Application: 3D Printing in Industry 4.0

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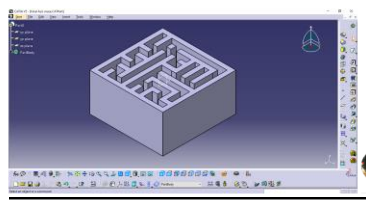
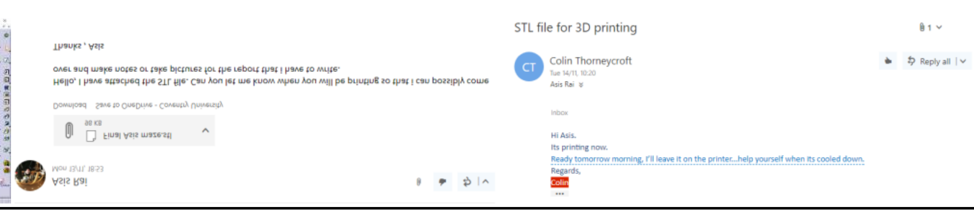
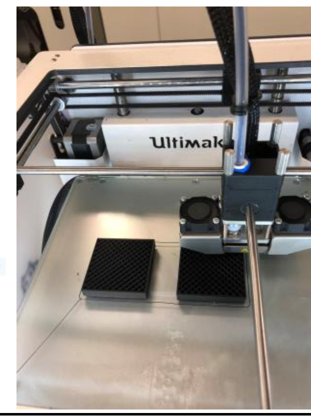
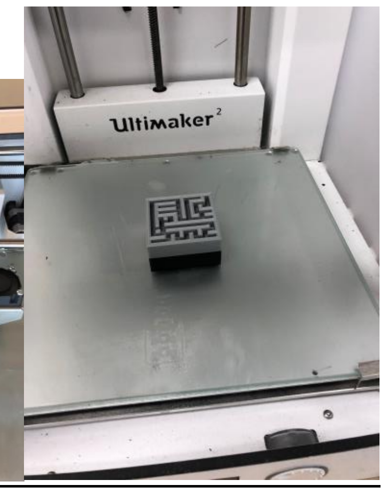
Description of the Lab activity

- Brief description of the lab activity and task given to you
  The task was to create a CAD Model of a Maze design of my choice in CATIA, save the CAD Model file as *.STL File Format for AM Process. The file had to be emailed to Colin Thorneycroft, so that the CAD Model of the Maze designed in CATIA would be 3D printed by an inkjet style printer head, building the maze part layer by layer.

- The exercise out put
  I designed the Maze of my choice in CATIA, and saved the file as *.STL file Format. I then emailed the file to Colin and he replied me back saying it would 3D printed and completed the next morning for me to be collected. I went the same day to see how the 3D printer was printing the maze, then I also went the next morning to collect the completed 3D printed maze. I made sure that my CAD design of the Maze was not very complex, because then it would require more material and the STL file would be high tolerance, this means that it would have taken more time and materials to get the Maze printed into a 3D Maze.

- Challenges
  The challenged to consider when the Maze was being 3D printed was that if the process stopped due to a fault then it would have to be started all over again back from square one. This would have wasted time and material therefore I made sure that the process was going smoothly by visiting the place where it was being printed and I monitored the process to check if the material was enough to print the whole model, it wasn't. I then informed Colin about this and he paused the process and replaced the material with a grey colour because the initial black polycarbonate filament had run out. He then informed me that I was lucky because if it material had run out then the 3D printer would have kept printing because it doesn't have a sensor which checks if there is enough material to print or not, then it would kept printing and then he would had have to start the process again which would have wasted time and material.

The product/production life cycle

- Where in life cycle and how can it be integrated with the previous and following step in the life cycle
  In a typical product/production life cycle, the steps are: Product concept → Design Engineering → Drafting → Process Planning → Order New Equipment & Tolling or Production Scheduling → Production → Quality Control → Customer & Market. (vask82, 2015)

  Rapid Prototyping can be integrated into the current product/production life cycle. Rapid prototyping has become a game-changing innovation for designers, engineers and manufacturers since it was introduced two decades ago. Rapid prototyping technology has progressed significantly over the years improving on both the cost and quality fronts. Combining high-quality surface finish, highly accurate geometries and large versatility of materials and material combinations, Object 3D printing technology, perhaps more than any other rapid prototyping method - enables the best representation of the intended final product. Therefore, revised system would like look:

  Product concept → Design Engineering → Drafting → Process Planning → Order New Equipment & Tolling or Production Scheduling → Production → **Rapid Prototyping** → Quality Control → Customer & Market. (Stratasys Ltd, n.d.)

- Identify important attributes which affect the application, for example format of information sharing
- ➢ Awaiting the breakthrough consumer model
  Widespread consumer adoption will depend on 3D printers dropping in price. Currently, printers less than $1,000 use a DIY-style kit that requires assembly of the machine itself and they often don't replicate the CAD designs accurately. Until reliable, convenient, sleek 3D printers hit the market, the revolutionary effects of the technology will be stymied.
- ➢ Expense of SLS printers
  SLS printers offer the ability to print with more materials such as glass, metal, plastic, and ceramic, but with the high-powered lasers comes a higher manufacturing price. It may never be as cheap as an FDM machine, and therefore may take a longer time to catch on in the consumer market.
- ➢ Patents and legal murkiness
  Many patents on 3D printers will soon expire, possibly creating more competition, innovation, and lower prices. However, there are still quite a few overlapping patents out there, however, which causes a lot of murkiness. During the last decade, the Patent and Trademark Office has received more than 6,800 3D printing patent applications. Since 2007, almost 700 patents have been filed annually.
- ➢ Plastic filament isn't sturdy enough
  For the foreseeable future, the cheapest and most accessible 3D printers will be FDM. These are the desktop printers that use PLA and ABS plastic, which easily melt and fit small molds. However, the plastic isn't sturdy and not many household products with moving parts can be created from the material. Printers will need to use carbon composites or metals to become more useful to the average consumer, as well as manufacturers.
- ➢ Complex design software
  If you want to design your own file, you need a working knowledge of CAD design. Setting up the model and using the printer takes quite a bit of patience and time, which is another reason the technology has primarily been used by enthusiasts up to this point.
- ➢ 3D printers are still slow
  3D printers are great for mass customization, but are still too slow for manufacturing lots of objects. To change the manufacturing industry, the parts need to be printed in minutes, not hours. It currently takes anywhere from several hours to several days to print, depending on the size of the model and the quality of the printer.
  (Gilpin, 2014)

Benefits to industry

- Identify the issue this application could improve
  3D Printing improves Modern Manufacturing. Every sector of the economy will feel the positive reverberations of this evolving technology and we'll one day look back and wonder in amazement at how processes were handled in a pre-3D world. And while virtually all industries will be impacted, few will be changed quite like mass manufacturing.

  "Mass production is the biggest challenge in 3D printing," tech writer Lyndsey Gilpin claims, "but with the adoption of large-scale printers and rapidly evolving technology to produce parts faster, the printers will completely disrupt traditional manufacturing in many industries." Impact of 3D Printing in Manufacturing:
  - ➢ Replacement parts - 3D printing is that the technology gives you the ability to print custom designs. This is extremely valuable when it comes to replacing parts on existing products.
  - ➢ Healthcare - 3D printing used to print things like prosthetic devices, surgical models, and even living tissue.
  - ➢ Retail – Customizable products for modern shoppers.
  - ➢ Food – 3D Printer, The Foodini, for example, uses fresh ingredients loaded into stainless steel capsules to make foods like pizza, stuffed pasta, quiche, and brownies. Pasta-maker Barilla's machine prints noodles with water and semolina flour. (Wiggers, 2017)
  - ➢ Lower impact on environment - 3D printing means there are fewer wasted materials, less product transport, fewer unsold products, and the possibility of longer life spans. (Alton, 2015)

  In conclusion, 3D printing is an influential technology in the coming years. It is a technology which produces parts faster and is less harmful to the environment. Being able to test ideas quickly and discover what doesn't work accelerates discovery leading to an ideal solution. 3D printing allows a product developer to make breakthroughs at early stages that are relatively inexpensive leading to better products and less expensive dead-ends improving modern manufacturing. (Innovation, 2014)

- How it will impact on the product/production life cycle
  In the early phases of product development, the ability to create multiple versions of a basic product design with subtle but noticeable variations by rapid prototyping, allows designers the ability to determine the product's best fit and feel possible. Performing clinical trials in-house, and quickly streamlining the process of moving from concept to functional testing, helps ensure that deadlines for manufacturing can be met.

  3D printed models contribute to improved communication between design and manufacturing departments. The ability for a design department to produce working prototypes that can be held and manipulated by the manufacturing team helps bridge the gap between 3D CAD data and the final look of the product. Working prototypes enable a designer to identify and make needed adjustments to a design before handing it over to the manufacturers. The same applies for the manufacturing team who, based on the physical 3D model provided, may see problematic spots on a part that the design team could address. This is much more efficient than shipping the CAD data off and then finding the issues when the part goes to production.

  In conclusion, the ability to save time and maximize every dollar spent in product and production development are the primary drivers for incorporating 3D printing. The ability to produce tools in-house that help speed up and optimize the decisions to move a product to the next phase of design gives companies an edge against their competition, and helps them better meet the demands of their customers. (Stipek, 2015)

Reflection and conclusion

- Reflection on how the application can impact on industry 4.0 and the digital engineering environment
  3D printing, digitization, and capital efficiency are ushering in the era of digital manufacturing and smart production from design, to shop floor, manufacturing, and across the entire supply chain.

  With the advent of 3D printing, parts and products can be designed, prototyped, and manufactured in a fraction of the time that it takes using conventional manufacturing technologies and processes. Redundancy and large volumes of unused inventory will be replaced with new efficiencies and just-in-time manufacturing. In our ever-increasing hyper global and hyper-local world, digital manufacturing will enable product design and build files to be sent anywhere around the world, bringing manufacturing closer to the consumer. Local 3D print service bureaus will accelerate product delivery, reduce carbon footprints, and simplify logistics and inventory management. Products will be produced based on consumer demand and can be easily customized based on local market taste and personalization.

  In conclusion, accelerated adoption of 3D manufacturing in industry 4.0, reaches well beyond the product being manufactured with impact on the labour force, new skills development, and certification. With digital manufacturing systems often running 24/7 with less need for human oversight and fewer skills required to run those systems. At the same time, it opens an opportunity for new careers related to oversight of the digital processes, service engineers, machine operators, software developers, professionals with a Materials Science and Metallurgy, IoT, and data analytics background. (Nigro, n.d.)

- Implementation requirement hardware
  - ➢ Applications - The applications to be used with 3D printer should be the number one decision driver. If its it only 3D printed scaled models early in the design process to check look and feel and to sell new concepts, a small desktop printer could be a great solution.
  - ➢ 3D printed parts per year and what mix – Consideration of the volume and variety of parts Is needed. High mix of part designs, at generally a low volume - it may make sense to invest in a machine because there is no need for multiple systems working at once.
  - ➢ How familiar is the team with 3D printer - 3D printing is quickly becoming a part of mechanical engineering education, but it's still not fully established. Bringing a 3D printer in-house still means training or even hiring new talent. (Stratasys Direct Manufacturing , n.d.)

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