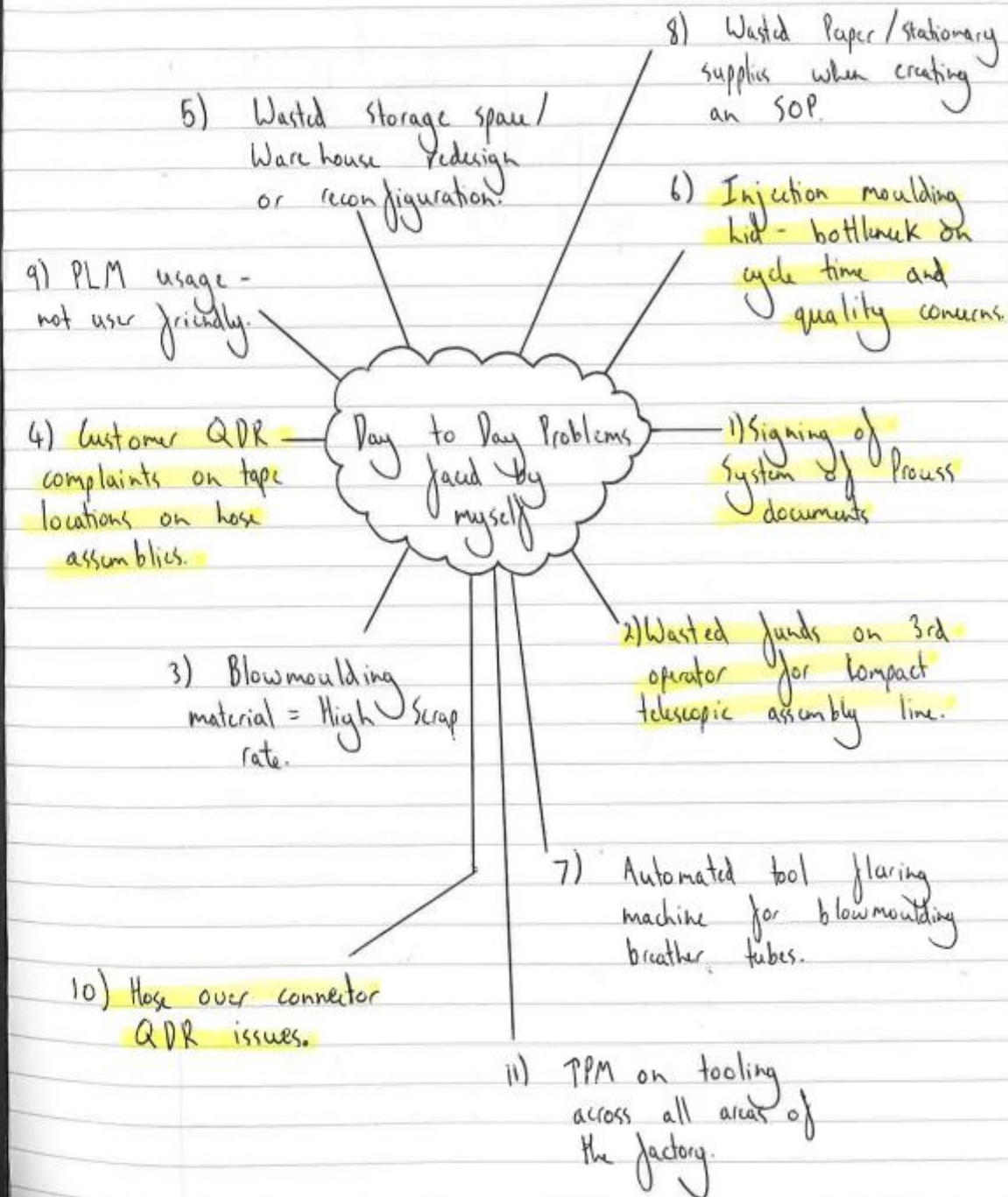
References

N/A

**"IF YOU FELL
DOWN YESTERDAY,
STAND UP TODAY!"**

H. G. Wells

NEVER GIVE UP

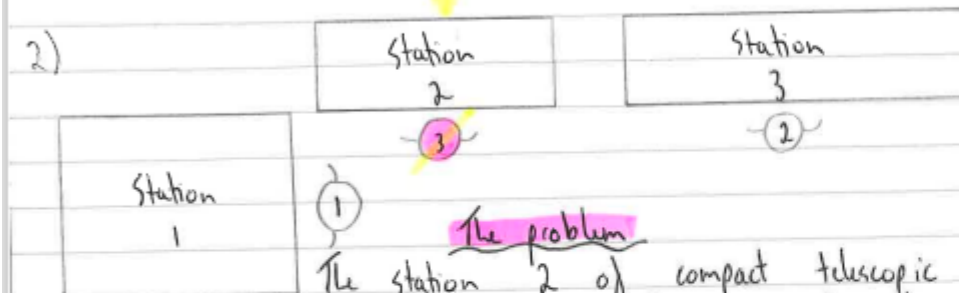
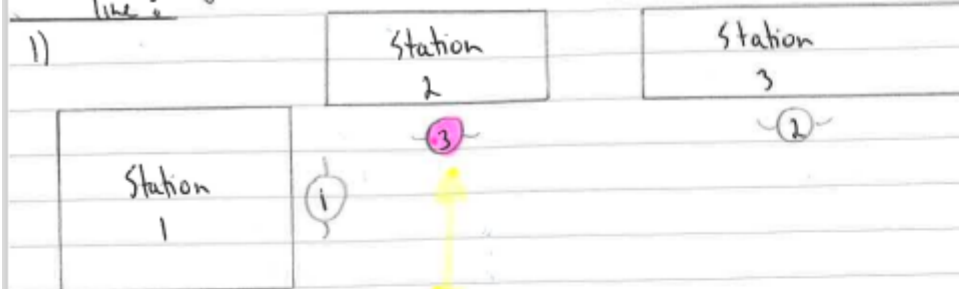




Project Timeline.



2) Wasted funds on 3rd Operator for compact telescopic assembly line:



The problem

The station 2 of compact telescopic (eyeball insertion) produces 2/3 times of the number of parts in comparison to stations 1 and 3.

This often means that the third operator is waiting around to make the parts due to the bottleneck of other 2 stations.

This means that there is a significant amount of their day as non-value added ~~data~~ labour (collecting parts).

Robo tised Station 2

If the station is automatic then both operators could be cut out and run 24/7 to build stock.

Operator 1 running stations 1/2

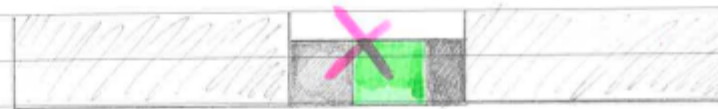
This would cut out the third operator on both lines and all work taken out will be value-added.

Solutions

Rotate Station 2:

If station 2 is rotated then the 3 operator can work between the stations and it will cut out 1 operator which would be a huge saving.

4) Customer QDR complaints on tape locations on hose assemblies:



The problem

This is an existing / ongoing issue faced by the company on a regular basis.

The issues faced:

- Operators facing disciplinarys due to the lack of care being taken when taping hoses.
- QDR customer fines for incorrect parts being produced.
- Wasted funds on reproducing parts that should've been correct in the first place.
- Not all benches have the newly introduced intelligent bench system so lots of issue are still going unseen.

Colour coded tabs:

If the colour of the tapes were attached in tap form to the base of the tool then it reminds the operators to tape.

100% check on each project:

If a 100% check was implemented then this would mean no part would go unchecked for missing tapes or tapes in the wrong position on the hoses.

Spring loaded tape locators:

If the tape locations were clearly indicated with a spring loaded device such as this it would be ~~by~~ poka yoked so they physically couldn't ignore it.

Solutions

6) Injection moulded lid - bottleneck on cycle times and quality concerns:

The problem

The problem that the company has with injection moulding the windscreen washer container bottle is that the 2 halves of the bottle are moulded at the same time. The problem with this process is:

- Increased cycle times on base due to lid being more complex.
- Higher scrap rate of good parts due to bases being correlated to lids for no reason.
- Vast amounts of storage space wasted due to parts being made when not needed to keep up with production.

Re-engineer base-lid ratio to make them equal:

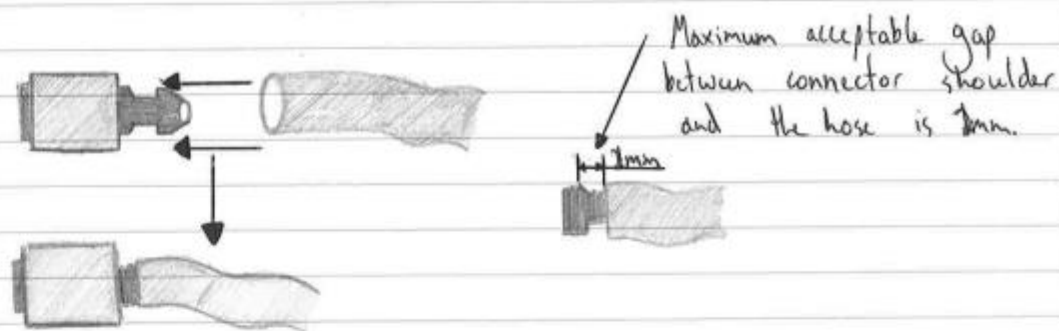
If the lid and base were redesigned to an equal complexity and size, it would equalise the process and remove the bottleneck in the process.

Solutions

New tooling to run separate halves:

If the lid and the base were run using separate tools, it would mean that lots of bases would be made quickly and be stored ready for when the lid is produced.

10) Hose over connector - QDR issues:



The problem:

Over the last few years there has been several issues with this procedure. This is a huge part of our production line at Kaultex due to the fact that every single hose assembly fixture contains a hose-over-connector action and if the checks are not thorough initially, lots of assemblies are slipping through the net and causing financial problems for the company. The issues the company are facing at the moment are:

- Large QDR customer fines due to wrong/incorrect parts.
- Financial implications due to extra checks having to be taken out.
- " " " " training needed.

Increased training on maintaining standards:

If the group of operators causing this problem could be found, they could be given extra training and a 100% check could be taken out on their work until it was up to standard.

Air-Sprung trigger:

If an airsprung trigger was implemented it would create a very effective poka yoke addition to our system as this would not release the fixture until the hose-over-connector tolerance was reached.

Solutions

Best 3 defined problems

Examples of the problems being faced:

HONDA
The Power of Dreams

Confidential, property of Honda

Line Support Incident Analysis Sheet

Utilise drop down box

Supplier Code and Name	1T0032 Kautex Texton Cvs Ltd
Part Number	76801 TGG E011
Part Name	WASHER COMP WSHLD 2.5L FR RR
Concern Title	MIS-SET TUBE
Utilise drop down boxes	
Effects to Honda	Miss - Assembly
	Rework
	Stock Check

Problem Rank	Nuisance Rank	Document Control Number
A B C	A B C	Date 05 July 2018
PIPS raised	PIPS number	PTS No 027020
QIR raised	QIR Number	

APPROVAL	CHECKED	ISSUED
		JONATHAN HAINES
Supplier Return Date		

Initial Non-Conformance	Qty	Reject Sticker Number	Recurrence
	1	TBC	Y N

CONCERN DETAILS

Who, What, When, Why, Where, How, How Many

WHO: Concern reported by Assembly Frame on CIVIC on WASHER COMP WSHLD 2.5L FR RR
(Found the concern, raised & part)

WHAT: Process associate discovered the Tube partially set to the bush
(In the concern / description on parts or car)

WHERE: HUM - AF Zone 6
(Add the concern stock)

WHEN: 05/07/2018
(Was the concern detected)

WHY: As the Tube is not fully set to the bush, this causes a risk to leakage failures & ultimately incorrect to Drawing
(Have we judged the parts as NG to drawing or spec)

HOW: First identified during fitment, Drawing verified which states "insertion dimension 'a' to 10mm min"
(How was the concern identified, how was analysis carried out, i.e. CPM, shadowgraph, future etc.)

HOW MANY: AF detected x3 in the NG state, x1 more found by line support during initial containment
(Cars / parts affected)

Additional Comments A full stock check is required on all variants & derivatives to ensure drawing condition. Please forward a LPN cut off for verified stock.

CONTAINMENT ACTIONS

Utilise drop down boxes

STOCK CHECKS REQUIRED	HUM	SDC/WAREHOUSE	PARTS IN TRANSIT/SUPPLIER
-----------------------	-----	---------------	---------------------------

Primary Containment at Honda			
Check Mark	Containment 1st VIN / EIN Number		

100% of stock checked at Kautex across all washer bottle variants. Sort still ongoing. x100 NOK parts found as of 10:15.

Containment Actions at Supplier	Supplier Check Mark	Containment IPP tag N°	LPN (Licence Plate Number) of Odette label from 1st Delivery of confirmed OK Parts
			1T0032-01-63183861

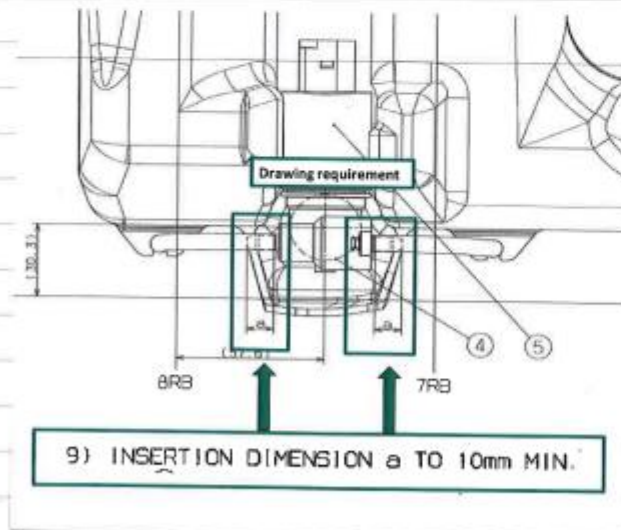
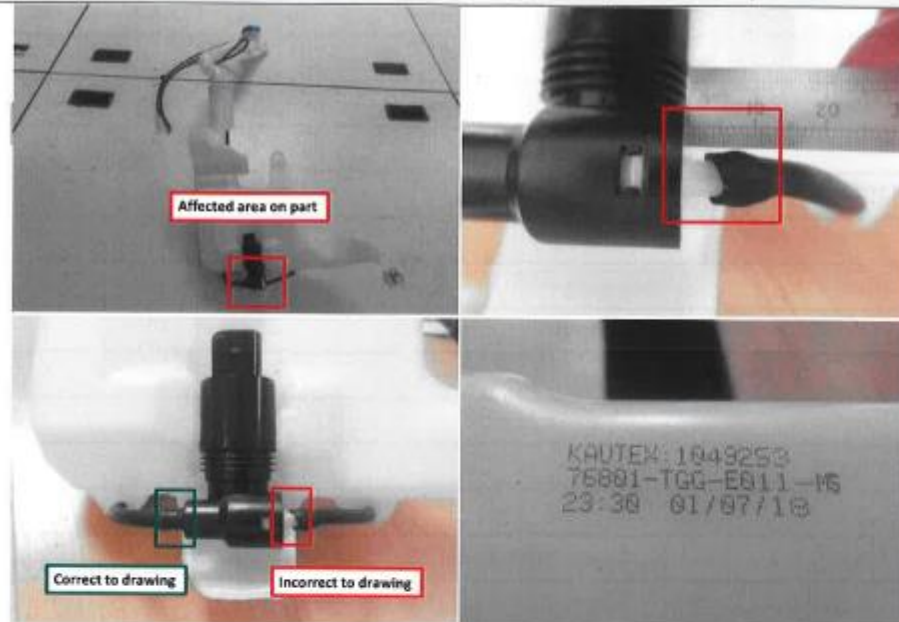
Utilise drop down box

DOCUMENT RAISED BY	JONATHAN HAINES	Contact Number	Date 05/07/2018
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Document control number.	
Date	05 July 2018
PYS No	007825

Line Support Incident Analysis Sheet

Attach analysis pictures and any other appropriate analysis data.



AA3170
Enclosure 1/01.10
Page 1 of 3

Claim report

LEONI

Grey areas to be completed by LEONI

To	From	Claim N°:
Rowles, Philip Philip.Rowles@kautex-textron.com	Name: BASSOU Fatima Department: AQF Phone: +212 6 11 45 66 02 Mobile: E-Mail: fatima.bassou@leoni.com	Date: 27/11/2017
Copy		Inc. inspection
Helen.Lewis@kautex-textron.com		LEONI prod.
		Customer prod. ☒
		Warranty
		Recurrence: YES ☐ NO ☒
		Customer Incident Number:

Component Identification	Supplier: KAUTEX TEXTRON CV5 LTD Part designation: WATER TUBE	Supplier part N°: 1052333002 LEONI part N°: P00290416
--------------------------	--	--

Problem description (5W 2H) complete information with pictures, sketches... if necessary

What happened?	Washer hose not conform (Part deformed).
Why is it a problem?	Not conforming with drawing.
When detected?	27/11/2017.
Who detected?	Operator.
Where detected?	In production line.
How detected?	At the time of assembling.
How many bad parts?	50cases.

Traceability (complete information with pictures of the labels if necessary)

Component traceability	Product reference	Prod. date	Shift N°	Time	Cavity	Others
Packaging traceability	Delivered quantity	Delivery note N°	Delivery date			
Comments						

LEONI actions already engaged:

Non Quality Costs: Based on your responsibility level, all costs supported by LEONI due to this quality issue will be charged to your company. Details of those costs will be notified later.

LEONI expectations from Supplier

YES	NO
☐	☐
	For information only, no feed back from supplier expected.
☐	☐
	Singular defect.
☐	☐
	Serie defect, sorting done by LEONI for account of the supplier until response.

FEEDBACK EXPECTED WITHIN 24 HOURS MAXIMUM. See details on next page

Grey areas to be completed by the supplier; tick grey cells to formulate your decision

Supplier commitments for raw material			
Replacement of the affected parts within 24 hours by the supplier/vendor			
Quantity:	Delivery date:	Time:	
Identification:			
Sorting of the raw material within 24 hours by supplier/ vendor			
Sorting of the raw material by LEONI to be charged to supplier/vendor			
Request to send back delivery at risks			

Supplier commitments for WIP and Finish Goods

- ☐ Rework of WIP and finish goods by supplier / vendor within 12 hours
- ☐ Rework of finish goods by LEONI to be charged to supplier/vendors
- ☐ Scrap to be debited to supplier / vendor

Supplier comments:

Supplier agreement
Name - Date - Signature

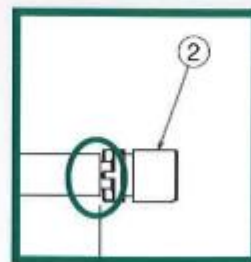
to be completed by LEONI

Additional data : pictures, sketches concerning defective parts

BAD PARTS



GOOD PARTS



Fire wall incidents

Part No.	No. of Parts	Date
0000 13461	1	20/01/19
10000 13491	3	20/08/18
40000 10040	2	23/03/19
40000 13461	1	08/02/19

Problem Costs Incurred

04/10/18

Cost / technician / week = \$2848.56

Customer costs for the last year = > \$1000 (cannot release exact figure)

Quality Department dealing with issue = 7 \$600 per issue

Hose Stretch / Shrinkage:

EPDM hose is prone to stretching. Especially when operators are not taking care when laying the hose into the tool / fixture they will stretch it and if left to sit in the fixture it will shrink and pull off the connector.

SOP Documentation:

If this documentation is not correct and does not specifically specify that the hose needs to be pushed right up to the shoulder of the connector, the operators will not do so.

Possible Reasons for Problem

Training:

Even though the SOP documentation is provided for the operators to read at all times, they are all firstly trained by a qualified trainer. If the standard of training isn't up to scratch then this could easily become an issue.

Operator Negligence:

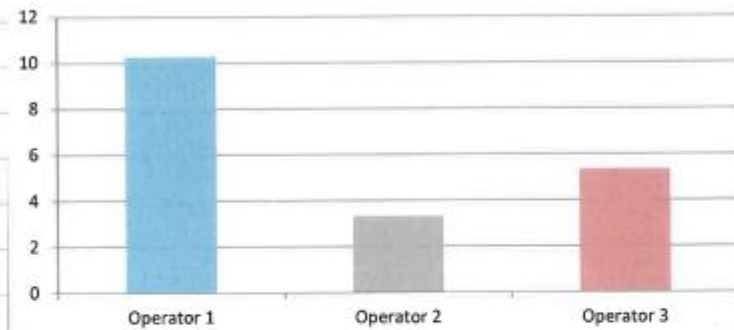
With all manual tasks there is a margin for human error. If the operators are not concentrating or have a lot of pressure on them to produce parts, the chance of them not completing operations like this is very high.

2) Wasted funds on 3rd operator for Compact telescopic assembly line.

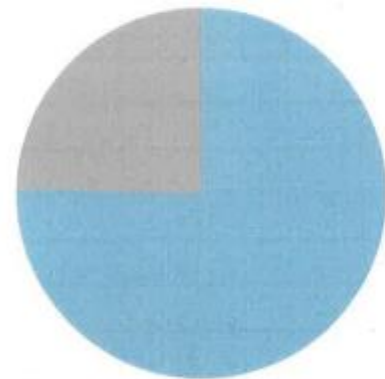
Operator	Operator 1	Operator 2	Operator 3
Operator Time (s)	10.274	3.33	5.34
Machine Time (s)	10.997	3.572	25.38
Total Time (s)	21.271	6.902	30.72

Examples of the Problem being faced:

Operator Time (s)

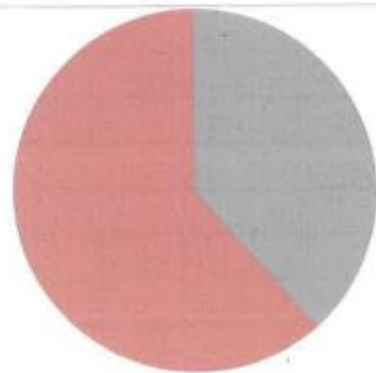


It is evident that Op 2 has the least work load and is being wasted.



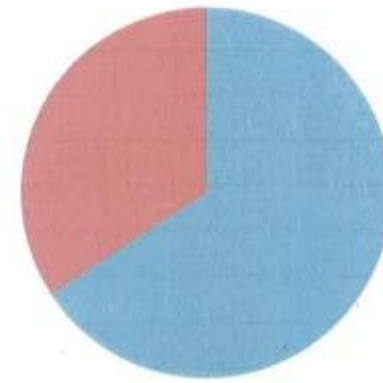
Operator 1
Operator 2

least time working = Op 2.



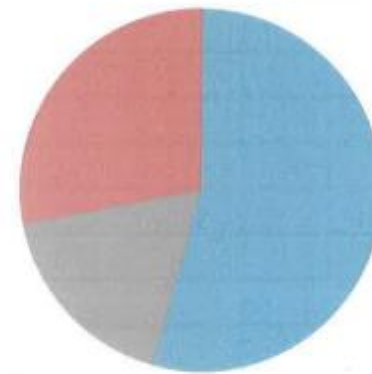
Operator 2
Operator 3

least time working = Op 2.



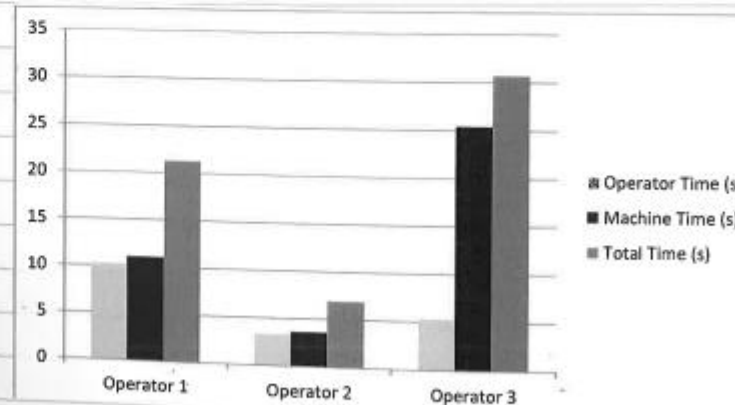
Operator 1
Operator 3

least time working = Op 3.



Operator 1
Operator 2
Operator 3

least time working = Op 2.



At every operation stage they are waiting for the machine to complete task.

After prior investigations by the CI department, machines are running at maximum capacity.

If the operator 2 is not doing all assigned roles expected of them and are coasting then the company is not gaining the maximum out of their labour.

Possible reasons
for problem

Other Operators not working fast enough:

As my work balance charts show, operators 1 & 2 are working significantly slower than operator 2, these could have the potential to be sped up to increase productivity and improve work balance.

Complexity of tasks not occupying operator 2 time:

Operator 2 may not be given enough to do, this means they are waiting around for the other 2 stations to catch up. If all operations are not value added then this means the company is paying for something that is not beneficial / profitable.

3) Signing of System of Process Documentation 06/10/18

 KAUTEX A Textren Company	PACKAGING SPECIFICATION		SAP No	4000012525																		
	DESCRIPTION : Screen Wash Hose Assy	KIM SCORE	DATE :	12/02/2016																		
CUSTOMER : VOLVO Y555	1051300 001	CUSTOMER PART NO : 31457824	Karban No																			
PACKAGING CODE / DESCRIPTION 780 Emb LID - 5100000271 780 Emb BOX - 5100000269 9 x KRAFT PAPER SHEETS 21910 (565 x 365) ODETTTE LABEL																						
PACKAGING METHOD 1. COIL 2 PARTS INTO BOX AS SHOWN 2. COIL NEXT 2 PARTS INTO BOX WITH A PAPER DIVIDER OVER THE FIRST 2 PARTS 3. REPEAT FOR 8 MORE LAYERS, BOX QTY OF 20 TO COMPLETE BOX 4. ATTACH ODETTTE LABEL TO BOX																						
PACKAGING INFORMATION <table border="1" data-bbox="1578 1178 1665 1451"> <tr><td>QUANTITY / BOX</td><td>20</td></tr> <tr><td>QUANTITY / LAYER</td><td>2</td></tr> <tr><td>NUMBER OF LAYERS</td><td>10</td></tr> <tr><td>WEIGHT (KG)</td><td>3</td></tr> <tr><td>PACKAGING SUPPLIED BY</td><td>VOLVO</td></tr> </table>					QUANTITY / BOX	20	QUANTITY / LAYER	2	NUMBER OF LAYERS	10	WEIGHT (KG)	3	PACKAGING SUPPLIED BY	VOLVO								
QUANTITY / BOX	20																					
QUANTITY / LAYER	2																					
NUMBER OF LAYERS	10																					
WEIGHT (KG)	3																					
PACKAGING SUPPLIED BY	VOLVO																					
<table border="1" data-bbox="1706 1451 1834 1587"> <tr> <td>DEPARTMENT</td> <td>SIGNATURE</td> <td>DATE</td> </tr> <tr> <td>MANUFACTURING ENG</td> <td></td> <td></td> </tr> <tr> <td>MANUFACTURING</td> <td></td> <td></td> </tr> <tr> <td>QUALITY</td> <td></td> <td></td> </tr> <tr> <td>LOGISTICS</td> <td></td> <td></td> </tr> <tr> <td>SALES</td> <td></td> <td></td> </tr> </table>					DEPARTMENT	SIGNATURE	DATE	MANUFACTURING ENG			MANUFACTURING			QUALITY			LOGISTICS			SALES		
DEPARTMENT	SIGNATURE	DATE																				
MANUFACTURING ENG																						
MANUFACTURING																						
QUALITY																						
LOGISTICS																						
SALES																						



All sections need to be signed and dated by every department in the factory. Often managers aren't in and are hard to contact.

Problem Costs incurred

Weekly labour cost = \$33.80

Monthly labour cost = \$135.20

Yearly labour cost = \$1,622.40

(Month)
Cost of Paper ~~135.20~~ = \$41.20

Wasted Paper/Ink:

A huge amount of stationary supplies are wasted when producing these documents. Often these documents are lost by the operators and have to be replaced.

Management not fulfilling role:

There has been easing in the past where certain members of staff will avoid signing these documents due to their busy work load.

Possible reasons for Problem

Unnecessary Departments Signing:

There are several departments that have no involvement with the packaging and shipment of the parts. Therefore the time is wasted on chasing these signatures.

Out of Date process:

Intelligent hose assembly bench systems are being implemented into our factory. This means that paper copies will be phased out in the near future.

Initial Evaluation

1) Hose over connector - QDR Issues - Evaluation.

Pros

- Readily available resources and funding. +
- Backing from all parties. +
- Lots of data readily available. +
- Huge quality benefits/improved process to main process in the factory. +
- Customer complaints resolved and improved relations. +
- Resolves an ongoing problem and takes pressure off quality/plant in general. +
- Potential payback = Good. +
- Achievable within designated time frame. +
- Good reflection on myself if implemented. +
- No other existing Poke Yoka system in the world like it. +

Cons

- Initial costs relatively high. -
- Very large project to roll out across all fixtures in the plant. -
- Increased cycle time. -

$$\begin{aligned} \text{Total score} &= + + - \\ &= 10 + (-3) \\ &= 7 \end{aligned}$$

2) Wasted funds on 3rd operator for Compact telescopic assembly line - Evaluation

Pros

- Cost saving on extra operator. +
- Greater level of value added work. +
- Work balance on the cell improved. +
- Improved working environment for the operator. +
- Low cost activity. +

Cons

- Could possibly overload the second operator. -
- Quick fix = not a big enough project to meet all criteria. -
- The working time of operator 2 could then be too much which would make the operation of cost saving a failure. -
- Operators have more people to talk to.
More talking = less parts and extra costs. -

$$\begin{aligned} \text{Total score} &= + + - \\ &= 5 + (-4) \\ &= 1 \end{aligned}$$

3) Signing of System of Process Documentation - Evaluation

Pros	Cons
• large cost saving on ME team not having to waste time getting signatures. + • Puts the onus on document assessors. + • Saves alot of money on stationary supplies. + • Valuable asset to the intelligent bench project. +	• Alot of people will ignore the document and it will never be signed. - • Funding may not be available for this type of project. - • Lots of people will be irritated by the automatic pop up. - • If the manager is away for some reason then there will be a hold up on the document until the person returns. Hold up = extra costs. - • Intelligent benches are not connected to the hardrive so the documents would have to be manually uploaded. -
Total Score = + + - = 4 + (-5) = -1	

Evaluation Conclusion

Now that I have weighed up all possible solutions, I feel that the best project option for me to go ahead with is option 1 - Hose over connector - QDR Issues.

The reason why I believe this is the best option is because:
1) I have a strong backing and support from the Kautex management team.

2) Lots of pressure on the quality department to resolve this problem which has not yet been done.

3) Newly ~~introduced~~ introduced company initiative to close out all QDR's as soon as possible by implementing a viable solution.

4) Funding is readily available for the project now.

5) Tool maker available to give support and produce the solution if and when necessary.

6) It is an achievable project within the allotted time frame.

7) There is lots of data available to support the project.

Numerical Evaluation

Idea	Score
1	7
2	1
3	-1

These results show that my chosen idea has produced the highest evaluation score, which proves it is the best issue to solve.

Final
Numerical
Evaluation
of Cost
to Connect QDR
17/10

Specification

solution specification on hose over connector - 4.2.2

Performance/Functionality - My solution must ensure that the operators have to push the ~~hose~~ hose over the connector barb and up to the shoulder of the connector with a gap of no more than 2mm. Tolerance = $1\text{mm} \pm 1$

Reliability - My solution must ensure that 100% of parts produced are within the specified tolerance of $1\text{mm} \pm 1$.

Operational Conditions - My solution must not affect the functionality of the existing tooling, e.g. cannot increase the push force of 42 Newtons.

Scale of Operation - My solution must be flexible enough to be able to be implemented on problem tools and any new tools coming into the factory.

Maintenance - If a tangible solution is implemented, it must have a monthly PPM taken out, but if the solution is process it must also be reviewed monthly.

Cost - My solution implementation costs must not exceed \$350 per tool and maintenance costs of no more than \$50 per year.

Aesthetics - If tangible, my solution must be made from a combination of Mild steel and tooling steel. It must also incorporate an air trigger to release the part.

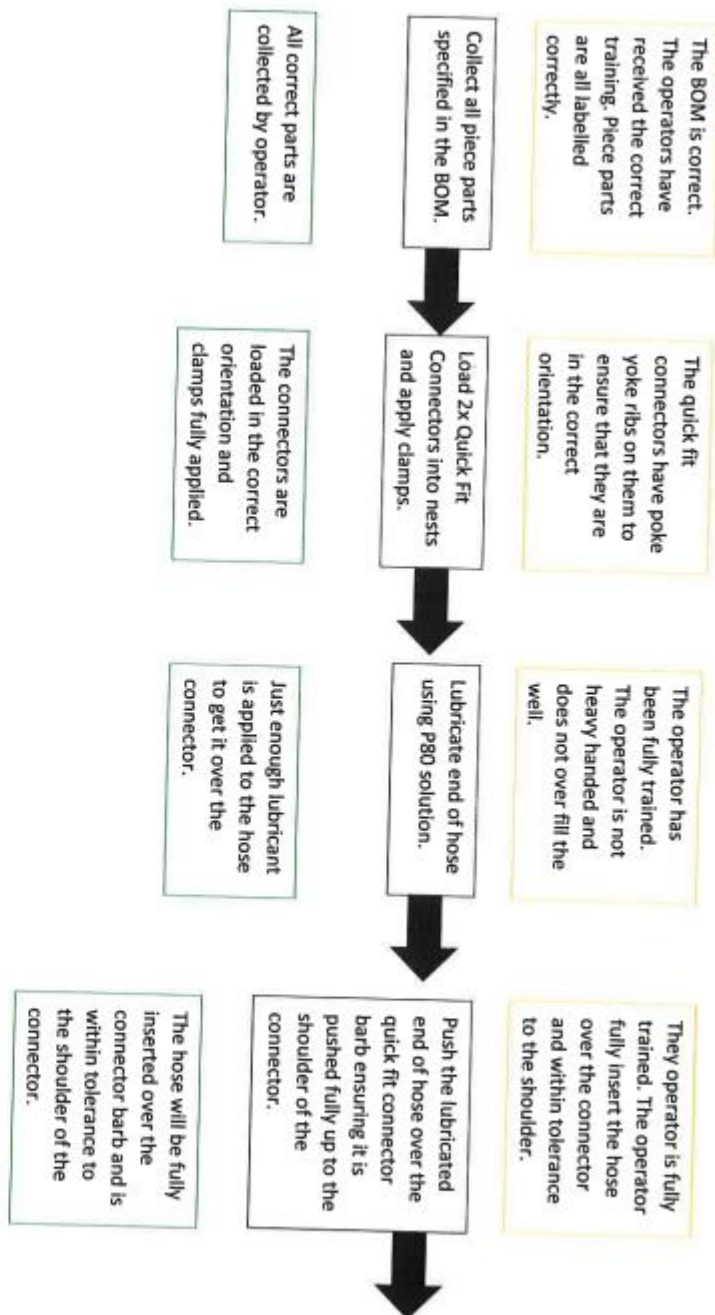
Ergonomics - My solution must have no adverse effects on the cycle times or ease of use of the tool, no more than 25.6 sec per ^{mt.} part.

Size/Weight - My solution must not ~~have~~ have any impact on the tooling footprint and must not increase the weight by any more than 500g.

Capacity - My solution must make sure that it checks for the problem on every hose assembly that passes through the tool and it is with the $1\text{mm} \pm 1$ tolerance.

Health and Safety - My solution must be able to run off of 2 bar pneumatic pressure; All edges/corners must be rounded off and not sharp; must not cause the operator to exert more than 10 lbs

Process Map



22/10/18

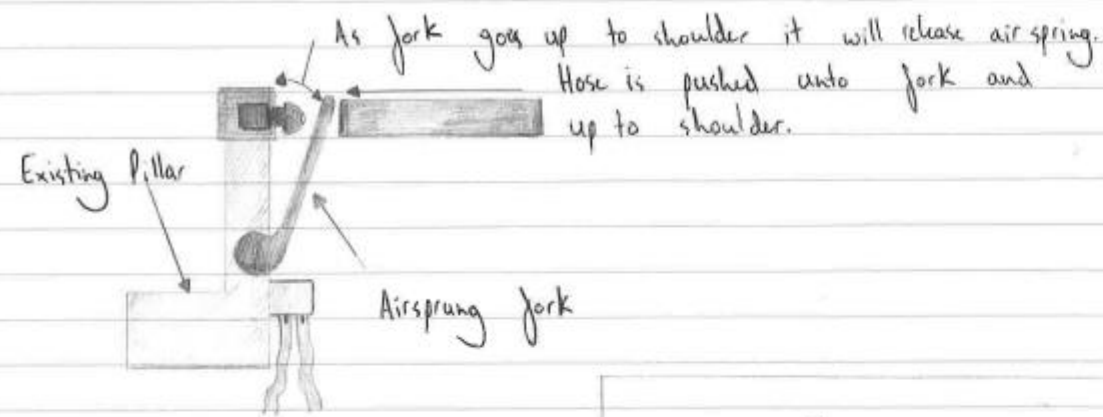
of force to complete the operation; must not have an adverse effect on the amount of people needed to lift the fixture, it must not exceed 25kg to remain a 1 person lift; must be designed to that all hand operations are safe and doesn't increase the risk of injury on the fixture.

Legislation - My solution must be within the Textron's Manual tooling Handbook. *NUMERICAL DATA INCLUDE RE-LOOK AT SPECIFICATION THEN LOOK FOR SOLUTIONS TO PROBLEM. R24110*

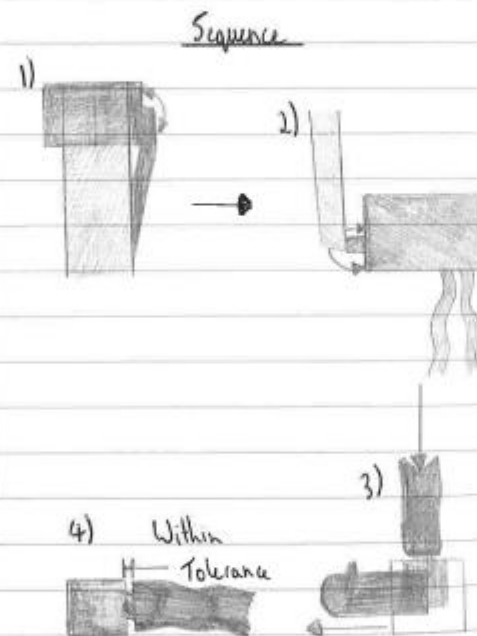
- Rule recognised standard.
- Kim recognised standard.

1) Hose over connector - Air sprung fork release

7/11/18



The fork will be at the nominal width of 1mm to ensure all parts are within tolerance & the width will differ depending on the width of the hose.
 1mm
 Dependent on hose length.



The fixture modification sequence works as follows:

- 1) The release fork will sit just behind the shoulder of the barb (connector). As the hose is pushed over the barb it will engage the fork and when within the correct tolerance the fork will stop at the tool post.
- 2) Once the barb is up to the pillar it will trigger the air switch at the bottom of the pillar.
- 3) Once the air switch is triggered it will complete the pneumatic circuit which will release the forked slide and will allow you to remove the part from the fixture.
- 4) Within H - Tolerance

4) This fixture will ensure that the hose over connector is within the specified tolerance of $1\text{mm} \pm 1$. If any of these operations fail within the sequence and the gap is out of tolerance the part will not be released until it is exactly correct.

Good Progress!
Includes Process map.
Continuous improvement
Date: 7/11/18.

Prototype Examples:



Estimated Costs:

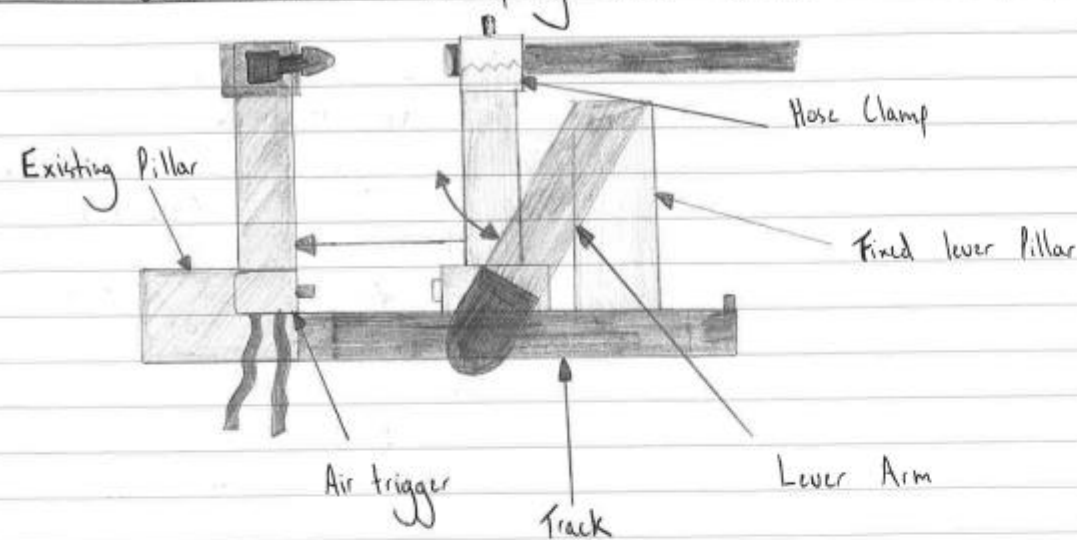
\$180 for full fitted assembly on fixture.

BOM =

1. Tooling Steel fork.
2. Air Trigger
3. 1x Bolt
4. 1x Locking Nut
5. Aluminium Back Plate.

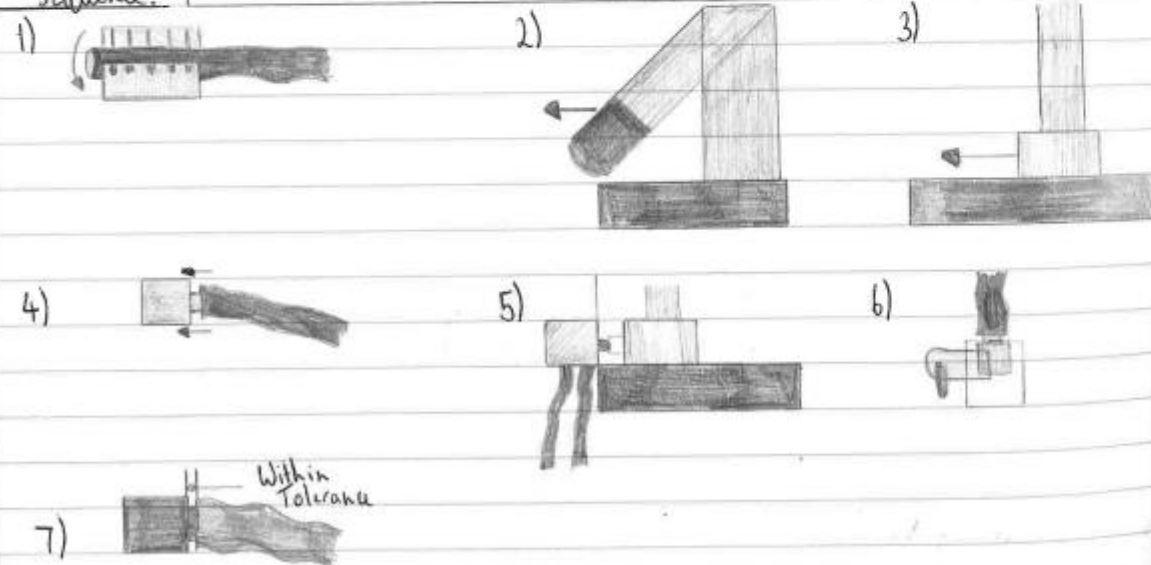
2) Hose over connector - Air Sprung Lever Arm

15/11/18



As the Lever is pushed forward by the operator it will push the hose over the barb and release the fixture.

Sequence:



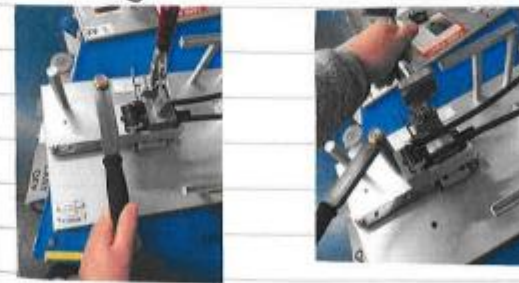
The fixture modification sequence work as follows:

- 1) Clamp the hose in the pillar which is freely moving

along the track.

- 2) The operator will then push the lever arm forward (towards the connector).
- 3) As the lever is operated it will push the hose clamp pillar forward on the track towards the existing pillar containing the connector.
- 4) As the lever arm is fully pushed forward and the hose clamp pillar is right up to the existing pillar..... the hose will be pushed over the connector.
- 5) Once the hose is pushed right over the connector (to within the specified tolerance) the air trigger will be engaged.
- 6) When the correct tolerance is achieved and the air circuit is complete, the ~~assembly~~ can be released from the fixture.
- 7) This fixture will ensure that the hose over connector is within the specified tolerance of $1\text{mm} \pm 1$. If any of these operations fail within the sequence and the gap is out of tolerance the part will not be released until it is exactly correct.

Prototype / Existing Examples:



Estimated Costs:

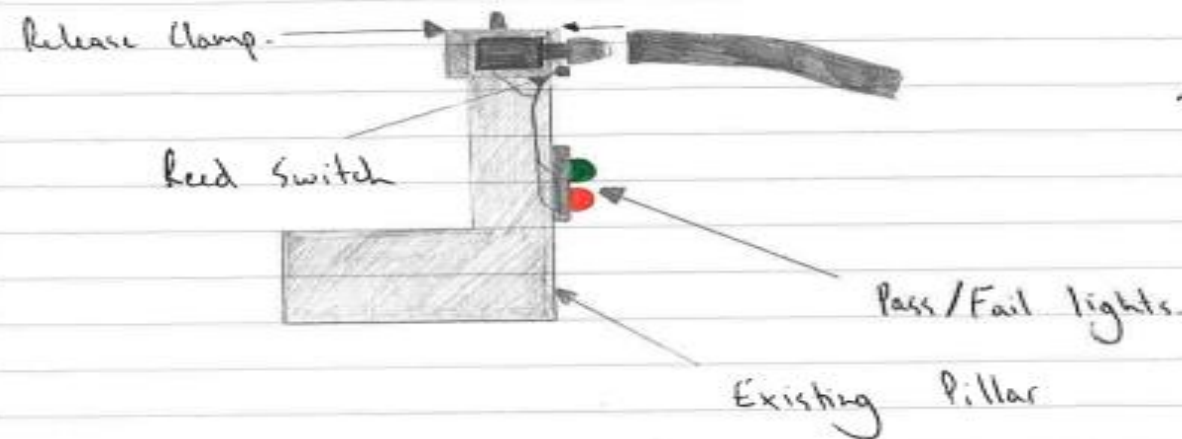
\$600 for full modification Assembly.

BOM =

1. Rail
2. Tool post - Clamp Assembly
3. Lever
4. Air trigger.

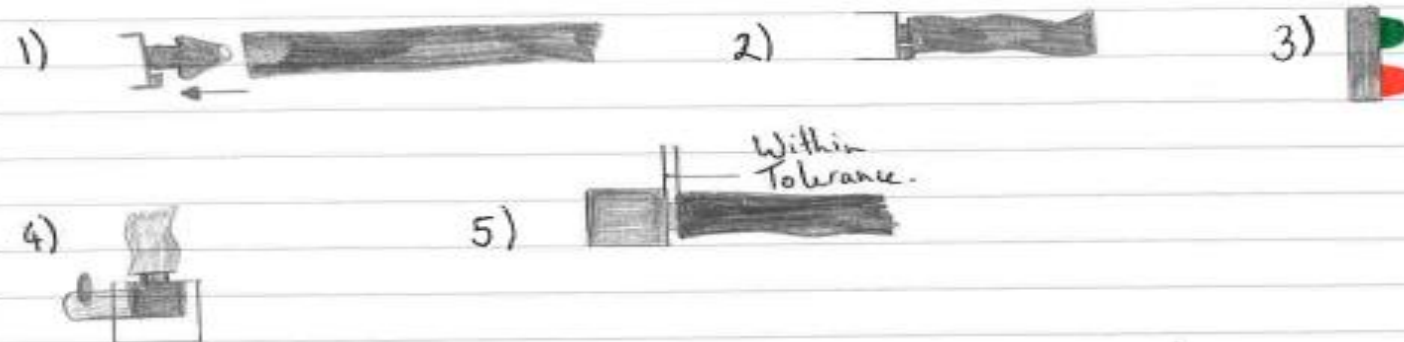
3) Hose over Connector - Reed Switch

19/11/18



As the hose comes into contact with the reed switch that is fixed to the existing pillar the light will show flashing green to show the part is good. If not pushed all the way on to the connector the red light will show to indicate it not being fully pushed onto the connector.

Sequence



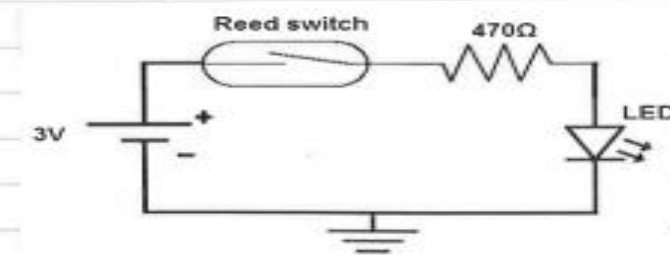
The fixture modification sequence works as follows:

- 1) The operator will manually push the hose over the connector up to the shoulder.
- 2) The hose should come into contact with the mounted reed

switch.

- 3) If the reed switch is in correct position and with reed switch will trigger part). If the part is not be triggered and it on.
- 4) Once within tolerance the the green light.
- 5) This fixture modification is within the specified tolerance operations fail within the tolerance the part will not

Prototype / Existing Examples:



Estimated Costs

£ 1000 for fully modified

BOM =

1. Reed Switch circuit.
2. Multiplex circuit board
3. 2x Lights.

Evaluation of 3 Solutions

Nieu David! 7/5/12
30/11/18

Evaluation Method 1 - Pros and Cons

05/11/18

1. Air Sprung Fork Release

Pros	Cons
• Would Ensure that the part is within tolerance. + • Easily retrofitted across any fixture. + • Doesn't increase push force. + • Only costs roughly £180 per modification. + • Easily maintained. + • No effect on cycle time of process. + • No increase of tooling area. + • In compliance with all health & safety specification points. + • Pass on rule and Kim scores. +	• Cost for fixture mod would be very high for some fixtures that have 6+ tool posts. - • Minimal weight increase. -

2. Air Sprung Lever Arm

Pros	Cons
• Would Ensure that the part is within tolerance. + • Reduces push force. + • Easily maintained. + • In compliance with all health & safety specification points. +	• Tooling foot print would be drastically increased. - • Increased weight. - • Would increase cycle time. - • Extra material needed that is not specified. - • Outboard on needed function. -

35

36

- Pass on Aka and Kim Scores. +

- Changes whole process and operations are added. -
- Still reliant on operator competency. -
- Wouldn't cover all tool posts. -

3. Head Switch

- | Pros | Cons |
|--|--|
| • Ensure good parts within tolerance are produced. + | • Very expensive. - |
| • Ties in with existing process. + | • Requires electricity supply to be added. - |
| • Doesn't increase push force. + | • Minimal weight increase. - |
| • No increase in tooling area. + | • Maintenance would require expert contractor. - |
| • No effect on cycle time + | • Extra material needed that isn't on specification. - |
| • In compliance with all Health & safety specification points. + | |

Solution	Total Score
1	$9 + (-2) = 7$
2	$5 + (-8) = -3$
3	$6 + (-5) = 1$

Evaluation Method 2 - Characteristic Matrix.

1. Air Spring Fork Release

Input Variables (X's)		Output Variables (Y's)									
Ranking	Output Ranking	Performance / functionality	Reliability	Scale of Operation	Cost	Aesthetics	Ergonomics	Size / Weight	HSE	Legislation	Operational Conditions
1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10	10	10	10	10
11	11	11	11	11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12	12	12	12	12
13	13	13	13	13	13	13	13	13	13	13	13
14	14	14	14	14	14	14	14	14	14	14	14
15	15	15	15	15	15	15	15	15	15	15	15
16	16	16	16	16	16	16	16	16	16	16	16
17	17	17	17	17	17	17	17	17	17	17	17
18	18	18	18	18	18	18	18	18	18	18	18
19	19	19	19	19	19	19	19	19	19	19	19
20	20	20	20	20	20	20	20	20	20	20	20

- 1 - Good
- 2 - Satisfactory
- 3 - Bad

Project: HSE Over Loader - OLE Issues.
Date: 05/12/18

XY Matrix

- 1- Good
2- Satisfactory
3- Bad

Project: Hose air connector - AOR Issues
Date: 05/12/18

XY Matrix

Input Variables (X's)	Output Variables (Y's)									
	Performance/ functionality	Reliability	Scale of Operation	Cost	Aesthetics	Ergonomics	Size/ weight	HSE	Legislation	Operational conditions
Output Ranking	10	9	7	8	3	6	9	10	10	9
Association Table										
1. Reduce weight factor	1	1					1	1	1	1
2. Use % Poly rate		1								
3. No impact on fuel flow										
4. Early delivery	1						1	1	1	1
5. Early Manufacture		3								
6. Use more than 435g										
7. Make 100% M11 Std										
8. Lowball Air Travel										
9. Drive fast to find parts	1									
10. Design manufacturing										
11. Design a 2 bar							2	2	2	2
12. Smooth edges										
13. Design rotary drum									2	2
14. Make a lift	1	1								
15. Make soft										
16. Make stiff										
17. Roll out to new tools			1					1	1	
18. Tooling steel										
19. 450 10 year										
20. Monthly flexures			1	3				1	1	
Rank	6	2	5	12	10	11	12	10	11	14

3. Red Switch

- 1- Good
2- Satisfactory
3- Bad

Project: Hole Over connector - AOR Issues
Date: 05/12/18

XY Matrix

Input Variables (X's)	Output Variables (Y's)									
	Performance/ functionality	Reliability	Scale of Operation	Cost	Aesthetics	Ergonomics	Size/ weight	HSE	Legislation	Operational conditions
Output Ranking	10	9	7	6	3	6	9	10	10	9
Association Table										
1. Reduce weight factor	3							3	3	1
2. Use % Poly rate										
3. No impact on fuel flow										
4. Early delivery	3									
5. Early Manufacture		1								
6. Use more than 435g										
7. Make 100% M11 Std										
8. Lowball Air Travel	2									
9. Drive fast to find parts	3									
10. Design manufacturing										
11. Design a 2 bar		1								
12. Smooth edges										
13. Design rotary drum										
14. Make a lift										
15. Make soft										
16. Make stiff										
17. Roll out to new tools										
18. Tooling steel										
19. 450 10 year										
20. Monthly flexures										
Rank	13	6	17	14	14	14	14	14	14	14

2. Air Spring lower Arm

Evaluation Method 3 - Payback

10/12/18

Costs Incurred by QPR on leoni fixture with the targeted issues:

- 1) Customer Containment = \$1600
 - 2) Firewall Inspection Cost = \$650
 - 3) Quality Containment at Kautex = \$800
 - 4) Customer Sanction = \$1500
- Over a 1 Year Period.

Total = \$3550

Monthly Cost = $\$3550 \div 12$
= \$295.83

1. Air Spring Fork Release

Cost of fixture modification = 2 x Pillars Mod
= 2 x \$180
= \$360

~~Payback Period = $\$3550 \div 360$
= 9.86 Years~~ Payback Period = $360 \div 279.16$
= 1.28 months.

2. Air Spring Lower Arm

Cost of fixture modification = 2 x Pillars Mod
= 2 x \$600
= \$1200

~~Payback Period = $\$3550 \div 1200$
= 2.96 Years~~ Payback Period = $1200 \div 279.16$
= 4.29 months

3. Reed Switch

Cost of fixture Modification = 2 x Pillars Mod
= 2 x \$1000
= \$2000

Payback Period = $2000 \div 279.16$
= 7.16 months.

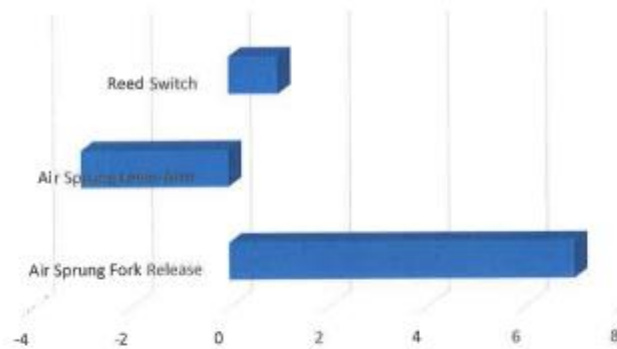
Evaluation - Conclusion

12/12/18

(All missing numbered pages at back of book)

is paramount.

Pros & Cons Results



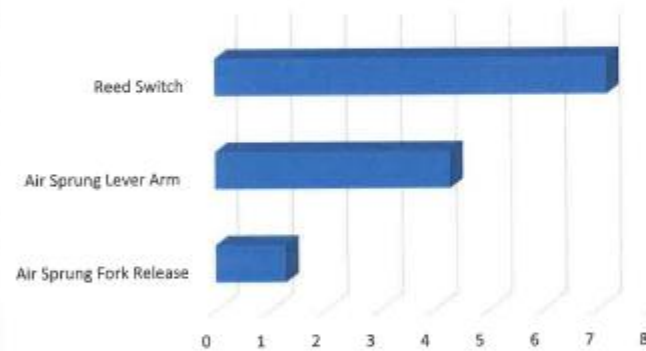
As you can see from the table, the most viable solution has been the air sprung fork release. This is due to the fact that the amount of pros significantly outweighs the cons and all other ideas were significantly lower scoring.

To conclude, throughout all aspects of my evaluation the Airsprung Fork Release modification has proven to be the best option in rectifying the issue at hand.

- It has proven to be the cheapest out of all options.
- Most easily maintained.
- Fastest turn around on implementation time.
- Does not increase push forces.
- No impact on fixture footprint.
- Easily retrofitted across all problem fixtures.
- And many other benefits.

There are the reasons why I believe that this solution is the most viable way of bringing this issue to a close and putting to bed a long lasting issue which has caused many problems for Kantex as a whole.

Payback Results (Months)



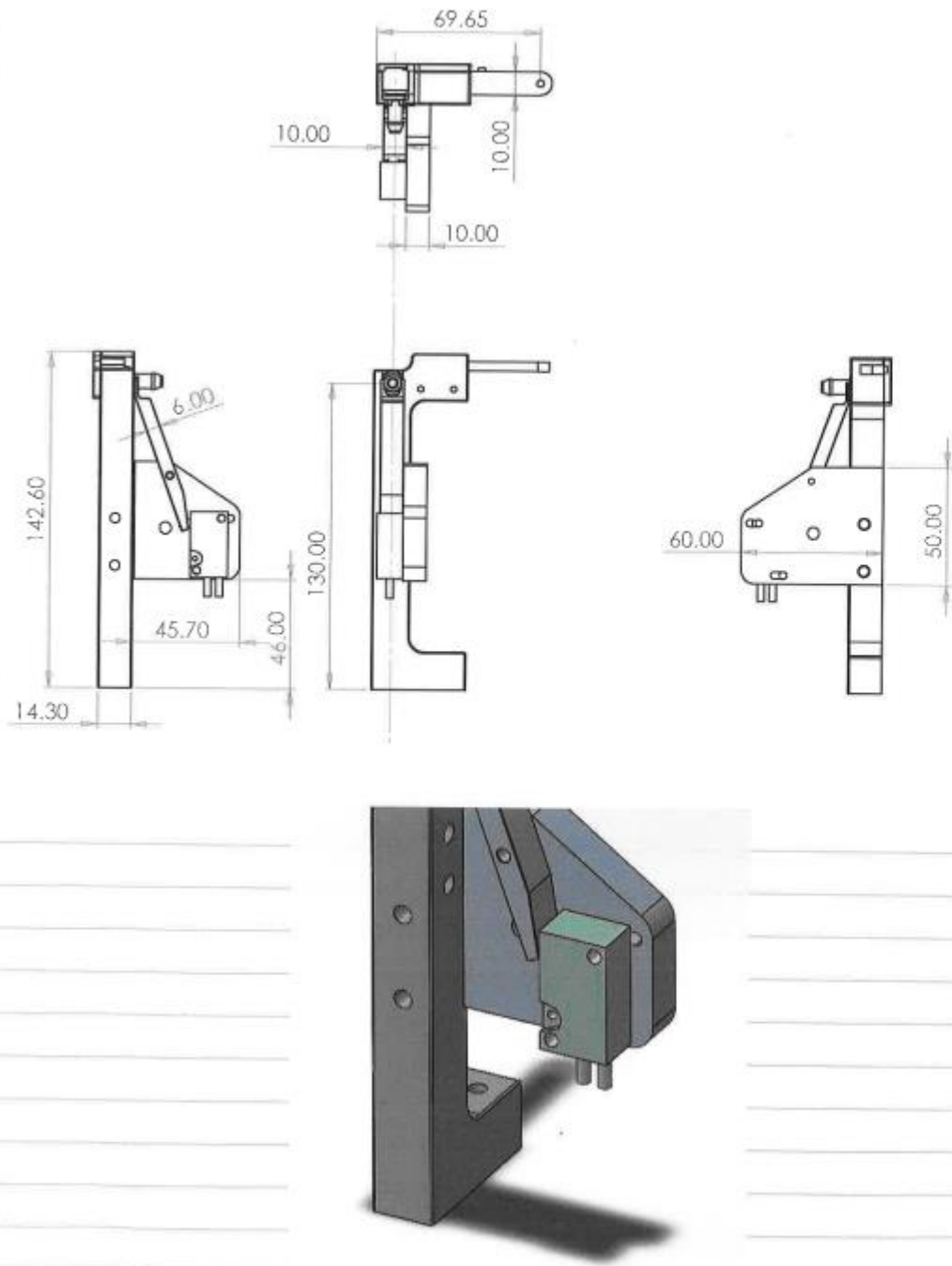
The air sprung fork release has also proven to be the quickest pay-back solution. This is because of the simplistic design and cheaper construction materials. The other solutions either were too expensive in machining costs or in complexity of electronics.

Characteristic Matrix

For all 3 possible solutions had their strengths and also weaknesses. After studying each aspect of all the tables I feel that the results shows that the air sprung fork release is the best option. This is due to the fact that it was the best scoring across all aspects and meets all specification requirements. Another reason why the other two solutions were ruled out is due to the lack of specification points met and bad scores on health & safety as this

Finalised Design

Dimensioned CAD Drawing:



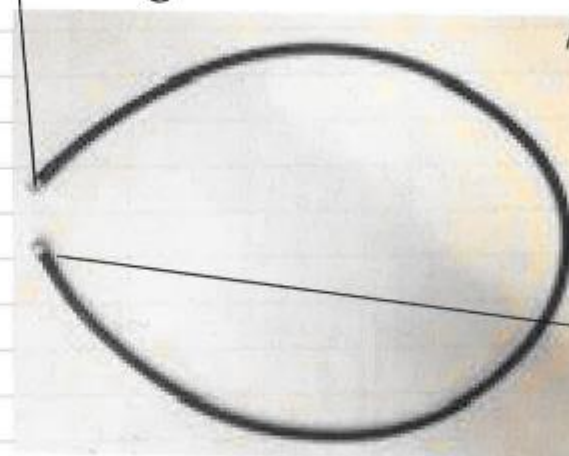
Selected Problem Fixture

55. $\frac{1}{2}$

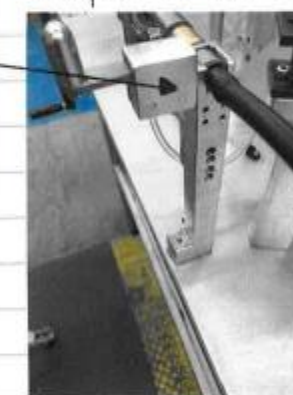
Tool Customer & Tool No:



Fully Assembled Part:



Tool posts on Fixture:



Reasons for selecting this fixture:

- One of the original problem fixtures.
- Most recent problem with QDR against it - needs to be resolved.
- Simplistic design on tool.
- High runner - Test the designs durability.
- Leak test operation / pneumatic system pre-installed on the fixture.
- Lots of available space on the fixture & tooling post.

Orders for parts off this fixture this year:

Material 4000014005 AssyHoseSW P00290416
Plant 5023 MRP type 21 Material Type 2380 Unit PC

Days Weeks Months						
A. Period/segment	Plnd ind.re...	Requirem...	Receipts	Avail. qua...	ATP quan...	Actu...
Stock				3,760	0	3.1
M 02/2019	0	15,200	17,580	6,140	0	6.0
26.02.19 End of Planni						
M 03/2019	0	17,520	15,760	4,380	0	6.0
M 04/2019	0	20,550	16,240	70	0	3.0
M 05/2019	0	9,150	12,880	3,800	0	6.0
M 06/2019	0	16,800	13,040	40	0	9.0
M 07/2019	0	4,350	4,310	0	0	0.0
SLocSt: 0104				0	0	0.0

83,570 parts for 2019.

TPM For this tool modification:

- Monthly clean and lubrication/inspection.
- Tooling steel forks - Spares required for any breakages (2x spares).
- Pneumatic air triggers changed after 900,000 parts (maximum shots for trigger = 1000000 shots).

Cost of TPM per year =

- 15 minutes per month inspection by myself = \$3 labour
- Tool steel fork 2 backups = \$80 (original forks forecasted to last 3-4 years).
- Pneumatic air triggers = $2 \times \$12$ for 900,000 shots
 $= 900,000 \div 83,570$
 $= 10.77$
 $= \$24 \div 10.77$
 $= \$2.23$ per year

Total cost per year = \$85.23

This is the initial start up cost with a larger investment in backup piece parts. This will then be far lower in years going forward with bulk manufacture & purchasing.

02/02/19

BUDGET CODE FOR FIXTURE = 5023911

For this trial fixture the cost will be taken by maintenance, going forward with successful trials all new customer fixtures will go against initial tooling costs invoiced to the customer.

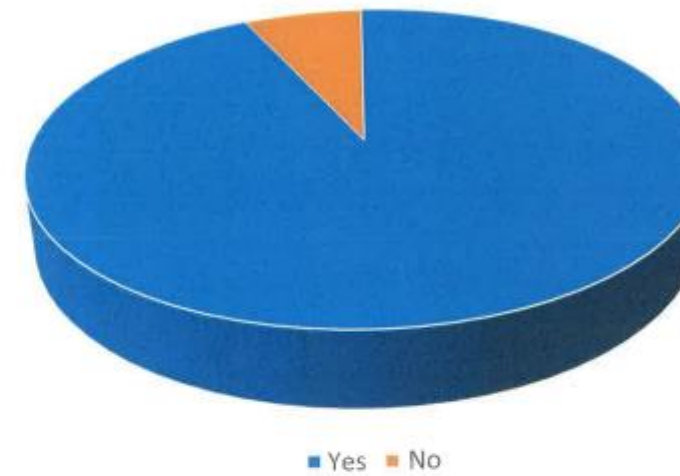
Official Quote

Production Line Feedback

26/01/19

Air-sprung Poke Yoke Production Feedback Pole and Team Leader Summary

Do you agree/like the fixture modification?



Reasons for the "No's":

1. Operator 1 said that they think it is 'pointless' and 'operators shouldn't have a job if they cannot complete simple operations.'
2. Operator 2 said that they think it will increase cycle times so they cannot hit their targets.

Team Leader – Overall comment

I feel that this would be a hugely beneficial change within the process and will be a great asset to the overall Poke Yoke system of the fixture. As a whole the operators also really liked the modification and feel that the change needs to come as soon as possible. It gives the operators the piece of mind that the part made is correct and they will have no comebacks on themselves by following the process exactly. There are always going to be a few pessimists within the bunch but I would take their feedback with a pinch of salt.

Daryl Kilby – Hose Assembly Team Leader :

Trial 1 – Capability Study

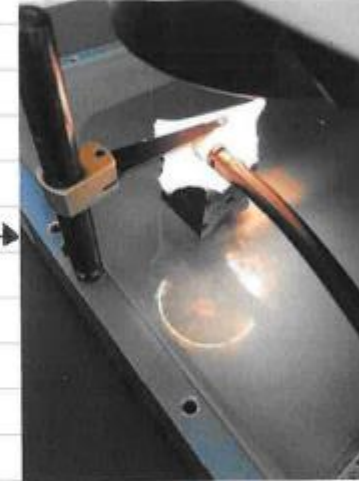
1) The Quickscope measuring device:



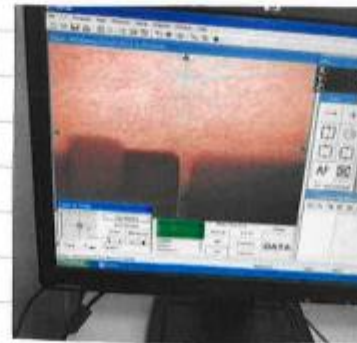
2) Set up clamp:



3) Clamp Hose Assembly to Bed:



4) Set the camera axis to the connector edge:



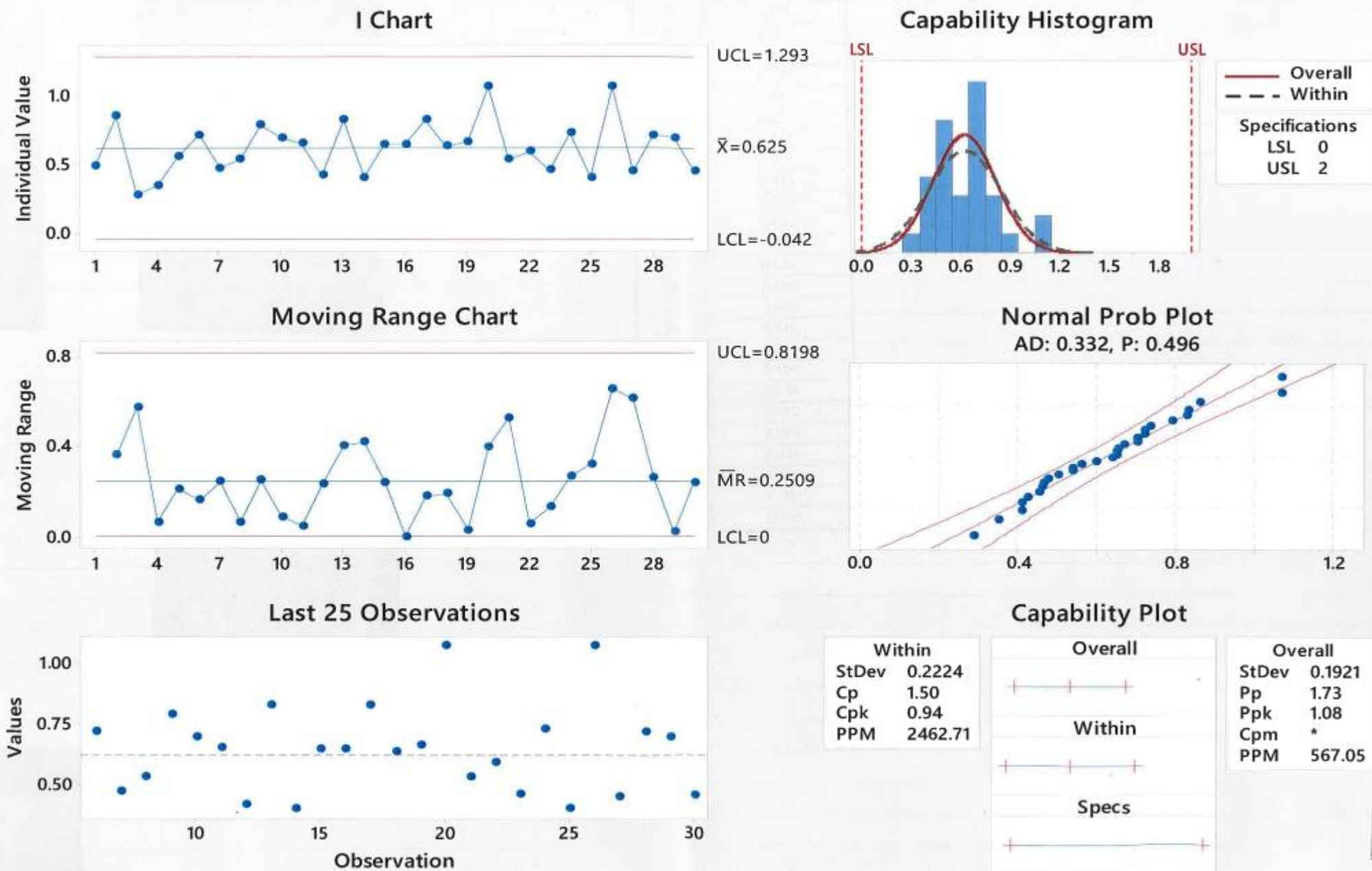
61

62

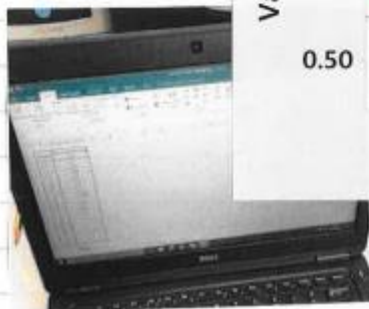
5) Set to zero as



Process Capability Sixpack Report for Connector Gap



6) Note result is



1. Capability Study Summary

When looking at the capability study results, it clearly shows that the process is capable.

It shows the CP & CPK values leaning towards the lower limit of the tolerance but that is what I am aiming for due to the fact that the further the hose is pushed onto the conductor barb the less chance and more resistance it will have to the water pressure forcing them apart.

Going forward I feel that the modifications need slight adjustment to bring the hose down to the lower specification limits again.

Overall I am very happy with the outcome and am confident that this project will be a success.

14/02/19

Required Modification:



1. In order to push the capability results down further towards the bottom tolerance of 0 (which has the most resistance to the water pressure) I decided it was best to move the pneumatic switch back a fraction so that the

release tolerance is pushed closer to the bottom end which will fine tune the process and further improve the quality of the parts.

Process Capability Sixpack Report for Connector Gap

I Chart



Capability Histogram

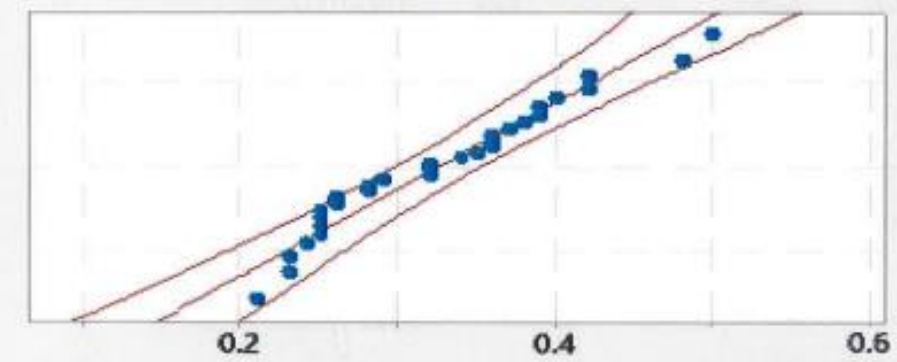


Moving Range Chart

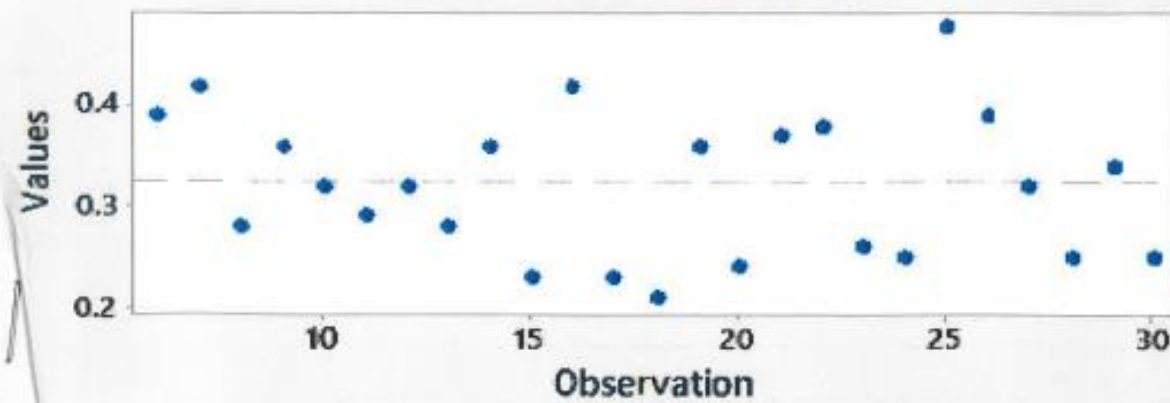


Normal Prob Plot

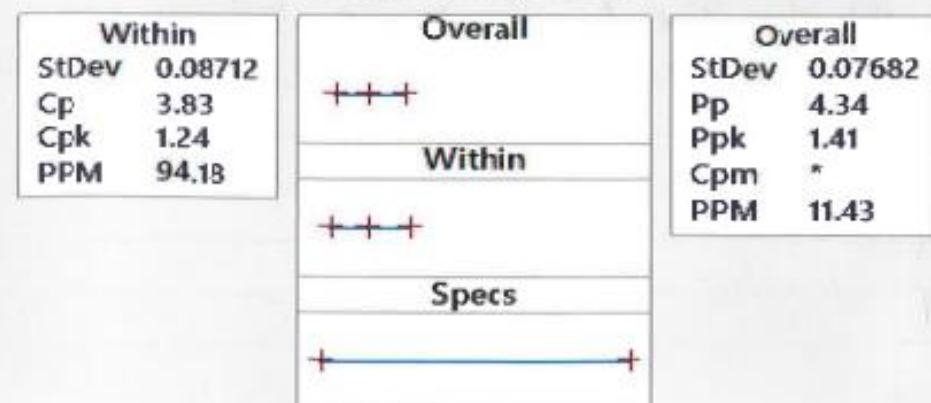
AD: 0.530, P: 0.162



Last 25 Observations



Capability Plot



Capability Study Summary

27/02/19

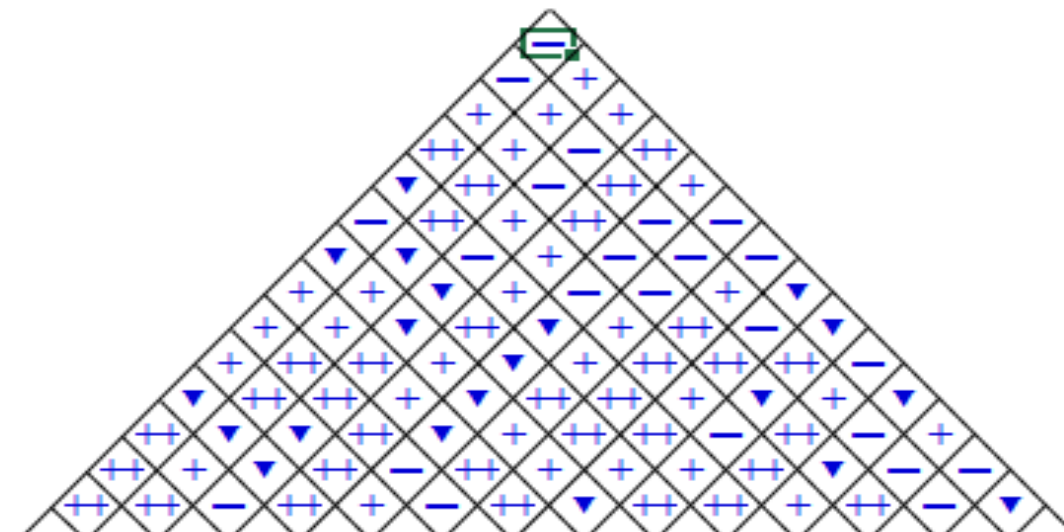
This capability study shows a positive decrease in the defect parts per million. The graph shows that the very minor adjustments that I had made have improved the capability in my opinion due to the fact that all values/measurements have been pushed further towards the bottom specification limit of zero which would be the most reliable part.

Quality Control within Kautex and all of the engineering team have confirmed that this is as capable the tool can get with the modification and it is now Poke Yoke'd and ready for production.

Trainer Comments:

- Very good modification which will reduce risk of quality problems.
- User friendly and doesn't pose any obstructions to the operation.
- All in all very happy and will make life easier for everyone.

Title:	How many connector QDR issues - Airspring Park Release
Author:	William David Davies
Date:	05/02/2019
Notes:	There has been a major problem with knee assemblies being supplied to the customers of Kaulen Toolless CVSLTD. The problem at hand is that the knees are slipping off the assemblies due to them being outside of the specified tolerance. The customers are not happy about this problem and demand for there to be a countermeasure solution implemented. It is my task to come up with the control measure and implement it.



Legend		
⊕	Strong Relationship	3
○	Moderate Relationship	2
△	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
-	Negative Correlation	
▼	Strong Negative Correlation	
▽	Objective To Minimise	
▲	Objective To Maximise	
X	Objective To Hit Target	

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Quality Characteristic (i.e., "House")	Column #														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				Direction of Improvement: Minimise (▼), Maximise (▲), or Target (X)	▲	▲	▲	▲	▼	X	X	X	▼	X	X	X	X	X	X
				Demanded Quality (i.e., "House")	Problems: 100% good parts	Easy for operator to use and adjust tools the assembly	100% efficiency	Access all problem and new tooling features	Less than 200 per modification	Must be made from metals with no sharp edges	Must not increase the difficulty of the original operation	Must not be an obstacle for operators	Must not increase the weight of the tool by more than 500 grams	Must be in accordance with all HSE requirements	Must be in accordance with the RULA Legislation	Must not increase the difficulty of the operation	Must not increase cycle times	Must not increase the existing tooling footprint	Must run off of 2 bar pneumatic pressure
1	3	7.8	578.1	Performance	⊕	⊕	⊕	⊕	▲	○	⊕	⊕	○	▲	▲	⊕	⊕	▲	○
2	3	3.4	264.3	Flexibility	○	○	○	○	▲	○	○	○	○	○	○	○	○	○	○
3	3	6.6	534.2	Reliability	○	○	○	○	▲	○	○	○	○	○	○	○	○	○	○
4	3	7.8	635.1	Scale of operation	○	○	▲	○	○	○	○	▲	○	▲	▲	○	○	○	○
5	3	7.3	593.5	Cost	○	○	○	○	○	○	▲	○	○	▲	▲	○	○	○	○
6	3	6.5	528.6	Realisation	○	○	▲	○	○	○	○	○	○	○	○	○	▲	○	○
7	3	7.1	572.7	Ergonomics	○	○	○	○	▲	○	○	○	○	○	○	○	○	○	○
8	3	6.8	484.4	Size	▲	○	○	○	○	○	○	○	○	○	○	○	○	○	▲
9	3	5.2	422.1	Weight	○	○	○	○	○	○	▲	○	○	○	○	○	○	○	▲
10	3	5.3	434.8	HSE	○	▲	▲	○	▲	○	○	○	○	○	○	○	▲	○	○
11	3	5.2	419.5	Legislation	○	▲	▲	▲	○	○	○	○	○	○	○	○	○	○	○
12	3	7.3	593.5	Operational conditions	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
13	3	6.2	508.8	Cycle time	▲	○	○	○	○	▲	○	○	▲	○	○	○	○	○	▲
14	3	5.8	468.8	Tooling footprint	▲	▲	○	○	○	○	○	○	○	○	○	○	○	○	○
15	3	6.7	544.6	Time into Existing system in place	○	○	▲	○	○	○	○	▲	○	○	○	○	○	○	○
				Target or Limit Value	100%	No bad parts released	100%	Easy retrofitable	Within allocated budget costs	Rounded corners and R&D steel aluminium & stainless steel	No adverse effects on operation	Not obstruct the original operation	No more than 500 grams	All safe working practices included	All push forces must be within tolerance and within tolerance	No increase in operational difficulty	Cycle times must remain the same	Must be retrofitted to existing plant	2 bar pressure
				Difficulty (1-Easy to Assemble, 15-Extremely Difficult)	5	6	4	7	1	2	3	2	2	2	2	2	2	1	1
				Max Relationship Value in Column	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
				Weight / Importance	422.3	566.7	497.1	784.6	468.7	618.6	619.1	687.2	589.4	549.7	519.3	719.8	581.2	555.3	529.3
				Relative Weight	5.8	6.7	5.8	8.3	5.4	7.2	7.2	7.1	6.3	6.5	6.8	8.4	6.8	6.5	6.1

Title: New QRR Controller QDR Issues - Rinsprung Park Release

Author: William David Davies

Date: 05/02/2015

Notes: There has been a major problem with hose assemblies being supplied to the customers of Kuster Toolless CV5 LTD. The problem at hand is that the hoses are slipping off the assemblies due to them being outside of the specified innerline tolerances. The customers are not happy abt this problem and demand for there to be immediate action to improve it is my task to come up with the correct measure and implement it.

Legend		
⊖	Strong Relationship	3
○	Moderate Relationship	2
△	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
-	Negative Correlation	
▼	Strong Negative Correlation	
▽	Objective To Be Minimised	
▲	Objective To Be Maximised	
X	Objective To Hit Target	

				Column B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Competitive Analysis (8-Weak, 5-Real)											
				Direction of Improvement: Minimise (▼), Maximise (▲), or Target (X)	▲	▲	▲	X	▼	▲	X	X	X	X	X	▲	X	X	X												
Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Quality Characterisation (i.e. "Functional Requirements" or "Needs")																											
				Demand Quality (i.e. "Customer Requirements" or "Wishes")	Performance	Functionality	Reliability	Scale of operation	Cost	Aesthetics	Ergonomics	Size	Weight	HSE	Legislation	Operational conditions	Cycle time	Tooling footprint	This line existing systems not in place	Our Company	Competitor 1	Competitor 2	Competitor 3	Competitor 4	Competitor 5						
1	3	15.0	5.0	Produce good parts	⊖	⊖	⊖	▲	○	⊖	⊖	▲	▲	▲	○	⊖	○	▲	○	5						Our Company Competitor 1 Competitor 2 Competitor 3 Competitor 4 Competitor 5 812345					
2	3	15.0	5.0	100% pass rate	⊖	⊖	⊖	○	▲	▲	○	○	○	▲	▲	○	⊖	▲	○	5											
3	3	10.4	4.0	No impact on peak forces	○	⊖	○	▲	▲	⊖	⊖	⊖	○	⊖	⊖	⊖	○	○	⊖	5											
4	3	9.1	3.5	Easily refilled	○	⊖	⊖	○	○	○	○	○	○	○	○	⊖	▲	○	○	5											
5	3	5.2	2.0	Easily maintained	○	⊖	⊖	○	○	○	○	○	○	○	▲	○	▲	○	○	5											
6	3	15.0	5.0	Cost No more than £350 per modification	▲	▲	○	○	○	▲	○	⊖	⊖	○	○	▲	▲	○	▲	5											
7	3	7.0	3.0	Contains air outlet	○	⊖	○	○	○	○	○	○	○	○	▲	⊖	⊖	○	○	5											
8	3	15.0	5.0	No impact in cycle time	⊖	⊖	○	○	○	○	⊖	▲	▲	○	⊖	⊖	⊖	○	▲	5											
9	3	5.2	2.0	Doesn't increase finished weight	○	○	▲	○	▲	○	○	○	○	○	○	○	▲	○	▲	5											
10	3	10.4	4.0	Operates at 2 bar pneumatic pressure	⊖	⊖	○	○	○	○	○	▲	▲	○	○	○	⊖	▲	○	5											
				Target or Limit Value	produces 100% good parts	Easy for the operator to use and Polar Value the same	100% efficiency	Across all problem and new tooling features	Less than £250 per modification	Must be made from Metals and no sharp corners	Must not increase the difficulty of original assembly	Must not be an obstacle for operators	must not increase the weight of tool by more than 500g	Must be in accordance with all HSE regulations	Must be in accordance with the local legislation	Must not increase the difficulty of the assembly	Must not increase cycle times	Must not increase the existing tooling footprint	Must run off of 2 bar pneumatic pressure												
				Difficulty (8-Easy to Assemble, 10-Extremely Difficult)	5	6	4	7	1	2	3	2	2	2	2	2	2	1	1												
				Max Relationship Value in Column	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3												
				Weight / Importance	578.1	764.3	531.2	635.1	539.5	528.6	572.7	484.4	422.1	481.8	419.5	539.5	588.8	468.8	541.6												
				Relative Weight	7.0	9.4	6.6	7.8	7.3	6.5	7.1	6.8	5.2	5.9	5.2	7.3	6.2	5.8	6.7												
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