MSc Industry 4.0 Advanced Manufacturing

Advanced Industry 4.0 Essay

Assessment of the current Manufacturing Systems and the impacts of Industry 4.0 at Safran Seats GB

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Introduction

Consumer requirements have always been the driving force behind manufacturing, and this desire is what led to the first industrial revolution. As customer needs have changed by becoming more demanding, other industrial revolutions have taken place to meet those wants. These needs have manifested in more technologically advanced products and cheaper, quicker delivery times.

The ability to customise products has gained more significance in our culture. (Pulman, n.d.), According to Fiat, their options would allow for the manufacturing of 500,000 vehicles before one became exactly like the other. The third industrial revolution's further innovations, as well as the resulting advancements in systems and automation, are what made this level of personalization possible. Environmental deterioration and population growth are related, along with the quick growth of innovation.

The Fourth Industrial Revolution has begun because of these levels of development and environmental effects on technology. To satisfy consumer needs in a way that is less harmful to the environment, industrial systems may be harmonised using the technology that surrounds us.

Nine technical pillars serve as the basis for the fourth industrial revolution. While it is not required to integrate all of them to take advantage of Industry 4.0, doing so allows organisations to include some that support progress. German researchers invented the phrase "Industry 4.0" in 2011 and presented it at the Hannover Fair. (Ines Guyon, 2019)

This paper will discuss the current manufacturing processes that are utilised within the industry and evaluate their current effectiveness. Further to this activity the identification of new and/or emergent technology and how they influence or will influence the current processes and how they will ultimately look.

This will be looked at with a bias towards the current systems utilised at Safran Seats GB, in specific the Final Assembly line (FAL) at the main facility located in Cwmbran South Wales.

What is a Manufacturing System

A manufacturing system is a group of devices, procedures, and equipment used to create products or render services. Typically, it covers the purchase of raw materials, processing, assembly, and distribution phases.

For a manufacturing system to function it must include the following basic functions:

- Inputs - components or raw materials that will be employed in the production process
- Processes - the procedures and strategies applied to convert the inputs into the intended result
- Outputs - the items produced by the manufacturing process, such as goods or services

Any production system aims to create outputs with the greatest possible quality, at the lowest possible cost, and in the shortest period of time. Manufacturers need to work hard to continually enhance their systems and tools in order to do this.

What are the Key characteristics of a manufacturing system?

- Cost - The manufacturing process must be set up to produce goods or services at the lowest reasonable price.
- Efficiency - A quick and effective production process must be built into the industrial system.
- Flexibility - It must have the flexibility to respond to shifts in demand and develop new goods or services as required.

What are the types of Manufacturing systems?

(Lemay, 2021) helps us to establish that there are several Manufacturing systems some of which are as follows.

- Discrete
- Repetitive
- Mass Customisation
- Batch
- Continuous
- Additive

Discrete Manufacturing System

The work conducted by (Lemay, 2021) and (Intel, 2020) helps us define that, a method of industrial production known as discrete manufacturing yields unique finished goods. Incoming materials, parts, components, and/or subassemblies are put through a sequence of production procedures to achieve this. Products produced using discrete manufacturing may be numbered and are unique from one another. Additionally, it creates products that may be disassembled into their component pieces.

Although the aerospace & military, automotive & transportation, and electronics & semiconductors sectors are some of the most well-known discrete manufacturing cases, a wide range of other industries also use discrete manufacturing techniques to make their products.

Repetitive manufacturing System

The industrial process function known as repetitive manufacturing produces goods for a high rate of production flow. The major use of assembly and/or production lines, with a focus on repetitive output, is a defining characteristic of repetitive manufacturing.

This manufacturing process is used by manufacturers to mass-produce goods with a similar design and functionality. If there are any minor adjustments to the product design, they won't have a significant impact on how it is made. Production rates can be increased by combining this method with discrete manufacturing. The repetitious production method, however, does not lend itself to someone who produces things with greater creative variability.

For repeated manufacturing, a rigid schedule is utilised to maintain a certain degree of quality while achieving a predetermined production rate. A determined KPI is utilised and taken into consideration while setting these production rates.

The process setup time is much less than with other production processes since the products are so comparable. As a result, the lead time for manufacturing is shortened.

A master production schedule (MPS) is necessary for manufacturers to operate effectively. Given that production is done in this location before clients place orders, this will aid in staying ahead of production demands.

Durable goods, automobiles, and electronic items are a few examples of production businesses that use repeated manufacturing techniques. (Management Study Guide , 2022).

Mass Customisation Manufacturing system

When a customer requests personalised, made-to-order items yet you need to create and sell the item at a low price to compete with mass production, mass customisation is seen to be the ideal solution. Sometimes customers are very particular about the products they purchase, which puts pressure on manufacturers to reply quickly, which may lead to producers giving inaccurate information. In such circumstances, businesses frequently quote a price that they are unable to pay. The greatest approach is therefore mass customisation, where manufacturers provide their clients a minimum quantity that may be expanded or lowered based on the features needed.

Mass customisation combines the unique and distinctive qualities of personalised goods with higher levels of manufacturing and sales. Mass customization is a fantastic concept. Who wouldn't want to be treated with respect wherever their needs are top priorities? This idea of particularly meeting customer wishes has been around for a long and has just reappeared on a more practical and sophisticated platform. (CIRP, 2019)

Batch Manufacturing

A manufacturing process known as batch production involves producing similar or identical goods in large batches. The technique enables objects, ranging from vehicle doors to children's toys, to be manufactured in batches with little to significant alterations to the product.

Before going on to the following stage to create the intended product, each batch only completes one stage of the process. It's a crucial solution that companies of all sizes and in several sectors employ. A product may change between batches, for example, by being made in a different colour, size, or style. As the manufacturing process shifts from one batch design to another, this variability can be changed if a product must be modified. (Pearson, 2021)

Continuous Manufacturing

Continuous manufacturing, often known as flow manufacturing, is one of the most frequent manufacturing methods. It denotes that a product is made constantly, with no gaps or pauses between batches. Continuous production has generally been utilised for high-volume goods that do not require customisation choices, such as paper and pulp manufacturing, petrochemicals, oil, and gas refineries, and/or items used on a continuous basis, such as power generation or water treatment facilities.

Continuous production differs from batch manufacturing. Machines and equipment are constantly used in continuous production, and there is little fluctuation in the process to generate different types of goods. While batch production is the most basic and straightforward method of production,

continuous manufacturing may assist overcome production bottlenecks and boost both product quality and quantity.

(Coutinho, 2021) Breaks the system down into 3 simple areas:

- Large Product volume
- Standard Process
- Low Product Variability (Think Henry Ford and the Model T)

Additive Manufacturing

The term used in industrial production for 3D printing is additive manufacturing, sometimes known as additive layer manufacturing. This computer-controlled technique deposits materials, often in layers, to produce three-dimensional item. In additive manufacturing, the machinery is controlled by computer-aided design software 3d model scanners to deposit material layer by layer in exact geometric designs. In additive manufacturing, an object is made by adding material, as the name implies. When making an object the traditional way, it is frequently essential to remove mass by machining, cutting, milling, moulding, or other industrial processes.

Although additive manufacturing may appear to many to be a recent development, it has been applied for many years. When used properly, additive manufacturing offers the ideal trinity of complicated geometry, increased performance, and streamlined manufacturing. As a result, people that are actively engaged with additive manufacturing have a variety of choices. (Autodesk, 2022) (Linke, 2017)

Loughborough University (Loughborough University, 2022) breaks down additive manufacturing into the seven different types,

- Vat Photopolymerisation
- Material Jetting
- Binder Jetting
- Material Extrusion
- Powder Bed Fusion
- Sheet Lamination
- Directed Energy Deposition

Vat Photopolymerisation

Vat photopolymerization, as the name indicates, uses a vat of resin that hardens the exposed region when subjected to ultraviolet light or a laser. Once the fresh resin has been exposed to the light, this layer is then moved away, and the process is repeated until the object is complete. The resulting pieces from this process have excellent surface finishes.

This process can be further split down into other types (Jalili, 2022)

- Stereolithography (SLA) – Cured by Laser
- Digital Light Processing (DLP) – Cured by Projector
- Continuous Digital Light Processing (CDLP) – Cured with LEDs and Oxygen
- Continuous Liquid Light Processing (CLIP) – Cured with LEDs and oxygen

Material Jetting

Similar to how an inkjet printer works, material jetting is a method of producing items. As the material is added to the build surface, the item is built up layer by layer. Material is deposited via a nozzle that moves across the construction platform horizontally. The material layers are then hardened or cured using UV (ultraviolet) radiation. Due to the method of application of the material to the build platform, the list of available products is limited. The material must be viscous enough to form droplets and really only Polymers and waxes are currently suitable.

(Xometry, 2022) splits this down to the following

- Polyjet – plastic prototypes utilising photopolymer droplets and curing with UV
- Nanoparticle Jetting (NPJ) – suspended metal or ceramic within the polymer
- Drop on demand (DOD) – application of wax for the manufacture of casting moulds

Binder Jetting

In order to generate a component, the technique of "binder jetting" involves a layer-by-layer deposit of a binding agent on a powder bed. These layers are produced one after the other up until the component as a whole is created. When a printer passes over a surface of powder and deposits binder droplets, the powder particles adhere to form each layer of the final 3D object. After each finished layer, the powder bed is lowered by a layer, and a new layer of powder is placed over the layer that was previously bound so that the printhead may deposit a new layer of binding agent.

Material Extrusion

Material extrusion is a method for building 3D components layer by layer by depositing a continuous strand of thermoplastic material. A heated nozzle warms the filament as it is pushed through it before depositing it onto what is known as a build platform.

The technology and materials are affordable, making it the most common 3D printing technique for home use, despite the fact that it is not as precise or quick as other additive manufacturing techniques. Rapid prototyping is accomplished using material extrusion in an industrial context.

Powder Bed Fusion

The powder bed fusion method uses fine powder as the foundation medium to build up a 3D component one layer at a time. This powder melts or is sintered with the application of heat. Sintering and melting are both types of powder bed fusion, despite the fact that their consequences are distinct.

(KBM Advanced Materials, 2022) further breaks this method down to the following

- Selective laser Sintering (SLS) – Utilising a laser and Polymer in item creation
- Direct Metal Laser Sintering (DMSL) – Utilising lasers and metallic powder in the creation of items
- Electron Beam Melting (EBM) – Utilising electrons to bond the layers of powder

Sheet lamination

A technique called sheet lamination involves bonding thin layers of material together layer by layer to create a consolidated piece that may then be shaped into a three-dimensional item. Ultrasonic consolidation and the production of laminated objects are two types of sheet lamination methods. This process does not create very accurate models but has its place in the creation of non-moving prototypes

Directed Energy Deposition

By using laser or electron beams, directed energy deposition is analogous to powder bed fusion. The main distinction is in the way the powder is fed, with the powder being blasted into the super-heated region produced by the laser or electron beam as opposed to a layer of powder being deposited before the heat source acts on it.

Current Manufacturing system at Safran Seats GB

The Blue Sky completely bespoke and customisable tailor-made product is Safran Seats GB's unique selling feature since historically this sort of product lends itself to the discrete manufacturing system. The intricacy of the product is compared to traditional coachbuilders in the automobile sector. Large quantities of resources are used in this method of product conceptualisation. These resources might range from time, which costs money, and carbon footprint created to create the next unique design. To outperform the competition in the market, every customer has certain requirements and needs for the newest technologies.

It is extremely difficult and occasionally not financially viable to properly tool up for manufacturing with the Blue-Sky philosophy in mind and the low numbers that are required. This may cause problems with the product that are built into the design and life-cycle plan. Because of the volume and complexity of their products, Safran Seats GB (SGB) is now unable to implement some of the pillars, such as autonomous robots, however, there are elements of Industry 4.0 that will be greatly advantageous to the manufacturing system at SGB.

Industry 4.0 advancements to serve current manufacturing process

Cloud Computing

Cloud computing is the utilisation of offshore server facilities. To execute their programmes or applications, a user or company can rent a portion of the available space. The most popular kind of computing service is infrastructure as a service. Suitable for medium-sized enterprises is this kind. It does away with the requirement for on-site hardware, and because it is a pay-as-you-go service, it helps with scalability and dependability. Platform as a Service allows companies to manage and provide labour without being concerned regarding computing power and storage by maintaining the sorts of architecture that are present within a firm, albeit at the cloud level. The phrase "software as a service" describes several underpinning systems and services.

Businesses and individuals may choose from a range of cloud alternatives with various degrees of security. Since they might be readily attacked and if the incorrect cloud type is chosen, the theft of sensitive data might be made public, the firm or individual needs to understand the level of security. The pay-per-use solution that can be readily extended in the public cloud is not, however, the greatest choice for a business that handles sensitive data. Private clouds can be hosted by businesses, and security measures limit access to those with the right authorisations.

This system is expensive and necessitates internal IT administration and upkeep. The potential for remote accessibility also has a drawback. The hybrid cloud model provides businesses with the advantages of both worlds in terms of data hosting. While sensitive data may be stored on a private network, a public network can host generic apps. To ensure reliable and conflict-free network connection, however, caution must be exercised.

Big data and analytics

Big data refers to methods and tools that process enormous amounts of data and are used in manufacturing, supply chain management, and maintenance. Data can be retrieved from any point inside the plant through the Internet of Things (IoT) systems, which are connected to the production layer by sensors and related hardware. Because production equipment can now be equipped with low-cost sensors and electronics, large amounts of data may be captured and stored more conveniently and economically. These in-situ gadgets' plug-and-play ease enables continuous monitoring of a manufacturing system.

(Cognizant, 2022) A manufacturing system called a "digital factory" allows data to be quickly exchanged between equipment, people, and products. The location of the goods and the condition of the components are both tracked using this technique to increase efficiency. Lowering waste can also aid in the aspect of industrial production that contributes to environmental damage.

Horizontal and Vertical integration

Vertical integration is concerned with connecting different levels within a company through the use of IT systems, particularly in production planning, production, and low-level Programmable Logic Controller systems such as machine controllers, sensors, and so on, in order to increase productivity and flexibility in planning and management. In smart factories, the integration of vertical networking and Cyber-Physical Production Systems enables the organisation to respond based on stock levels or system faults. Additionally, they are not only focused on the autonomous organisation of production management but also focus on maintenance management.

Connecting every component of the value chain, starting with internal company logistics, production, sales, and services, and working outward to external stakeholders and partners, vendors, customers, energy suppliers, etc., is what horizontal integration entails in order to create a value chain with participants who can act independently. The organisation can create a new business model for working with customers and partners based on the idea of real-time networks that are optimised and promote transparency, flexibility to respond to issues and flaws, and better overall optimization thanks to horizontal integration. By implementing smart factories, which can improve an organisation's flexibility, communication with all partners, autonomy in organisation and

maintenance, and overall organisation performance, businesses are able to generate new values inside their organisations. (SL Controls , n.d.)

Industrial Internet of Things (IIOT)

The industry has advanced thanks in large part to the industrial Internet of Things. Industry 4.0 projects link individuals, objects, and processes to the potential of digital change by leveraging networked smart sensors and equipment. To boost productivity, optimise revenue growth, cut expenses, and do much more, businesses employ industrial IoT systems to communicate, monitor, assess, and respond to industrial data in novel ways.

Industrial IoT systems become powerful by interconnected machines and devices that can communicate in the same language, track, and analyse data on industrial performance, and provide real-time visibility into what is going right, wrong, and even if something will go wrong (predictive maintenance) anywhere, anytime. The Organisation can improve efficiencies, evaluate across sites, maximise uptime, and optimise operations in production and in the field thanks to a connected IIoT environment. Utilising this interconnectedness as a brand image gives businesses a competitive edge.

(3 pillar Global, 2020) This reminds us that the adoption of IIOT can leave the organisation vulnerable to Cyber-attacks and breaks it down into the 3 main types of attacks.

- Cyber Terrorism
- IP Leakage
- Production Sabotage

Humanistic Implications

The Humanistic implication depends on the decided level and rate of integration that each business decides to undertake. Nevertheless, several patterns hold true regardless of the scale. There is a need for investment, skill improvement, and workforce integration, but certain integrated solutions have the potential to eliminate a portion or all of the low-skilled personnel. Instead, this pertains to flex time or contract workers, which are employed by the majority of businesses. It's crucial to comprehend how your business evolves throughout the year.

With the rapid development of technology and systems, there is a rapidly growing need for a highly skilled workforce to ensure technology integration and business flexibility. The gap between skilled and unskilled workers is widening and so are the economic expectations within the job market. (Schwab, 2016) Helps us to understand that this is known as Social tension.

Environmental Implications

Since the Covid outbreak, Global industry has experienced a decrease in the availability of raw materials for a number of essential elements of the Industry 4.0 technology concept. A worldwide scarcity of microchips has occurred as a result of a fire that devastated the primary production plant. The silicone needed to make them was then in low supply around the world. Leading manufacturers have accelerated additional processor downsizing to enable more processing on a wafer because of these two issues. With more than 50 billion transistors on a microchip the size of a fingernail, IBM has improved its performance. (Duffy, 2021).

If you consider the rise in global consumption of technology, all-natural resources will continue to be under tremendous strain in order to satisfy our never-ending need to advance. Industry and the companies operating within the sectors now have a responsibility to make sure they are performing responsibly. This obligation resides in the proper decommissioning and recycling of equipment rather than just disposing of it; this is the first step towards a technological breakthrough that is genuinely sustainable. We have a wide range of options thanks to Industry 4.0, which may help with issues like company sustainability and major environmental problems. Industry 4.0 enables us to see how connectivity may be inexpensive and lead to enormous efficiency benefits, both of which will reduce waste, whether it be physical or non-physical.

The rate of power consumption by all businesses and the increase in power prices as a result of recent geo-political instability are two factors that need to be carefully considered at the company level as we become more integrated. The changes may not have immediately reduced costs; instead, they might have increased costs; however, this might be countered in other areas of the business. Cloud computing is one area that is assisting businesses in reducing their energy usage, but this is a double-edged sword and what you gain on one hand is swiftly consumed by the other. The benefit is the decrease in fuel expenses, but you must pay for this in the cost of the service. What effect will the proliferation of server farms have on the global warming crisis? Since the majority of the energy used is released as heat into the environment.

In summary, progress for the sake of progress is not a sustainable business strategy, but when it is made while keeping environmental sustainability in mind, then it is really the best way to proceed.

Conclusions

The existing business model of Safran Seats, which falls midway between mass customization and discrete production, is not advantageous from an implementation standpoint. Both solutions meet the demands of our customers, but none are compatible with the organisational structure or the manufacturing methods and procedures. As a company, we need to know how to move forward. Does it mean making a significant change in strategy? or a decrease in abilities? Or are we poised to enhance the industry through the fusion of discrete and mass customization?

The manufacturing systems on Safran Seats GB's final assembly line will undergo a transformation thanks to the networked digital factory, cloud computing, the Industrial Internet of Things (IIOT), big data and analytics, as well as horizontal and vertical integration. Although the other pillars are not being neglected, they will be treated as a supporting role because they will be the ones that affect the business the least. The utilisation of Additive Manufacturing in aerospace is slow in its advancement due to the safety-critical nature of the industry. Due to the aerospace industry's emphasis on safety, the use of additive manufacturing in aircraft is still in its early stages. This has not prevented the adoption of rapid prototyping using various forms of Additive Manufacturing and its application to the production of fixtures and tooling aids. This is certainly an area of growth and more and more is being done via industry leaders to certify the use of Additive manufacturing methods.

Research has shown that the use of cloud-based solutions in collaboration with IoT devices leads to an increase in output and efficiency that's because the organisation can more clearly grasp the activities being carried out both horizontally and vertically. Agility and flexibility are kept or expanded depending on system information as it becomes simpler in real-time to adapt production in an increased or expanding pattern, or, alternatively, in a lessened or decreasing pattern. Along with the benefits of system change, this kind of quick development and change is made possible in large part by people's capacity to successfully collaborate with one another and advance one another's knowledge.

When a business adopts Industry 4.0 technologies, the demand for infrastructure increases. This infrastructure can be physical, such as buildings (on-site or off-site), but it can also be the infrastructure for training the workforce. This infrastructure demand is one of the biggest factors in business transformation because, without it, the organisation won't be able to successfully integrate Industry 4.0 pillars. To maintain business continuity and sustained growth, this delicate balancing act must be carefully managed.

Although the corporate parent has very strict firewalls, making it difficult at times to integrate the technologies, one eye must be kept on the cyber-security component of the business transformation. More work must be done to truly understand if it is effective or if more needs to be done by using blockchain concepts.

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