



E.D.M. CELL AUTOMATION

Introduction to Industry 4.0 ACPA7004

Abstract

This report was written to show how combining automation and value engineering can increase capacity and throughput without compromising on quality or employing extra staff.

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Introduction

This report aims to outline how Industry 4.0 thinking and market forces influenced the outcomes of the decision to automate the Electro Discharge Machining (EDM) cell within FSG. Taking on board the voice of our automotive customer, it became clear we needed more capacity and flexibility within the EDM cell. There were a couple of options available, and this report will outline the evidence that was put forward to lead to the final solution.

Aims & Objectives

Following extensive collaboration with a long-standing customer, it was made clear that they were looking to increase their market share and therefore needed to get more from their supply chain. The customer had to make some internal decisions, they could either find additional suppliers or get increased volume from their existing portfolio. FSG wanted to be able to exploit this opportunity by becoming efficient, lean and reliable. With our sales department working with existing data and the voice of the customer, it was decided to increase FSG's output and award us a larger contract. This opportunity came with some caveats, our lead times and price per part would have to reduce and the customer would be relying on FSG to deliver the same high-quality products just in time.

Objectives Summary

30% Output increase

20% Lead time reduction

0% Reduction in quality

10% Cost reduction year 1

20% Cost reduction year 2

30% Cost reduction year 3

Background Research

Before coming up with any predetermined solutions, the problem was scoped out in as much detail as possible and broken down into key areas.

Big data

All the information we held in our design vault and our sales records was analysed to understand the variety of work we had previously done for the customer. The sales team also worked closely with the customer to establish the intricacies of the new lines of business. We were looking to scope out the maximums, minimums, and trend data to establish some boundaries of where we would need to operate.

Capacity

When embarking on this project, it was thought, the current capacity of the EDM section was easy to calculate, Number of machines times the number of hours people worked. It became clear this was not the case as sometimes these machines were being set in the daytime then left to run unattended in the evenings or on weekends. This practice of running unattended was helpful

but irregular due to when the orders needed to be delivered or when they arrived on the section. Despite the uncertainty the overall capacity of the section was calculated at:-

6 machines x 40hours per week = 240 hours per week

Machine Overall Equipment Efficiency. [\(OEE Calculation: Definitions, Formulas, and Examples | OEE\)](#)

When the capacity of the EDM Section was calculated the results didn't match the actual output of the section so we looked deeper into the efficiency of the process. We took the hours the components were being processed and analysed each step of the process to work out the efficiency.

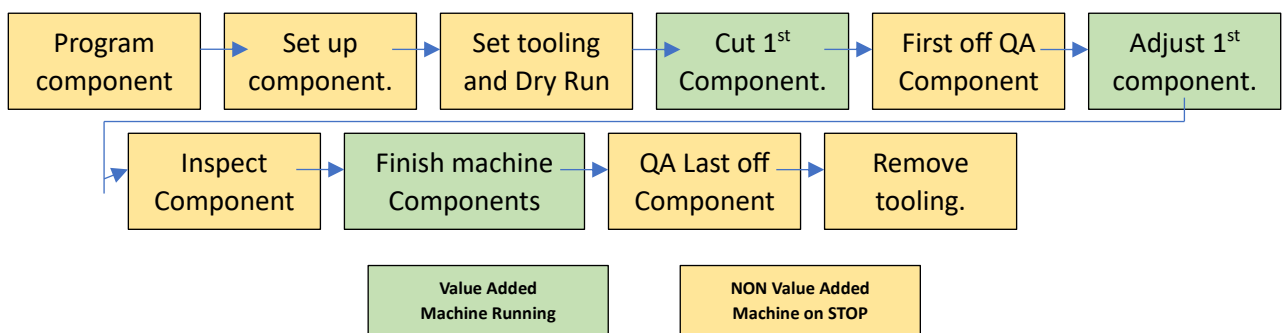
$$\frac{(total\ time - downtime - change\ over)}{total\ time} \times 100$$
$$\frac{240 - 30 - 60}{240} \times 100$$

62.5% efficient

From these findings it was evaluated that the section could become over 30% more effective with the equipment we have.

Value Added

To evaluate where to concentrate our efforts we broke the whole process down into its constituent parts and then found the parts of the process that add value and the ones that were stopping the machines from cutting. Then we looked at removing or taking the operations offline.



Process variables

To get the best solution to the problem we needed to understand the variables within the process. The batch sizes, repetition, range of components. Sizes/weight of the components, the quality requirements and cycle times.

Organisational barriers

There were several organisational barriers that came to light when the project was first announced. We tried to be honest with the workforce and explain the need for the change. Some employees were convinced that we couldn't increase production and thought we were working at maximum capacity, which was true the way we were working. The workforce thought the only way to increase production was to introduce a 1 in 2 shift pattern that they were opposed too. The shift pattern was explored but all it would have achieved was slight increase in the capacity of the inefficient process.

Implementation

After exploring several solutions, it was decided that we would automate the EDM process. This would use the existing machines and add a Polar Co-ordinate Robot to load/unload the machines. This option would use the same number of staff, take advantage of the unattended nature of the process, and get the most out of the assets we had already invested in.

Work cell

The System 3R Work Master Polar robot was chosen to feed two machines and set up to hold 108 tools and 12 workstations. The robot has three automatically changeable end effectors, the tool change gripper, work piece gripper and the Identification probe.

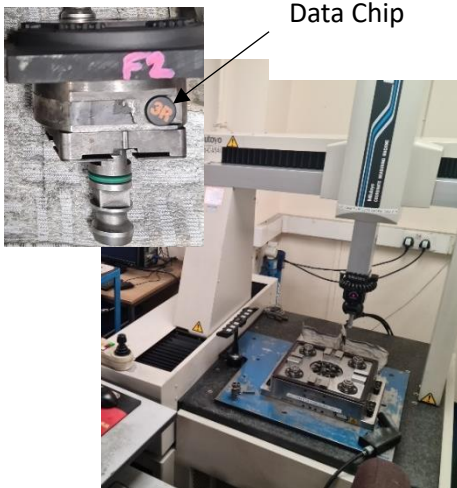
The robot relies on the reference plates that are bolted to the bed of all the machines to be able to clamp the work pieces in place accurately. The machines own tool changer has become redundant as the tools are fed directly from the robot to the machine.

[Automation - Palletized handling \(system3r.com\)](http://system3r.com)



Work Master Robot and EDM Machine

Agile manufacturing



CMM with Reference Base

After investigating the value-added operations, it became clear the machines were on stop while the operators were setting the workpieces and electrodes. With small batches this could be as much as 38% of the shift. By employing the robot to load and unload the tooling and workpieces the operators could do the setting offline while the machine was running. As part of the automation package a CMM was purchased with the same reference plate as the machines. This allowed the co-ordinates of each workpiece and tool to be recorded and fed into the robot via a data chip. The robot scans the chip and inputs the offsets into the machine. Not only did this increase capacity because the machine never stopped cutting but also increased quality by removing the time pressure from the operators trying to get the machine back running as quick as possible.

The next thing we looked to optimise was the process of leaving the components in a metal safe condition. This was inefficient because the finishing of the components took the longest time and effectively, we were doing it twice, once before inspection then back on the machine for finalising. The metal safe operation was removed by closely monitoring the electrode wear and machine condition to predict exactly when key features were going to go out of specification. To get this amount of consistency we started cutting and inspecting the electrodes in house, this ensured that we had control over the grade of graphite we use and the tolerances we achieved.

Waiting for components to be verified by the QA department was another restriction to the flow of the section. The work master robot helped with this process initially by starting or finishing off a different batch of work while the first component of a batch was being verified, therefore production never stopped, but the process still needed work.

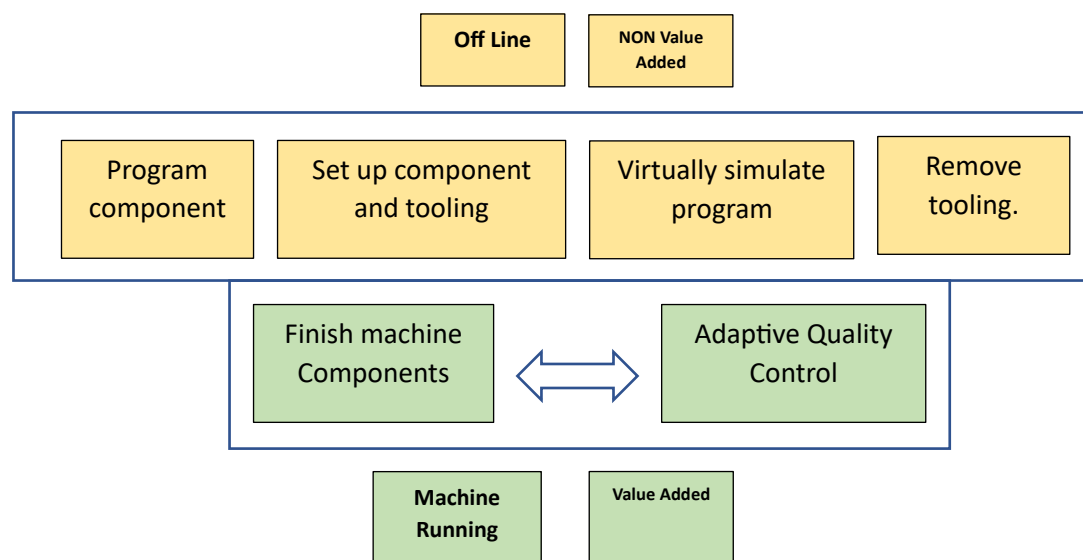
Adaptive Quality Control

AQC was introduced to eliminate the waiting time of verification. A series of in process checks are programmed into the machine at various intervals. When cutting electrodes, the [Renishaw](#) tool setter will check if a cutter is worn or snapped, the probe on the machine is programmed to check key features and update wear offsets. Even the CMM has set parameters that will tell the operator if the component is outside the machine boundaries or flatness tolerances. This not only ensures the components are right first time, but no time is wasted finishing components that are not in specification.

Systematic thinking

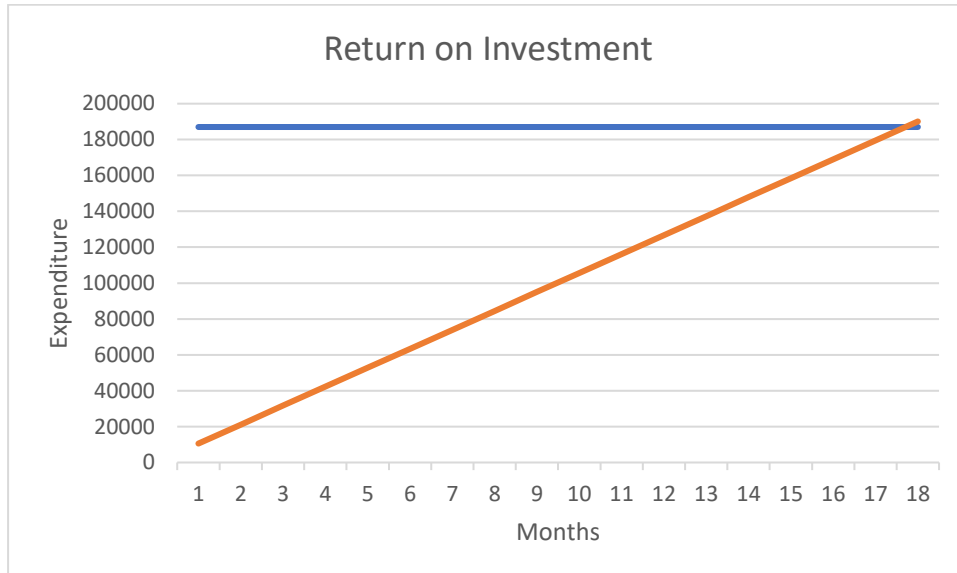
It was thought that to keep up with the new demands of the customer and the sporadic way in which they would order certain types of components we would have to have every variable of their product in stock. It took a few months, but when the sales department realised how much the lead time from order to delivery had reduced, FSG were able to make each component to order. A large amount of this time saved, was down to looking at each stage of the process and remove the non-value-added activities. If these activities were essential to the process, they were carried out concurrently in the background while the value added never stopped. A digital twin was created using [GTECH VERICUT](#) so that all the cutting and inspection processes could be simulated virtually to prove out programs without stopping the machines.

Flow



ROI

The return on investment was quite fast as because the initial investment was relatively small compared to investing in machines to increase capacity to the level of the automated robot.



Conclusion

The project was deemed a success and not only met the original brief but exceeded all internal and customer expectations. With a capital expenditure of £187,000 the capacity was increased 91.5% from 240 to 460 hours per week. Only the original staff were upskilled and there was no impact on quality. The biggest change to the section was removing constraints and improving flow (E.M Goldratt 2004). The cycle time per part stayed roughly the same but the automated machines went from processing a batch every 2-4 days to producing 2 batches per day. The plan was to get the first phase running within 3 weeks, which took 4, but the optimisation phase took 12 weeks longer than planned and is still on going.

References

[Automation - Palletized handling \(system3r.com\)](http://system3r.com)

E M Goldratt. (2004) The Goal 3rd edition. New York: Gower Publishing p349.

[OEE Calculation: Definitions, Formulas, and Examples | OEE](#)

[CNC Simulation Software - CNC Simulation - VERICUT UK \(cgtech.co.uk\)](http://cgtech.co.uk)

[Machine tool probes and software \(renishaw.com\)](http://renishaw.com)