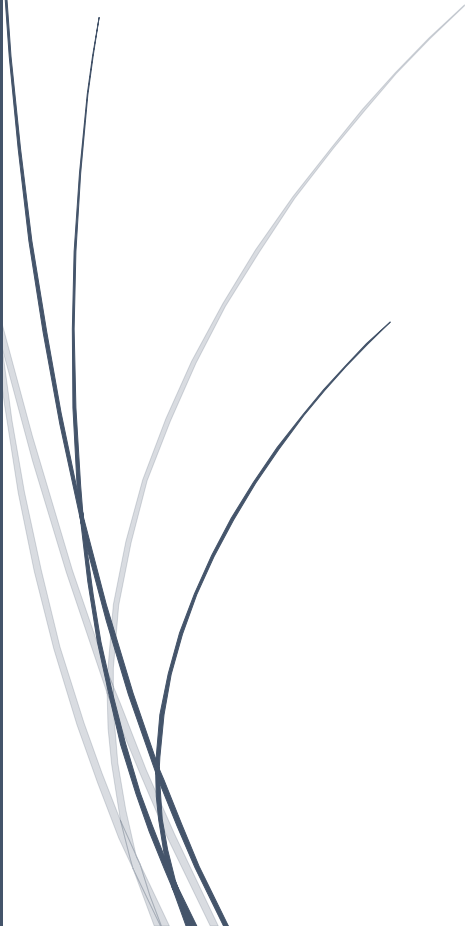


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8/12/2023

ATOM Production Lean Manufacturing Techniques

ACMA6002 – Manufacturing
Systems and Simulation

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2113455

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Introduction

One of Renishaw's most popular encoders is the ATOM. This encoder is early on in its product lifecycle compared to other alternatives on the market. The product was designed with the aim of completing the manufacturing process via automation processes. Due to this factor the ATOM assembly line spent many years within NPI (New Product Integration) at Renishaw's New Mills site. Now that a proven manufacturing process has been established for ATOM the assembly line is being transferred to Renishaw's production facilities in Miskin and Woodchester. This subsequently presents the opportunity to look at the process currently in place to manufacture the product and make it leaner.

The process of making the manufacture of the ATOM encoder leaner will involve identifying the forms of waste and removing them from the assembly procedure. There are often nine wastes associated with lean. These include Defects, Overproduction, Waiting, Non-Value-Added Processing, Transportation, Inventory, Motion, Employees and Energy. To identify the wastes within the ATOM manufacturing process it is important to understand the workflow of the cell. The techniques utilised within this report will enable the identification of wastes and suggestions can be made for appropriate solutions.



Figure 1 - Renishaw ATOM Encoder

Current ATOM Encoder Manufacturing Process

Before looking into possible lean improvements to the manufacturing process it is important to understand the measures currently in place. In total the production of the ATOM encoder can be split into six stages. These are as follow:

1) ATOM Loading Jig

The first stage in the ATOM manufacturing process is the 'Loading Jig'. This is where a PCB panel is loaded into a 'Cassette' which acts as a fixture so that the panel can be fitted and powered within the ATOM Burn-In Oven. Functions performed by this stage in the process include scanning the PCB panel for traceability purposes and fixturing the PCBs into the cassette via a pressing action. Once the cassettes have been loaded, they can be transferred into the Burn -In Ovens.

2) ATOM Burn-In Oven

One of the main components of an encoder is the light source, usually and LED, which is directed at the scale that the encoder runs along. The light reflected back is then converted into a proportional electronic signal which can be analysed. Before the LED can be built into the encoder it needs to undergo the 'Burn In' process which analyses its performance by powering the unit over a specified time and measuring the response. This is the purpose of the ATOM Burn-In Ovens within the manufacturing process.

3) ATOM Coring (Index to Body & PCB to Body)

After the PCBs have been validated through the previous step of the process they can be moved along to the 'Coring' stage. This is where the encoder body gets fitted with the index grating and PCB, hence it being split into two parts. The first part involves gluing the index grating, which is effectively a small piece of glass, to the encoder body. It will then pass through to the next part where the PCB is fitted within the body via adhesive. Both these parts of the process are carried out using automation equipment and require minimal operator intervention. Parts will be fed out of the machine in a tray which is stored in a magazine. These magazines have the capability to hold twelve trays allowing the process to run overnight until the magazine has been filled.

4) ATOM Lidding Rig

Following the completion of the coring stage the encoder then requires lidding and cables. This is where an appropriate cable is fitted to the unit and then a lid is applied to complete the mechanical assembly of the part. There are different variants of cables that can be applied to the unit and will be specified by the customer upon order. Once a unit has been cabled and lidded successfully it can move onto the next stage.

5) ATOM Final Test

The ATOM Final Test Rig functionally test the finished product and takes a series of measurements to confirm that the product is performing as expected. Some of the tests performed by the rig include current measurements, encoder ride height and yaw angle. All of which require a high degree of accuracy which makes this stage in the process one of the more advanced.

6) ATOM Laser Engraving

The final stage is the process before the unit leaves the production cell and heads to packing is Laser Engraving. During this stage the lid of the product is engraved via a laser marking device. Included in the laser marking is the Renishaw logo, unit serial number and part number. Vision checks are then performed on the finished unit with inspection cameras before the part is moved to the packing cell.

Spaghetti Diagram

One of the techniques often associated with lean manufacturing is the Spaghetti Diagram. This is a visual representation of the flow of the product and operators throughout the cell and can be used to identify areas of waste within the process. More specifically this method “helps to eliminate or reduce some of the 7 deadly wastes in processes such as transportation and motion” (Hessing, 2022). Based on the information of the process provided above a Spaghetti Diagram of the current manufacturing process for ATOM can be created and can be found in Figure 3.

One of the conclusions that can be devised from the Spaghetti Diagram in Figure 3 is the distance that the operator needs to travel to collect the inventory required for the build process. Specifically, the operator responsible for running the ATOM Coring process described on the previous page. This operator must collect two different types of inventories on separate occasions which when calculated is a total distance of 30m. When this step in the process was timed using a stopwatch it took a total of 5 minutes for the operator to collect the inventory and load it into the machine. This can be categorised as a waste of motion in relation to the ‘7 Wastes’ previously mentioned.

Another point that can be determined from the Spaghetti Diagram is the distance between the different stages of the process. This results in the unnecessary movement of operators around the production cell. It also increases the transportation time of the product and inventory which is another waste of lean manufacturing.

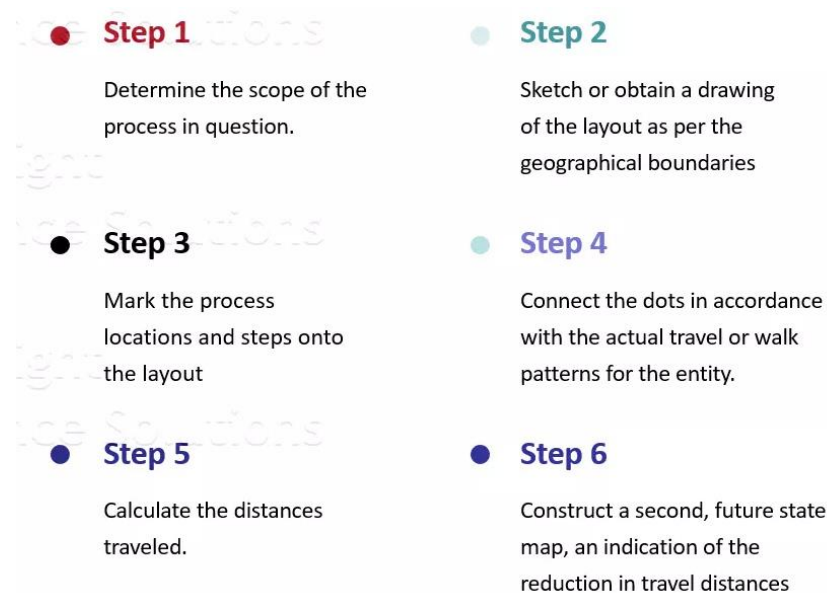


Figure 2 - Spaghetti Diagram Workflow

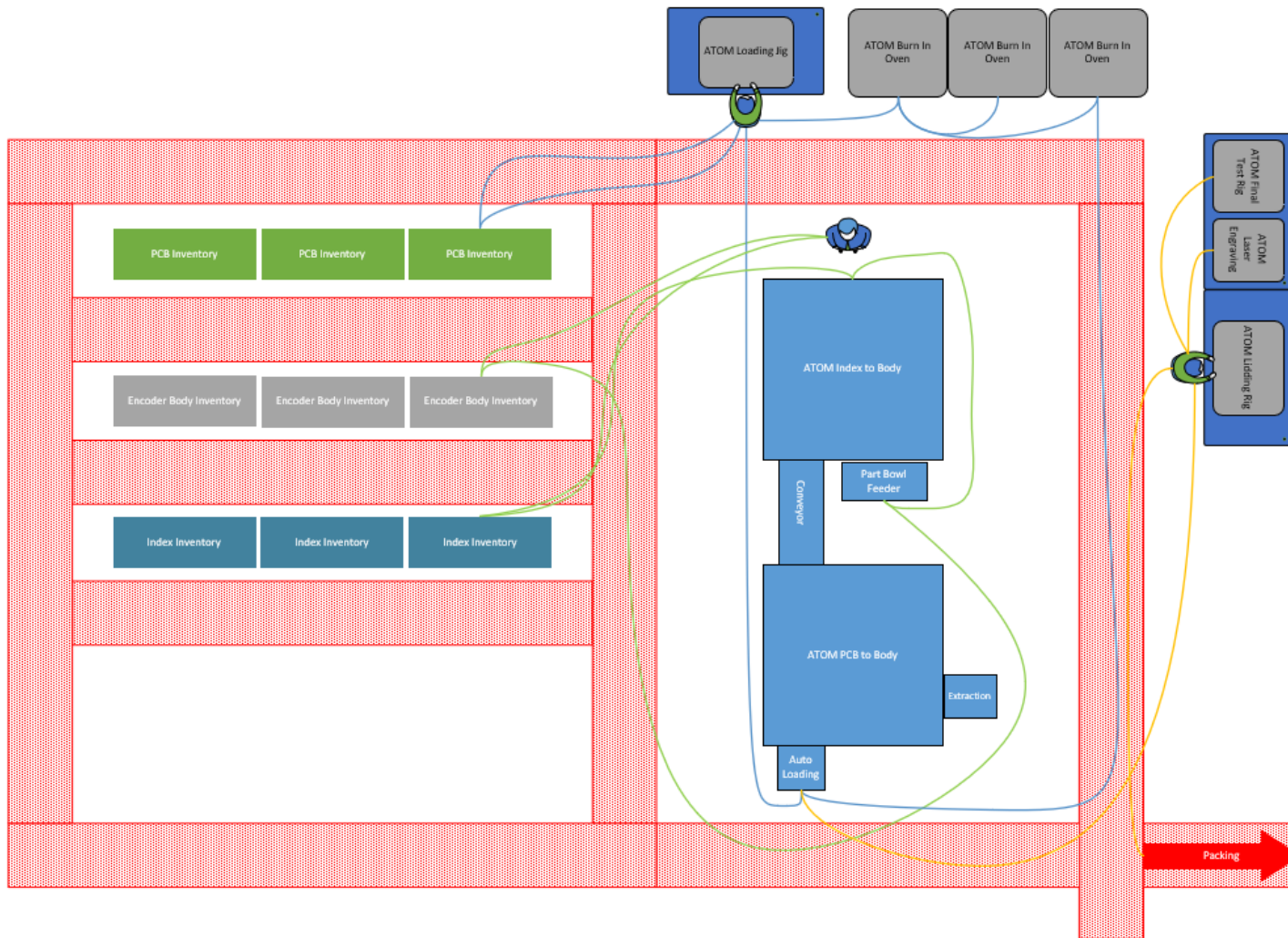


Figure 3 - ATOM Production Cell Spaghetti Diagram

Value Stream Mapping

Another lean manufacturing technique commonly used is Value Stream Mapping, often referred to as VSM. This is used to analyse the workflow of a product throughout the manufacturing process and assists with identifying wastes. It also helps to identify value adding and non-value adding stages within the manufacturing process. Other benefits of VSM include assisting with “visualizing the entire value stream” (Kanbainze, 2023). For example, each of the steps within the process will be displayed along with metrics associated with the various steps. Some of the metrics included are the cycle time, capacity, and utilisation of the equipment. Figure 5 shows the VSM for the ATOM encoder manufacturing process.

Shown in the VSM is the flow of the ATOM encoder throughout the manufacture. Customer orders will be received by production control who will then communicate the demand to suppliers to ensure that the material inventory is sufficient to meet the customers’ requests. Goods in will process the parts before they are processed into the inventory. The inventory will then be processed through multiple different stages of the manufacturing process until the final product is produced. This will then be sent to packing before heading to goods out. Product then gets sent to the Renishaw subsidiaries around the world where it will then be distributed to customers. It is often the case that product is put into stock if demand is low so that when customer orders pick up.

Based on the VSM below it can be determined that there are bottlenecks within the process. One of the first bottlenecks with the process is the Burn-In Oven. The current utilisation is 74% with the two rigs that are currently in production. This step in the process has one of the greater hours per part values which could explain the bottleneck at this stage. A solution to this would be to increase the number of rigs in production which would help clear the bottleneck. Another option would be to increase the number of shifts per day. Currently production is run on an 8-hour shift once per day however, this could potentially be increased to two or three shifts a day to meet the demand.

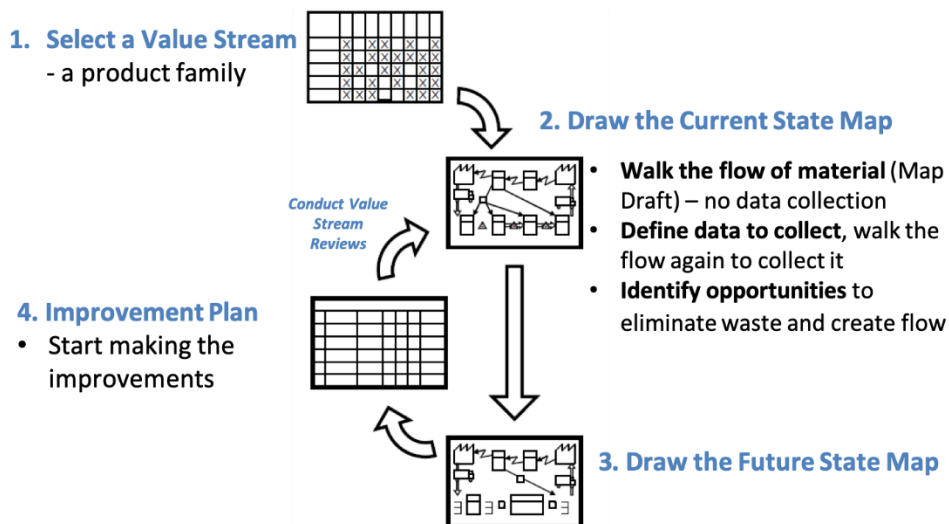


Figure 4 - Value Stream Mapping Workflow

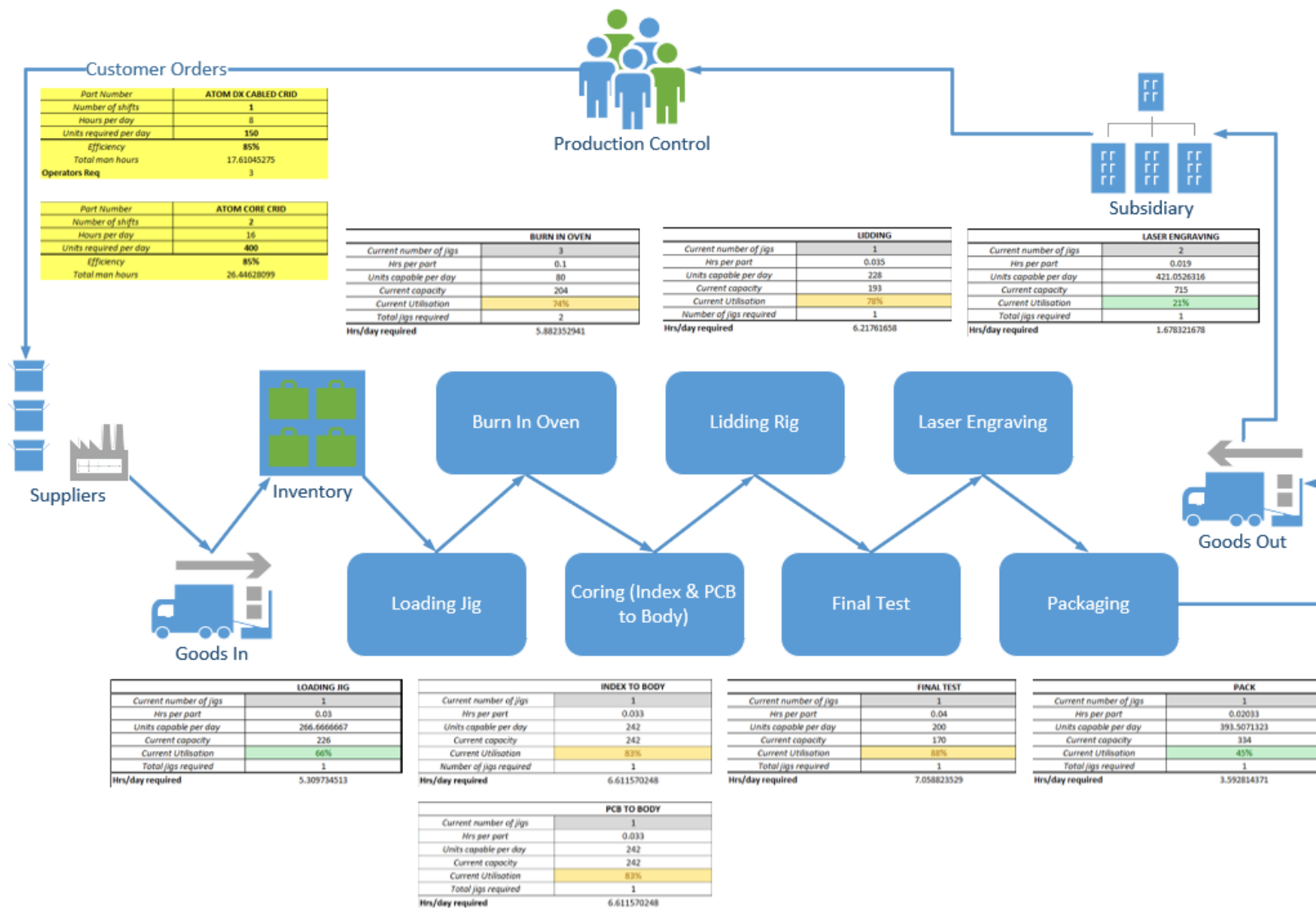


Figure 5 - ATOM Value Stream Map

Facilities Layout

Various factors need to be taken into consideration when it comes to developing an efficient Facility Layout. For example, reviewing the Spaghetti Diagram to establish the flow of materials throughout the process would be a key factor in establishing the layout. Other considerations such as trying to optimise the space physically available while still decreasing waste should also be contemplated. One of the main types of wastes that can be linked to the Facility Layout is time. This is because if it takes an operator 'X' amount of time to get from point 'A' to point 'B' then it may be possible to reduce this time by changing the layout of the manufacturing cell. Making this change could also result in increased productivity.

One of "the most famous product layout examples is Henry Ford's Model T Assembly Line. On the assembly line, there were around 200+ positions for employees and machines that produced millions of Model T cars in the 1920s" (Woerner, 2023). For this Facility Layout one of the factors that needs to be taken into consideration is the fact that various pieces of equipment utilised throughout the process are semi-automated. This means that the operator within the cell may need to occasionally interact with the different pieces of equipment at varying times. For this reason, the access routes between equipment should be considered when it comes to the layout.

Another important factor when it comes to the ATOM Facility Layout is the flexibility for future expansion. It is highly likely that production capacity will need to be increased at some point in the future to accommodate an increase in customer orders therefore, a flexible layout is a crucial aspect to be able to add further equipment to the cell. Even though there needs to be space for future expansion, it is also important to optimise the space available to reduce waste. Taking into consideration the current expansion of Renishaw's manufacturing site at Miskin, physical space should not be an issue. See Figure 6 for the scale of current expansion work.



Figure 6 - Renishaw Miskin Future Expansion

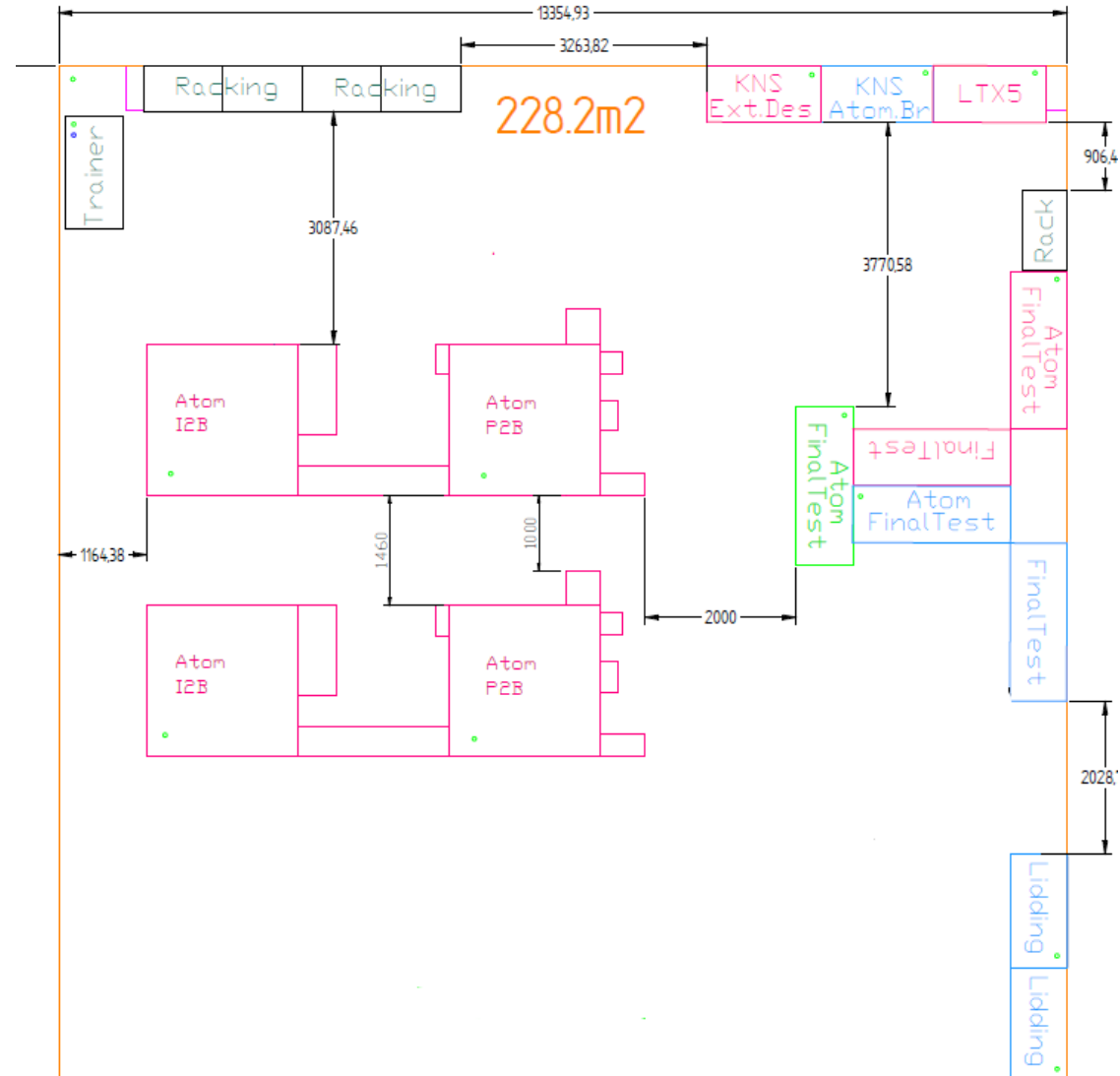


Figure 7 - ATOM Facilities Layout

Proposed ATOM Encoder Manufacturing Process

Now that the process has been analysed in its current state, the next section of this report addresses ways in which the process could be made leaner. For example, one of the ways the process could be made leaner is by identifying the types of waste that currently occur within the process. Also, identifying the areas in which value is added from a customer's perspective. Finally, this section will evaluate how the process can be made leaner and the potential problems associated with implementing the improvements.

Spaghetti Diagram

One of the wastes that can be identified from the Spaghetti Diagram in Figure 3 is motion between the point where the inventory is stored and the operator's workstations throughout the cell. There is potential to reduce the distance between where inventory is stored and the workstations in several different ways. By reducing the distance that operators need to travel to collect materials for the process, the time the process takes to complete is also reduced. This is another waste that can be identified within the current process.

It is important to consider the potential problems associated with implementing the improvements mentioned above. For example, one of the problems associated with changing the cell layout is the health and safety challenges it may pose. Another problem faced by changing the cell layout is the location of services for equipment. If there are no services to connect the equipment supply to upon relocation, then this would present a challenge to overcome.

After addressing the issues mentioned above and changing the cell layout to try reduce the inventory collection time the following data shown in Figure 8 & Figure 9 was obtained.

Inventory Collection Cycle Time (Before Change)											
Operator ID	Cycle Time (Seconds)										Average Time
	1	2	3	4	5	6	7	8	9	10	
A	50	60	52	61	64	51	55	68	65	58	58.4
B	62	68	53	55	61	61	65	58	63	60	60.6
C	65	66	51	70	53	59	65	61	54	55	59.9
D	60	65	69	55	51	49	60	54	55	59	57.7
											59.15

Inventory Collection Cycle Time (After Change)											
Operator ID	Cycle Time (Seconds)										Average Time
	1	2	3	4	5	6	7	8	9	10	
A	40	43	41	50	55	51	55	60	59	44	49.8
B	62	50	53	48	49	63	65	40	63	60	55.3
C	55	48	53	57	60	44	47	61	54	55	53.4
D	46	45	59	55	54	42	39	56	47	51	49.4
											51.975

Figure 8 - Inventory Collection Cycle Time Data

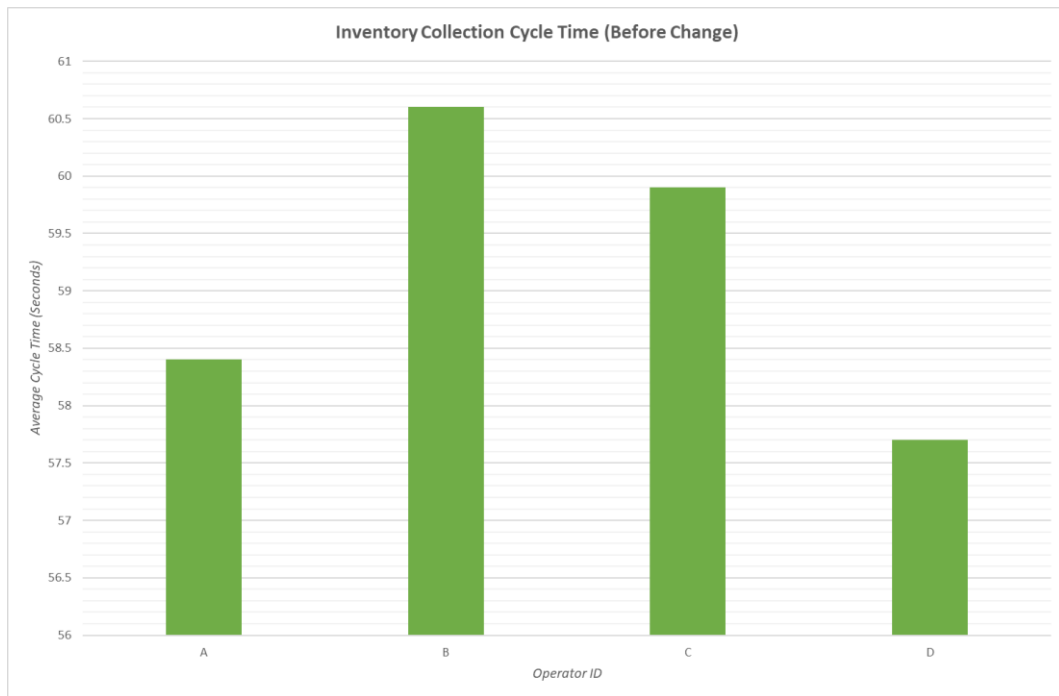


Figure 9 - Cycle Time Analysis Before Change (Average Cycle Time = 59.15 Seconds)

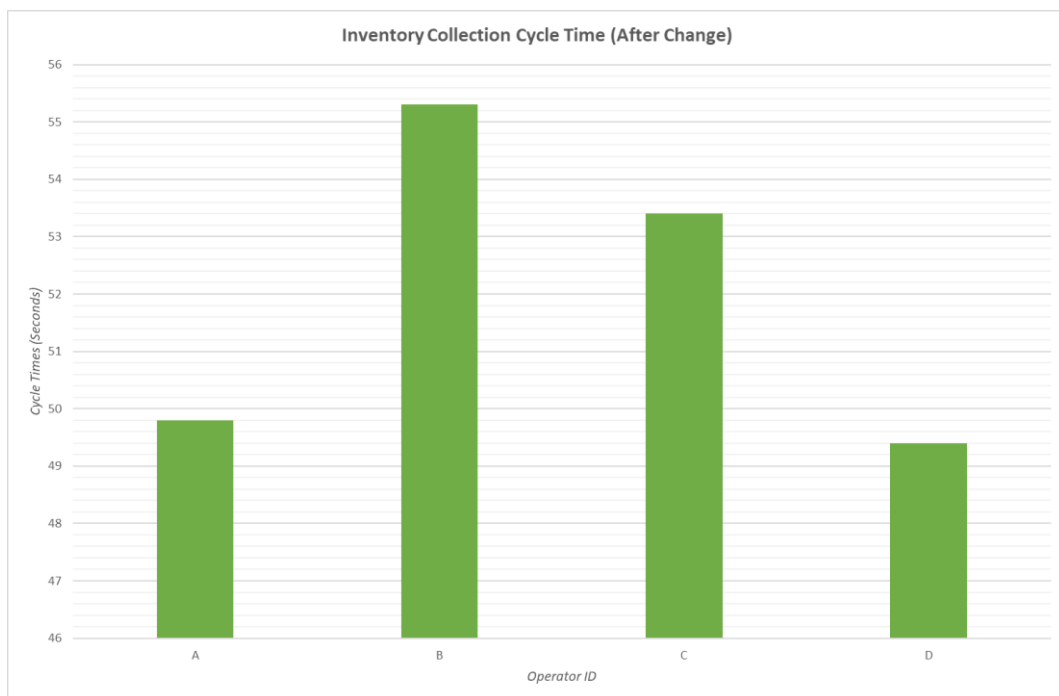


Figure 10 - Cycle Time Analysis After Change (Average Cycle Time = 51.975 Seconds)

Based on the data analysed above, an improvement could be seen in the inventory collection cycle time after the change was implemented. Ultimately this reduction in cycle time reduces the waste of time and motion within the ATOM encoder manufacturing process. Potentially additional improvements could be identified with further analysis of the Spaghetti Diagram.

Value Stream Mapping

Upon analysis of the ATOM Value Stream Map, shown in Figure 5, a couple of aspects where the process could be made leaner have been identified. The first of which is where product will be stored at a Renishaw subsidiary before heading to the customer. This point in the process can be considered non-value adding. Instead of building for product to sit in stock, other principals could be adopted such as JIT (Just in Time). JIT is where “rather than producing goods and supplying customers from stock, JIT processes focus on producing exactly the amount you need at exactly the time your customers need it” (NI Business Info, 2023). Adopting this approach has the potential to provide multiple benefits, including reducing the money stuck in stock, eliminating over production and minimising lead times. There are also disadvantages with JIT such as it being expensive to initially implement.



Figure 11 - Just in Time Benefits

Another point where the process could be made leaner and waste could be reduced is at the supplier end. Currently the value stream is heavily dependent on materials being received from suppliers. If there were to be a disruption in the supply chain, it is likely to cause delays to the customers. Waiting for materials causes unnecessary expense and potential breakdown in relations with customers due to long lead times. A solution to disruptions in the supply chain could be to move the manufacture of material in house if possible. Materials could also be sourced from multiple sources to avoid a disruption to the manufacturing process.

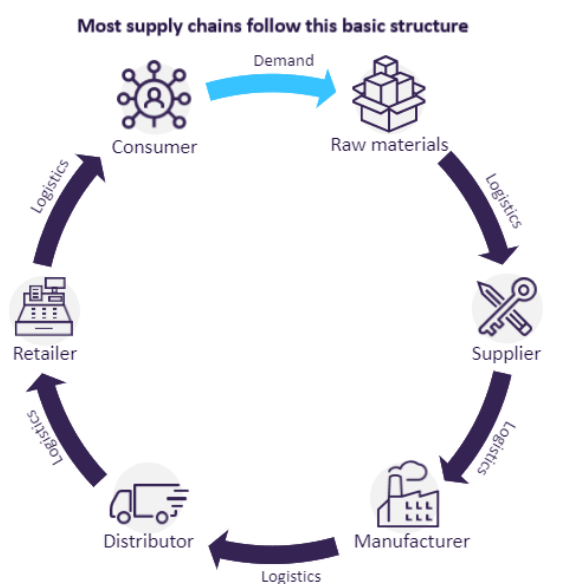


Figure 12 - Basic Supply Chain Structure

Facilities Layout

Taking into consideration lean principles when it came to the Facilities Layout assisted with identifying areas in which wastes could be eliminated and costs could be reduced. One of the areas identified as a positive in the current layout is the space for future expansion. New equipment could be integrated into the current layout with ease. A downside of this is that there are large amounts of space between workstations which increases motion and time within the manufacturing process.

Analysis of the Facility Layout also identified the opportunity to improve the flow of the product throughout the cell. There are multiple layout options with their own advantages and disadvantages that could be adopted in this case. For example, the U-Shaped flow “configuration allows the work cell to be laid out using a fairly small footprint” (Quality Training Portal, 2023). This flow configuration can be seen in Figure 13.

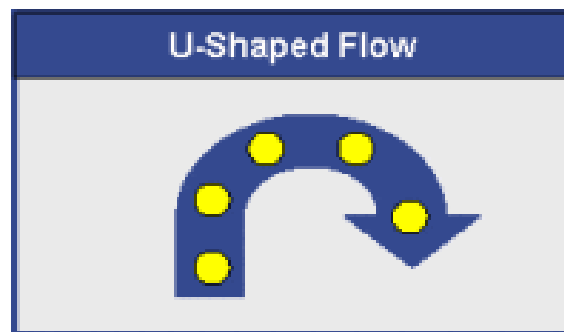


Figure 13 - U-Shaped Layout Configuration

For this layout it may be more beneficial to use the Comb & Spine flow configuration which can be seen in Figure 14. This layout “works well for assembly operations when products must exit the process flow at various levels of assembly” (Quality Training Portal, 2023). Some of the other consideration that need to be considered when selecting a flow configuration is if materials are shared by multiple products and the physical constraints of the building.

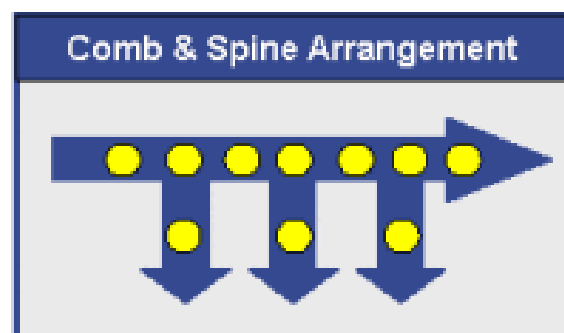


Figure 14 - Comb & Spine Layout Configuration

Conclusion

To conclude, after applying lean techniques to the current manufacturing process for the ATOM encoder, several types of wastes were identified. Once the wastes had been identified the analysis of the tools identified areas in which value was added, or not, to the process. The process was then evaluated and ways in which it could be made leaner were identified along with the problems that may be associated with the implementation of the improvements. There is now potential for these improvements to be implemented in the real world process with further investigation.

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