

University of Wales Trinity St David

School of Engineering

Plant and Asset Engineering

Evaluating the Effectiveness of Chosen Maintenance Strategies for Dedicated Equipment



Plant & Asset Engineering

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Author: Craig Petherbridge

Student No: 1904036

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1 Introduction

Mono equipment is a leading designer and manufacturer of bakery equipment based in the UK. It boasts a proud heritage of British manufacturing dating back to its origins in 1947. Mono equipment currently supply many of the leading food chains, supermarkets, and distributors with innovative bakery equipment including; provers, bread plant, volumetric dividers, and commercial / industrial convection ovens.

1.1 Aims

This project will critically analyse the maintenance strategies laid out by Mono equipment. The equipment chosen for this project is the Amada CNC Turret Punch Press. This machine is critical to the operation at Mono equipment. This is because the machine cuts over 85% of the sheet metal parts required to manufacture due to its automation and high performance.

1.2 Objectives

To propose changes to maintenance based on the evaluation of current practices, cost and resources will be considered.

2 Chosen Equipment – Amada EMZ 3510NT/3610NT

The equipment chosen to run an analysis of the current maintenance strategies based at Mono equipment is the Amada EMZ 3510NT/3610NT CNC Turret Punch Press with automatic tool selection and incorporated loader and unloader.

This piece of equipment is of high importance to Mono as it currently manufactures 85% of its sheet metal componentry. Its automatic loading and unloading makes it a valuable asset with efficiency like no other.

This machine is considered critical to business. This report will critically analyse the current approaches to the maintenance of this machine and look to improve. Figure 1 below details the machine and some of the features. Figure 2 details the automatic loading and loader function.



Figure 1: Amada EMZ CNC Turret Punch Press

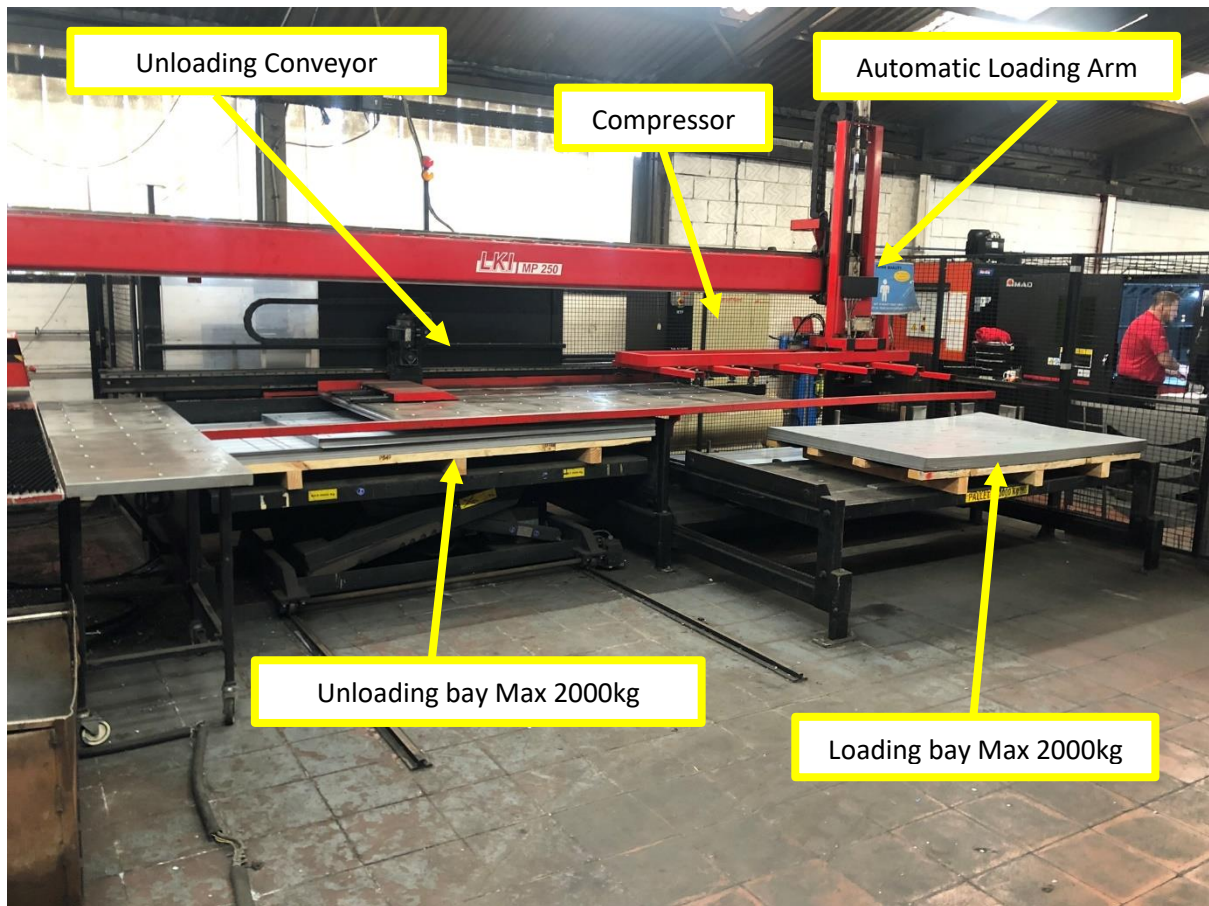


Figure 2: Automatic Loader

3 Current Maintenance Practices

Maintenance strategies vary considerably between various assets at Mono Equipment. An effective and robust maintenance strategy will increase reliability, increase service life, lower operating cost, improve first pass yield / quality and improve safety. (Legar, 2018) These benefits should motivate senior managers to implement and control excellent maintenance strategies.

Mono Equipment's current strategy can be considered blended between breakdown maintenance and outsourced maintenance. It has chosen this blended method due to the criticality of the machines function, if the machine isn't working it has the potential to stop everything downstream. By blending the two ultimately increases cost. Expensive outsourced maintenance packages can be problematic with time taken for engineers to react and schedule a visit, this might not always be with great urgency. This is why Mono has chosen to blend the two approaches between breakdown and outsourced to try and get the best out of both types despite the additional cost.

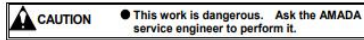
3.1 Amada Maintenance Plan – Mono Equipment

The main approach at Mono is purely reactive (breakdown) maintenance, there is limited down time strategically planned into the program, the machine is continuously run at maximum speed to increase output, this approach can overtime have a negative effect. By offering limited time in the schedule for maintenance the machines total life cycle is reduced. By running the machine with little to no time offered for maintenance will result in reduced life cycle and increased breakdowns. (Oakland, 2008) Over time the machine will see a higher failure rate. This reduction in life will ultimately result in an increased cost in the long term when thinking of the total life cycle. (Bicheno, 2009)

3.2 Daily Weekly Monthly – Periodical Maintenance

The operations manual for the Amada EMZ Punch Press stipulates that daily weekly and monthly maintenance should be conducted. Part VIII of the operations manual covers the required periodical maintenance as recommend by Amada. This section details exactly what should be carried out and gives a guide on how to complete each maintenance task.

CHANGING SHEAR PLATE



This machine has a shear plate installed between the striker and backup plate for its own protection. When the machine is overloaded during its punching operation, the shear plate breaks to protect the machine from damage.

When the shear plate is broken, it must be changed. Contact the AMADA service engineer.

- 1 Remove from the turret the punch installed near the bottom of the striker so that it does not interfere with the removal of the broken shear plate.
- 2 Turn off the power of the NC unit, and turn the machine circuit breaker switch to OFF.
- 3 Turn off the compressed air.
- 4 Remove the air tubes from the four one-touch fittings of the punch positioning air cylinders.



VIII-20

PERIODICAL MAINTENANCE

Every week

Inspect and maintain machine parts every week as described below as well as according to other periodical maintenance programs.

Tool change door interlock

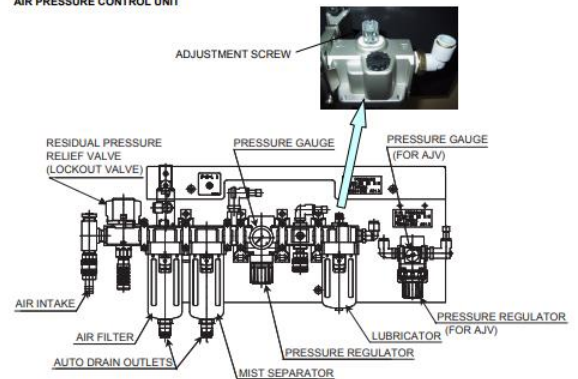
Open the upper and lower tool change doors, and check that the STOP button on the main control panel is illuminated.

Air lubricator

Check the lubricator of the air pressure control unit for the frequency of oil drops, and regulate the frequency as required:

One drop per 5 in-and-out operations of the turret index pins
Turn the lubricator adjustment screw clockwise to decrease the frequency or counterclockwise to increase it.

AIR PRESSURE CONTROL UNIT



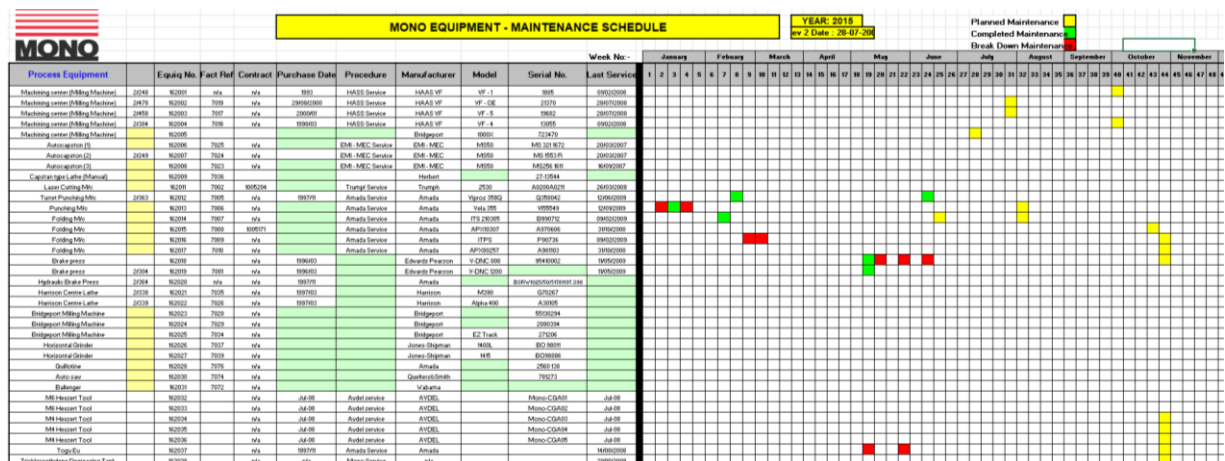
VIII-6

Figure 3: Example of Maintenance Recommendations in Amada Operating Manual

Despite the clear guidance none of the periodical maintenance is conducted by the operator. There is simply no time allocated to conduct any of the recommendations. Only essential tasks are carried out to ensure functionality. Including general cleaning and lubrication.

3.3 Breakdown Data

To adopt any form of maintenance strategy it is essential to capture data, Mono records and tracks breakdowns and scheduled services using an excel spreadsheet. The current data is recorded but gives limited information surrounding the impact to the business or customer as a result of the breakdowns. There is limited to no understanding of the cost implications to such occurrences.



3.4 Reactive Maintenance Strategy

Due to Mono Equipment adopting the reactive maintenance strategy means that the company needs to be equipped to react to any breakdowns. Over the years they have build up an understanding of the unique parts and components likely to fail on the machines, in anticipation of breakdowns Mono holds a buffer stock of components, these components ensure reduced downtime when a failure occurs and acts as a fail failsafe between lengthy lead times on components and parts. Figure 5 below shows the storage rack with emergency parts ready for when a breakdown occurs.



Figure 5: Reactive Maintenance Components/ Parts

3.4.1 Casualty Operating Procedure

Casualty Operating Procedures (COP) were introduced to build upon the knowledge of the production operatives. The COP is a type of standard operating procedure introduced to reduce downtime on failure. These procedures have been created as a step-by-step guide to see if the failure can be overcome without relying on the Amada engineers. These steps can be carried out prior to calling. This is a recent introduction and has already proven successful and prevented callouts and reduced the impact of the failure. Figure 6 below shows an example of the casualty operating procedure which has been introduced.

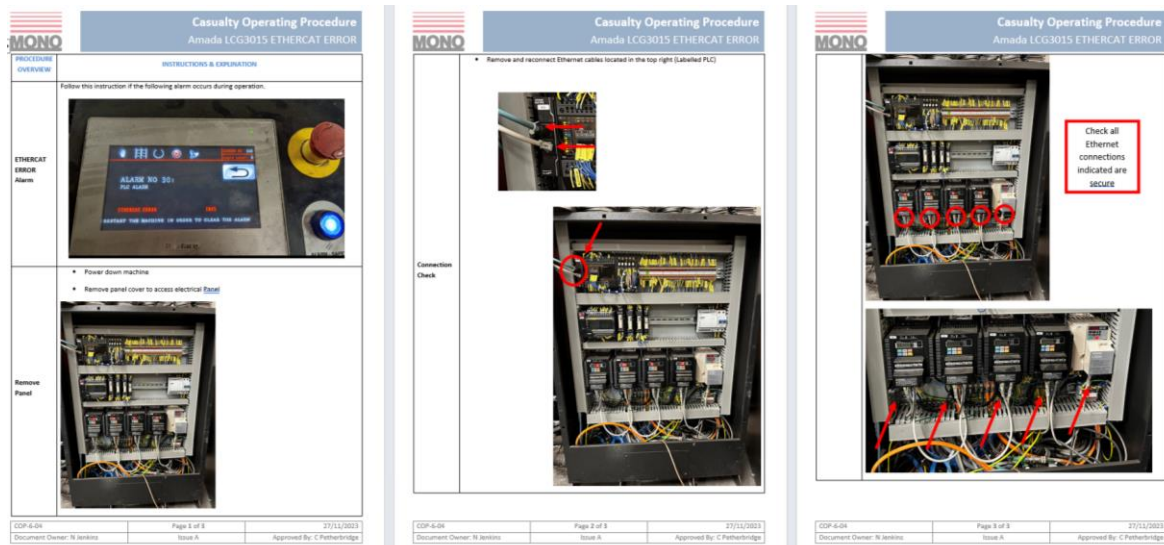


Figure 6: Casualty Operating Procedure

3.5 Reactive Maintenance Issues

The main issue with reactive maintenance is that all other forms of maintenance becomes neglected, the bare minimum is actioned to maintain functionality. The machine only gets repaired when it fails. (Legar, 2018)

Mono Equipment's maintenance strategy can be considered first generation, this approach can be summarised as fix it when it breaks. This is considered to be from an era circa 1940's – 1950's this was an era where machines were not highly available and manual labour was more prevalent. (Nicholas, 2011) There were less machines and more workers, so maintenance became less important. This typically involved servicing, greasing, and cleaning routines only to maintain functionality.

With all breakdowns there will be a period of repair and if there is no backup to call upon this can become expensive and disruptive to production. This is why steps have been taken to minimise disruption.

4 Maintenance Improvement

4.1 Equipment Life Cycle

The issues surrounding this type of maintenance ultimately reduces the life cycle of the equipment. This can have a significant impact to efficiency and reliability in the mid to long term. (George, 2002) Companies now more than ever should be taking more responsibility to create robust maintenance strategies to preserve the life of the machines, this equipment comes at a significant cost to the company so the lifecycle should be respected. This short-term mindset and poor maintenance planning results in reduced life of the equipment. It will inevitably result in more breakdowns at higher cost.

4.2 Alternative Approaches - TPM

4.2.1 Total Productive Maintenance

An alternative approach which could be explored is a maintenance strategy known as Total Productive Maintenance (TPM). Most organisations including Mono are driven by productivity and output TPM cleverly included the word productive to entice organisations to use this method. (John Bicheno, 2016) TPM recognises the involvement of their employees, ultimately the people using the machines are best place to recognise issues and giving them the tools to carry out basic maintenance. This method has the potential to reduce maintenance costs while increasing productivity.

It is believed that by involving the machine operators allows for continuous monitoring of equipment, this further reduces the risk of costly unplanned breakdowns.

Mono equipment has already started to introduce basic maintenance and fault finding tasks by including the operators in the breakdowns, this can be seen with the introduction of the casualty operating procedure. In doing so allows for a transfer of skill from operation to maintenance role building experience.

TPM can be difficult to implement, and it's considered to take time to successfully implement, however Mono has solid foundations to build upon applying TPM.

4.2.2 Four Stages of TPM Application

1. Awareness study conducted with development of analytical problem-solving methods such as 5 whys, Ishikawa, & RCA, Successful pilot programs delivered and clean and clear tasks co-ordinated.

2. Agreeing to bring best practices by determining the best approach across all areas and imbedding the principles ensuring compliance at all times.
3. Developing employees to proactively search for improvements to process in order to successfully raise overall performance.
4. Seek for perfection, although this is considered impossible organisations must aim for perfection by continuous improvement of methods. Targets must be set at this stage.

4.3 Overall Equipment Effectiveness - OEE

OEE is an excellent tool at benchmarking and quantifying the performance of an asset, it is based on 3 factors:

1. Availability
2. Quality
3. Performance

By multiplying these together gives the Overall Equipment Effectiveness. By benchmarking the OEE it is possible to monitor the performance pre and post changes. (Nicholas, 2011)

4.3.1 OEE Analysis – Amada EMZ Punch Press

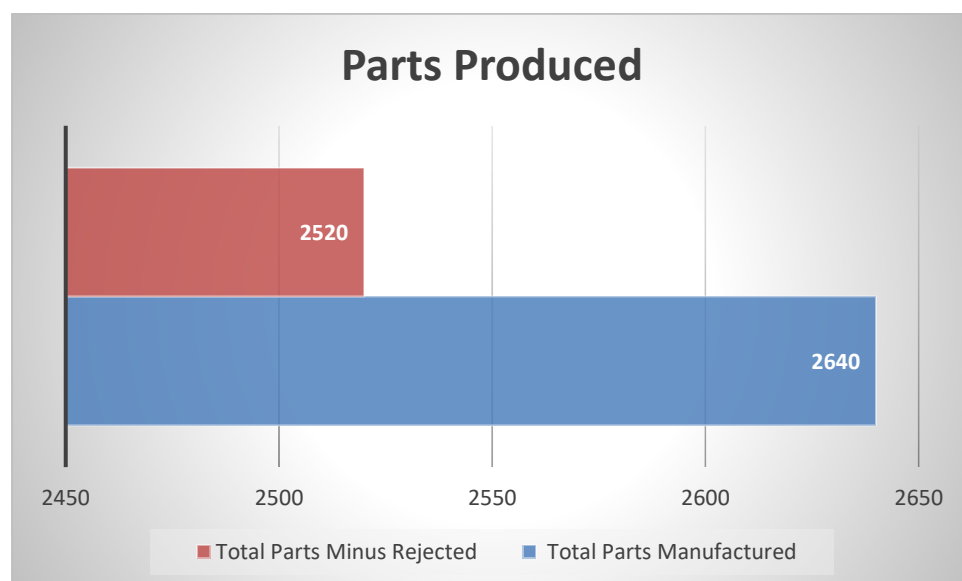


Table 1: Number of Parts Produced on Shift

Number of sheets/ batch	120
Average parts / sheet	22
Total parts manufactured	120 x 22 = 2640
total parts rejected	120
Total parts minus rejected	2640 – 120 = 2520
Run rate	9
Hours / shift converted to minutes	8 x 60 = 480 minutes available
Minus lunch break and tea break	480 - 45 = 435
Loading & unloading pallet time / shift	45 minutes
Minus loading / unloading time	435 – 45 = 390 minutes

Table 2: OEE Analysis Summary

$$Availability = \frac{390}{435} \times 100 = 89.7\% \text{ or } 0.891$$

Equation 1: Availability Equation

$$Quality = \frac{2520}{2640} \times 100 = 95.5\% \text{ or } 0.955$$

Equation 2: Quality Equation

$$Performance = \left(\frac{2640}{390} \right) \div 9 = 75.2\% \text{ or } 0.752$$

Equation 3: Performance Equation

Therefore the OEE is calculated as:

$$Overall \text{ Equipment Effectivness} = 0.891 \times 0.955 \times 0.752 = 0.64$$

$$Overall \text{ Equipment Effectivness} = 64.0\%$$

Equation 4: Overall Equipment Effectiveness Equation

A score of 64.0% is considered typical for any manufacturing facility. An OEE OF 85% or greater is considered world class. This should be the target for all organisations when seeking perfection and continuous improvement. (Oakland, 2008)

4.4 Failure Analysis

The data for the previous 6 months was used to calculate both breakdown frequency and mean time between failure.

6 months in days	182 days
5 Day working week	182 X (5/7) = 128.6 days
Number of hours available	128.6 x 8 = 1028.6 hours
1 hour / day lost on average	128 non-used time
Time lost due to breakdowns	75 hours
Number of breakdowns	2

Table 3: Failure Analysis Data

$$MTBF = \frac{\text{Total Time} - \text{Downtime} - \text{Unused Time}}{\text{Number of Breakdowns}}$$

Equation 5: MTBF Example

$$MTBF = \frac{1028.6 - 75 - 128}{2} = 413 \text{ hours}$$

Equation 6: MTBF Calculation

This calculation of 413 hours gives a representative figure on how long the punch press can be expected to run before the machine is likely to fail.

$$\text{Breakdown Frequency} = \frac{\text{Number of Breakdowns}}{\text{Total Time} - \text{Downtime} - \text{Unused Time}}$$

Equation 7: Breakdown Frequency Example

$$\text{Breakdown Frequency} = \frac{2}{1028.6 - 75 - 128} = 0.0024225$$

Equation 8: Breakdown Frequency Calculation

The breakdown frequency of 0.0024225 can be expressed as a percentage, from this it can be given that the probability of failure occurring within the next hour is 0.24%.

5 Costs & Resources When Implementing Proposed Changes.

Cost is always the driving factor when organisations consider maintenance strategies, careful analysis should be carried out to measure the advantages and disadvantages between adopting a new maintenance strategy like TPM, the method which will be more attractive will be the most cost effective overall.

Corrective Maintenance	Preventative Maintenance
Machine downtime	Machine downtime
Loss of sales / customer satisfaction	Loss of sales / customer satisfaction
Cost of parts and labour	Cost of Servicing
Lost time with workers on stop	

Table 4: Cost of Maintenance Strategies

To adopt a TPM approach will inevitably incur a cost, time will be allocated to training operatives, this will disrupt production. TPM will involve upskilling the operators to conduct maintenance tasks, when investing in employees the risk comes in staff retention, these employees may demand additional pay and should be expected. The payback will come in improved performance of the machine and less disruption when failure occurs.

Table 5 below give an example of increasing the operatives pay by £1.00 / hour and a maintenance course run at Amada. This total cost is said to be £2450 but it is expected that the potential loss of earnings when the machine is shut down is £21,935.50 / day if we can reduce this downtime there is justification in the initial outlay.

Staff pay rate	£11.50/hr
Staff retention Pay	£12.50/hr
Number of operatives	1 operative
Hours / week	37.5 hours
Hours / year	1950 hours / year
Yearly cost for 1 operative	£1950.00
Training course with Amada	£500.00
Total cost increase	£2450.00
Monthly financial target	£800,000.00/month
85% of the total revenue	800,000 x 0.85 = £680,000
85% Daily revenue target	680000 / 31 = £21,935.50

Table 5: TPM Cost Analysis

5.1 Managing Change

To introduce a change such as TPM is a huge undertaking and will take time and resources to implement, it is known that Mono's blended approach to maintenance will help ease any issues surrounding the change. Resources are currently being deployed to help upskill workers by involving them in maintenance tasks. This will help any resistance to the change. Tools could be used such as FMEA and Fishbone brainstorming sessions could be held giving greater input to all parties involved.

To manage the change deployment of the Kurt Lewin change model, this is a simple but effective tool which involves 3 fundamental steps; unfreezing, change process, refreezing. (Carnall, 2014)

5.2 Stage 1 - Unfreezing

During the unfreezing stage the need for change is recognised and communicated. Senior management must show support at this stage, it is essential that the doubts and concerns surrounding change are understood. (Hayes, 2018)

5.3 Stage 2 - Change Process

The second stage involves implementing the change, employees must accept that the change is happening and positive involvement is essential for success, regular communication to prevent false rumours and reduce fears. (Hayes, 2018)

5.4 Stage 3 - Refreeze

During the refreeze stage all employees must recognise this as the new normal way of working, for this to be successful they need to have confidence in the new processes, if there is confusion will impact the performance, training must be considered. (Hayes, 2018)



Figure 7: Kurt Lewin Change Model (Burnes, 2014)

6 Conclusions/Recommendations.

There are many arguments to be had when considering maintenance, whether the method aims to prevent breakdowns or react when they occur there will ultimately be a negative impact felt by the organisation and its customers. Careful consideration should be made and data analysed, ultimately the lowest cost method usually wins. Downtime is never eliminated but the aims of the organisation will always be to reduce the impact to the company whichever method is adopted.

The Amada EMZ CNC Turret Punch Press is a critical piece of equipment and the maintenance strategy chosen for this equipment reflects that, the machine is run at maximum feed rates for its maximum run time. Mono fears allowing time in the program to conduct routine maintenance. If better maintenance routines were adopted at Mono downtime and machine failures could be reduced and potentially improving quality and first pass yield.

The blended approach between breakdown & outsourced maintenance used on the punch press allows for a reduction in downtime when failure occurs, this comes at a higher cost between purchasing and holding replacement parts and costly service plans. The effect of failure could have a greater impact, if the machine fails Mono only has a maximum of a week before the whole factory is on stop. This would be catastrophic to business so robust maintenance package is required.

The report highlights the benefits of Mono adopting a TPM strategy, Mono has recently started trusting their operatives to undertake basic fault finding and repair tasks, if this approach could be successfully implemented it could improve the overall equipment effectiveness of the machine. Dangers such as staff turnover could become problematic so considerations to increasing staff pay along with structured training may be necessary to adopt this approach.

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