

Introduction to Industry 4.0

MSc International Innovation Management

Assignment 2 - Introduction to Industry 4.0 Essay

Module Code: ACPA7004

Due date: 30.09.22

Student: Neil F Lawrence

Student Number: 2125311

Email: 2125311@student.uwtsd.ac.uk

Title: The impact of industry 4.0 technology on SME's in Wales

Abstract

The impact of each industrial revolution on the Welsh industry has been profound. As the 4th industrial revolution is in full effect, Wales finds itself in an advantageous position to maximise on this new technology to better its industrial positions while global supply chains look to localise manufacturing supply amid global uncertainty.

Reviewing the impacts of previous industrial revolutions, we see that whilst not all industrial revolutions have been to Welsh SME's advantage, the introduction of industry 4.0 could mark a dramatic improvement if SME's react in good time and take advantage of the current political and economic situation.

The technologies available to industry 4.0 (Robotics, Artificial Intelligence, Internet of Things, Additive Manufacturing and Information Technology Security) are investigated with working principles of how each of the technology works.

The technologies of industry 4.0 have already been adopted by some SME's within Wales. These early adopters have developed their production process aligned with industry 3 and almost stumbled to industry 4.0 resulting in production improvements and unexpected commercial improvements.

While this new industrial revolution invites the potential for improved efficiencies and cost reductions within manufacturing, there are some bespoke manufacturing SME's that see the introduction of automation as a risk to their business. In addition, the introduction of connective technology presents new system vulnerability via external interference via industrial espionage, ransom wear, terrorism, malware and data capturing to name but a few.

Given the recent spate of global uncertainties, manufacturing companies are seeking localised manufacturing partners with security of supply in preference of costing. This accompanied with the adoption of industry 4.0 technology presents Welsh SME's with a unique opportunity to return high volume manufacturing to Wales.

Contents

- Introduction – Page 4
- Welsh Industrial history – Page 4
- Risks and Rewards – Page 4
- Identification of industry 4.0 – Page 5
- Key technology within industry 4.0 – Page 6
- Case study “choc 1” – Page 9
- Bespoke SME’s – Page 10
- Conclusion – page 11
- References – Page 12

Introduction

The interconnectivity technology has been common place within the social environment however, industry in Wales have been a little slow to react to this emerging technology and the benefits that it can offer when fully utilized.

Manufacturing in Wales has seen adverse reactions to industrial revolution in the past 100 years so industry are cautious of industry changes.

Industry 4.0 introduces technology that can make better use of existing equipment, process and workspace, with the potential to bring Welsh production SME's into the forefront of the production industry.

Welsh Industrial History

Before the first industrial revolution, Wales was made up of farm land and rural countryside with very little industry.

Throughout the 1800's the development of industry fuel via steam, sprouted a new generation of industry in the UK powered by coal. This resulted in mass industrialisation within the Welsh valleys, as the rich coal supply were found to be readily available.

This growth continued well into the 2nd industrial revolution with the introduction of communication and electrical powered equipment. This allowed for improved techniques of coal extraction and further supporting infrastructure to transport the fuel to the wider UK and Europe. During this time new supporting industries started to develop to support the growing workforce.

The start of industry 3 (aka digital revolution) at the end of the 20th century marked the decline of industry within Wales. The transport of data over greater distances and the movement of goods, resulted in world-wide competition that Wales was not prepared to compete with. Welsh industry was further hampered by the closure of the majority of the coal mines due to the power demands shifting from solid fuel, to electricity in support of this digital revolution.

As the next revolution (industry 4.0) has started, Wales finds itself perfectly positioned to take advantage of economical and commercial changes. Due to global events, European production is looking for a more consistent supply chain closer to the border. Should Welsh SME's decide to adopt industry 4.0 technology, Wales could find itself satisfying this new demand for localised production.

Key advantages and risk

Using automation and aspects of industry of 4.0 can have multiple advantages within SME's in Wales. While labour costs in Wales are among the lowest within the UK, compared to the global market labour costs they are very high.

Introducing industry 4.0 can have key impacts such as

- Reduction of process / assembly overhead

Robotics, AI and system integration is able to reduce manufacturing cost by improving production routing, increasing production output and reducing human input.

- Process improvement

AI's are able to track inflight productions, bottle necks and predict tooling failure allowing for planned maintenance

- Increased storage utilisation

Automated storage, stock management, JIT replenishment can improve stock efficiency

- Improved product consistence and quality control

The internet of things allowing for interconnectivity equipment and the free exchange of data, can be used to pro-actively make adjustments in equipment before tolerances are breached.

- Improved capacity

Robotics and automation increases production output. AI can also make better use of the available space and process routing to further improve production capacity.

- Rationalised BOM and strategic buying

Using the internet of things product BOM across multiple sites can be purchased together in bulk and reduce the overall cost of assembly

- Non-human order to dispatch processing

Automated order completion allowing for 24/7 processing and reduced human overheads.

However, implementation of automation also comes with risks that need to be considered. Chief among these are:

- The Capital investment to introduce automated practices
- Ongoing expenses to maintain and operate equipment
- Vulnerability to system corruption via malware/ ransomware
- Custom engineering skills and solutions needed for any given application
- Inflexible manufacturing solutions

Identification of industry 4.0

Industry 4.0 extends beyond the typical automation of production and implementation of robotics. Whilst the hardware of industry 4.0 is clearly visible on production assembly lines, the implementation of AI, automated software and interconnectivity allows for historically human functions to be automated.

An example of this can be seen in the change in production techniques driven by online sales. In a more traditional system, an order is taken by a manual interface along with payment. This order is then planned into production by another individual. When completed, it is then packaged and dispatched again with human intervention as needed.

In a completely automated system, the order can be collected, paid for, manufactured, packaged and dispatched all through the use of software. This has the potential to remove the overhead cost of a large workforce, negate human errors, increased production efficiency and capacity. Additionally there is reduced risk of disruption due to key personnel out of the office, and order processing can become a continual activity not limited by the typical working day

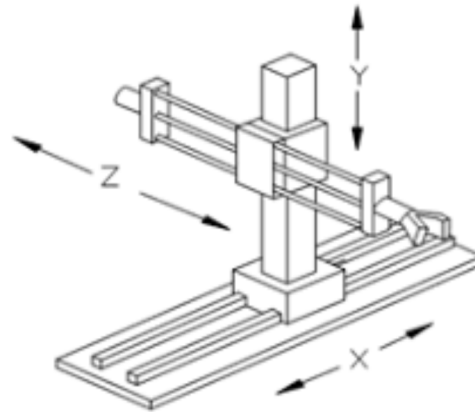
So how does this help SME's within Wales? With the recent uncertainties on the global market, many companies are now looking for supply stability over net cost of goods. This in essence returns the advantage to Wales for the manufacture of many EU goods. However, if this opportunity is to be capitalised on, not only is there a need for financial completeness, but consistent quality, high volume output, manufacturing tractability, design optimisation and socially accepted practices.

Key technology within industry 4.0

Robotics

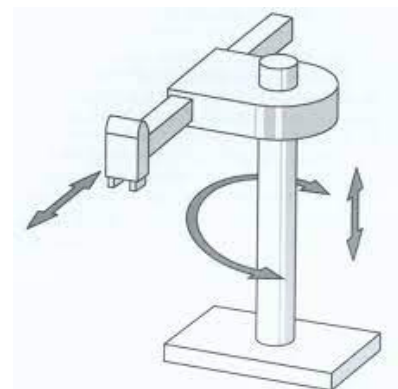
Robots can be typically divided into 4 categories: Rectangular Robots, Cylindrical Robots, Spherical Robots and Articulated Robots

Rectangular robots are able to move in 3 planes of X, Y and Z, however these are in straight line movements. This is primarily down to the construction of the robot. This robot type is constructed using 3 axis of movement all at 90 degrees to each other, allowing for the range of movement in this units capability.



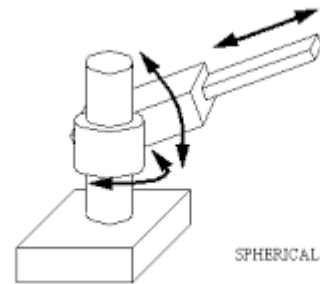
(<https://www.howtorobot.com/expert-insight/industrial-robot-types-and-their-different-uses>, n.d.)

Cylindrical robots have motion in X, Y and Z planes. However this is achieved by using a pivot on the one axis and then two linear motions along the other planes. The working envelope of this style of robot is therefore cylindrical.



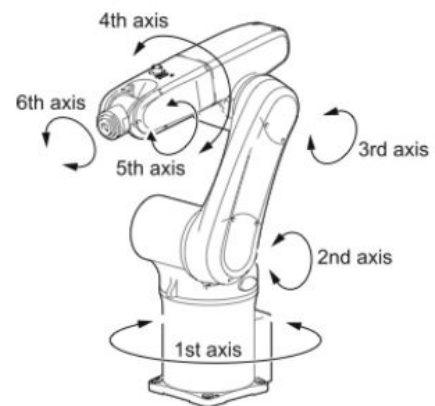
(https://www.researchgate.net/figure/The-Configuration-of-a-Cylindrical-Arm-Robot_fig2_336702692, n.d.)

Spherical robots achieve X, Y and Z movements via two pivot points and then one linear plane of motion. This produces a spherical working envelope of the robot.



(http://engineeronadisk.com/V2/book_integration/engineeronadisk-113.html, n.d.)

Articulated robots are one of the most commonly identifiable manufacturing robotics. Working in the X, Y and Z plane, this robot achieves its motion via the use of multiple articulated joints. This allows a diverse working envelope for as far as the robot reach allows.



(<https://www.howtorobot.com/expert-insight/industrial-robot-types-and-their-different-uses>, n.d.)

The robots require program inputs to effectively function within their environment. There are three ways that this can be achieved.

Lead through programming is a method of capturing the required function by first manually walking the robot through the actions needed while the actions are being recorded. The programmer interfaces with the robot via a controller, while the system records the real world motions of the robot. It is then stored and able to be called back when needed by the robots control software.

Simulation programming is done via an interface computer. A virtual robot is presented and the programmer provides instructions as to the actions required. When complete, the programmer can virtually monitor the robot for correct function. While this system benefits from flexibility of the programmer to work remote, often the simulation will not include potential clash points (such as high level cabling) and caution has to be taken to ensure there are no collisions.

Robot programming language is a form of programming that allows the programmer to directly issue instructions to the robot without the need of interface software. This can often cut out a lot of un-needed operations captured via simulation software. However, this form of programming requires greater skill and can often be time consuming.

For the robot to complete its task, it requires an end effector. The end effector is the key interface between the robot and the task it is assigned to. End effectors can be tools (welding, painting, polishing etc) or grippers. The end effectors are as diverse as the application that they are used with, each end effector custom to the task it's required to perform.

Artificial Intelligence

Artificial intelligence is a program designed to perform a task. However, unlike traditional programs, AI is able to rewrite part of its programming to better perform the task assigned. This rewriting process allows for improved performance and solutions that might not have been evident when the original program parameters were being developed.

AI has already been credited with improved productivity within farming and agriculture. New innovated designs of solar panels, road traffic management improvements, work flow handling improvements, strategic purchasing decisions and implementation of lean practises.

The support of AI process control, design and manufacturing can present unexpected system improvements. However, AI's are still limited by the factors placed in its original programming and the processing and storage limitations of the computer on which the AI is stored upon.

Internet of Things

The internet of things can be described as a collection of equipment that are in communication with each other and able to share data between all devices.

This concept may seem simple, however it has wide reaching benefits to many industries in Wales.

The internet of things are able to collect detailed and reliable data from product users allowing for more reliable marked data. This in turn can be used in a host of activities such as marketing, product development, product placement and advertising, targeted customer audience and user specific product improvements.

This data also allows for real time production monitoring. This can support with process flow and support in identifying manufacturing bottle neck. Sensors used to confirm manufacturing tolerances can now share this data with analytical machines that can track trends to identify when tooling requires replacing in advance of rejected parts or manufacturing breakdowns.

Similarly, production quality can be checked live and tracked allowing proactive actions, ensuring all parts made meet a consistent tolerance.

Consumables such as gas, electric, water and fuel, can be monitored, allowing identification of any potential faults and analytical data for improved usage of resources. Such as routing changes to reduce time and power needs, motors and assembly equipment being shut down if not needed etc.

Real time remote updates are also advantages, allowing all members of the team, despite their location, to confirm equipment status. Additionally, experts who might not typically be able to view the equipment data due to their location, workload or not knowing the existence of the equipment. can now support issues remotely and provide proposals for system improvements. This style of activity can also be supported via a method of duplicating devices virtually called digital twins. This process copies real equipment into a virtual interface that can be accessed by anyone needing the data.

The internet of things also allow for real time planning and logistics handling. Stock can be automatically replenished when the system detects that an item is running low, or when interfaced with AI, can be used for strategic purchasing decisions such as volume cost down if several production sites may have the capacity store a commodity typically ordered in smaller volumes.

Additive manufacturing

Traditional manufacturing methods require material to be machined to produce the desired final component. As the name suggests, additive manufacturing is a method of producing parts via applying layer upon layer to produce a finished component. Typically referred to as 3D printing.

Initially limited to plastic parts, additive manufacturing has developed to include a vast range of materials including metal. 3D printing has now become widely available to all industries including domestic use.

Further developments in additive manufacturing, include the use of multiple materials in one manufactured part and the use of matrix materials to further improve the material properties, such as carbon fibre and glass fibre. This development now allows for lower cost production via plastic parts, which have the strength and durability to perform functions typically reserved for components that require strength comparable with aluminium.

Currently, high volume production still uses traditional manufacturing techniques. Additive manufacturing has been widely adopted for prototyping and bespoke, low volume units however, as the technology continues to be refined this could change.

Repurposing paper printing technology, BMW are already using additive for main stream production for nylon parts used within the I3 car. This shows a more mainstream adoption of the technology.

Information Technology Security

As processes and technology become interconnected, systems become vulnerable to exploitation via a new generation of risks due to the interconnected nature of industry 4.0.

Exploitation of intellectual property stolen via online connection, robbery of financial details, theft of personal details, interference of production software and terrorism to name a few, all represent risks introduced by system interconnection previously not seen in manufacturing.

This has prompted the need for system protection. Such a system is cyber security / Block chain.

In essence, the block chain works by linking each block of data together via a digital chain. This chain is encoded and stored on the cloud. Once there, it can be checked and verified for authenticity of the data by any machine that has the encryption of the chain.

As data security continues to evolve so does the systems used to defeat it. It is because of this rolling effect that security will continue to evolve.

Case Study

Company "Chock 1" (company name changed to protect legally binding NDA in place) had been manufacturing chocolate and confectionary products in the South Wales region for over 50 years, and had already wholly embraced the utilisation of production automation equipment to improve the output yield of the production facility.

One of the products manufactured was a mixture of miniatures from the original product offering that had been packaged together in one container, giving the consumer product variation. This had been launched circa 25 years ago and proven so popular, that the product sales were greater than the traditional products manufactured on site.

Since its conception, the individual miniatures had been manufactured on their own production lines and transported to a holding area at the beginning of the packing and assembly area. The miniatures were then mixed into a large vat and the ratio of products were managed by a team leader whom inspected the ratio of the mixing vat and added products if he felt that the mixture was uneven.

While this had proven effective initially, now that demand continued to increase, a production shift of 9 persons was needed to ensure consistent output at 1000 saleable units per shift. This was also hampered by customer complaints where the chocolate received was missing a specific item or too much of another.

To tackle this, a system was commissioned to automate the chocolate mixing process. This would consist with a conveyor feed, and local storage from the miniature production assembly area. 4 ABB robots would pick and feed boxes into the mixing vat, a visual system would calculate the ratio of each product in the mixing vat and then automatically make adjustments accordingly. This investment represented £3,500,000.

The project took nearly 4 years to install and sign off due to the implementation of this type of equipment at the time was relatively new (2010).

Production output was initially 3000 units a day, however this was increased further to 6000 units a day with the addition of another mixing vat.

Now, arguably the above investment could represent a shift towards industry 3 however, 5 years after the project started, development started to implement AI to further improve the system using block chain security and system integration with other equipment. The new AI software was implemented not to further improve production output, but to reduce unit price.

The AI would have daily pricing updates on the raw material used in each product. Knowing the process timing, it would then adjust the mix of the confection within the vat (within pre-set limits) to ensure that products that were of lower cost would be higher in quantity. I.E. should the cost of desiccated coconut suddenly drop, then products using this would be presented in higher quantities, reducing the overall cost to produce a finished product.

Further improvements in this identified limitations with the end effector and resulted in multiple units being needed, with a carousel for storage and tooling change over.

While the official figures for product savings was not issued, we can see how the natural progression from simple robotics and automation can be further improved utilising AI software in previously unconsidered areas.

The system now only needs 1 operator per shift and is capable of running production for 20 hours a day, 7 days a week, or 100,000 units per week.

Considering the vast improvements shown in the above, can we draw to the conclusion that industry 4.0 is the one solution for all production needs? While this would seem the case from the example provided above, I am sure the 8 or so people per shift that would have previously had job security on the production line would disagree. In securing the business future via increased capacity and lower

running costs, there is a trade off in the reduction of work force needed to support manufacturing activities. However, this loss in personnel needed to manufacture the product has been replaced by skilled engineers needed to service and maintain the equipment.

There is also the capital cost that the project demanded. While we can now look back at this example and conclude the cost was justified, this was not certain at the beginning. The technology was not used in this type of production previously by the company and the employees being used beforehand had worked without issue.

Bespoke SME's

To expand further on the possible issues with introducing automation, AI, Ecommerce production etc. many of the skilled crafts in Wales are skilled due to the human input. Is it possible to put the same value on a beautiful writing desk, hand carved from Welsh oak over the course of 6 months by a master craftsman to produce, what is by nature of its design, a unique piece of art and furniture. As a table of similar construction and style made in the 100's in the most efficient manufacturing process as determined via an AI program?

This is a subjective question, but for those whose USP is not the end product but the traditional techniques that have taken years to master and products that are truly unique, the introduction of industry 4.0 can be seen as a threat.

However, this is a minority with the vast majority of industry 4.0 applications actively working towards improvements in product performance and efficiency in repeatable tasks.

While automated production is seen as a risk for these bespoke SME's, industry 4.0 can still be of use. Utilising AI and analytical software, these bespoke manufacturers can better utilise their marketing activities to reach a wider audience, furthering their customer reach.

Conclusion

Within Welsh industry, there is some cautious approach to change. While industrial revolution typically brings improvement to production, the introduction of the digital revolution left the Welsh industry crippled as the primary export, coal, became obsolete driven by a switch in power requirements from solid fuel to electrical power.

Many SME's in Wales will already utilise automated equipment within their process, aligned with industry 3 however, the movement into industry 4.0 brings with it the need for further capital investment. This may prove a struggle with many SME's. While they might have a viable business, the cash flow may not easily accommodate the capital investment needed.

Additionally, the skills needed to fully utilise industry 4.0 will require retraining for many employees to use, coupled with the available workforce who are not educated in the field of Industry 4.0.

SME's whom adopt industry 4.0 will also have to contend with a new raft of cyber security risks previously not seen in manufacturing

While many manufacturing industries in Wales will benefit from the introduction of industry 4.0 technology, Wales is known for its bespoke and handmade crafts whom will view the development of automation as a risk to their trade. However, AI and marketing analytics can still support these industries to reach a wider audience and prove critical to the continued success of this thriving bespoke industry in Wales.

The shift in sourcing attitude driven by global uncertainties (BREXIT, COVID 19, Russia / Ukraine conflict, global computer chip shortage), have driven many companies to source manufacturing partners on security of supply and not necessarily price. This shift in sourcing strategy has opened the prospect of production within Wales.

If the implementation of industry 4.0 technologies can be used to improve production, pricing, capacity, quality and reactive adaptability can be adopted by Welsh SME's. This industrial revolution could see a return to Welsh industry being a global leader.

References

B Chakravorti, A. B. R. S. C., 2018. *The 4 Dimensions of Digital Trust, Charted Across 42 Countires*,. s.l.:Harvard Business Review .

C, L. J. & F.-H. S. & L., 2018. *Trust, Privacy and Security in Digital Business*. Lyon: Proceedings.

Hahn, G. J., 2020. *Industry 4.0: a supply chain innovation perspective*. London: Taylor & Francis .

Hasliza Abdul Halim, N. H. A., 2020. *Challenges and opportunities for SMEs in industry 4.0*. Qaisar: IGI Global.

http://engineeronadisk.com/V2/book_integration/engineeronadisk-113.html, n.d. *Spherical*. [Art].

<https://www.howtorobot.com/expert-insight/industrial-robot-types-and-their-different-uses>, n.d. *A Cartesian robot*. [Art].

<https://www.howtorobot.com/expert-insight/industrial-robot-types-and-their-different-uses>, n.d. *Six axis robot*. [Art].

https://www.researchgate.net/figure/The-Configuration-of-a-Cylindrical-Arm-Robot_fig2_336702692, n.d. *The configuration of a cylindrical arm robot*. [Art].

Machado, C. G., Winroth, M. P. & Ribeiro da Silva, E. H. D., 2020. Sustainable manufacturing in Industry 4.0: an emerging research agenda. *Taylor & Francis*, 58(5), pp. 1462-1484.

M, O. F. X. & Z., 2016. *Research Handbook on Digital Transformations*. s.l.:Edward Elgar Publishing .

Rossit, D. A., Tohmé, F. & Frutos, M., 2019. Industry 4.0: Smart Scheduling. *Taylor & Francis*, 57(12), pp. 3802-3813.

V Dhillon, D. M. M. H., 2017. *Blockchain in Science*. In *Blockchain Enabled Applications*. Derkley: Apress .

Y, K. J. & L., 2014. *Introduction to modern cryptography*. CRC Press.