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FERROUS AND NON-FERROUS SURFACE ROUGHNESS ANN IN LASER BEAM MACHINING FERROUS MATERIA

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ABSTRACT

Machining modern materials with traditional techniques results in an increase in the high cutting temperature, high cutting force magnitudes, tool wear, reduced tool life, and a poor quality machined surface. The machining of these materials using traditional methods is initially going to result in a loss of profitability. Among the many unconventional approaches to machining, laser beam machining, also known as LBM, is garnering the most attention from researchers. In this work, we focus on the possible applications of LBM for the machining of a variety of materials, as well as recent developments, advantages and difficulties associated with machining, process parameters and performance characteristics, modelling, and optimisation. It is necessary to have process parameters that have been conscientiously designed and are suitable for LBM. To produce a model that delivers extremely good fitting with tests while determining the effects of many process parameters, it is unquestionable that investigationally based modelling and optimisation approaches are necessary components.

Keywords: *non-ferrous, laser beam machining, ferrous material*

INTRODUCTION

The actual physical process that takes place during laser cutting is characterised by a vast variety of characteristics, and selecting the best process parameters is essential for the quality of the output, the productivity, and the costs associated with the manufacturing process. Through ongoing investigation, efforts are being made to perfect the procedure in order to enhance its quality while simultaneously boosting its productivity. According to Madic (2017), the following methods may be used in order to establish the ideal laser cutting process conditions for a certain application. The method of trial and error, the method of Taguchi, the method of ongoing optimization, and the method of discrete optimization are some examples of these types of approaches. The conditions for the most efficient laser cutting process may be determined by using any one of these strategies. It is based on the experience that is gained by working with the process, and although it is a common approach in the industry due to its simplicity, the possibility of finding the optimal parameter settings is minimal, and as a result, the machine is not used to its full potential. Despite the fact that it is a common approach in the industry due to its simplicity, it does not allow for the machine to be used to its full potential. This is due to the fact that it is derived from the experience that is acquired during the course of working with the process. The way of learning via experience obtained by working with the process is the foundation for the trial and error approach.

In terms of modelling and optimization strategies, Madic (2014) used a hidden single layer Artificial Neural Networks (ANN) trained with the Levenberg.Marquardt algorithm to relate cutting tool parameters with cut quality factors like surface roughness, kerf width and HAZ, and material removal rate, and to optimise them. These factors include surface roughness, kerf width and HAZ, and material removal rate. Surface roughness, kerf breadth and height at zone, and material removal rate are some examples of these qualities. Some examples of these characteristics are the surface roughness, the kerf width and height at zone, and the material removal rate. He was responsible for laying up both the operational diagrams for each performance feature as well as the trade-off diagrams for increasing several performance aspects all at the same time. These diagrams have the capability of presenting a number of alternatives, which may make it possible to pick the fundamental settings for laser cutting in order to achieve the degree of cutting performance that is wanted. It was discovered that the method is both feasible and effective in its application in order to be able to be used in the employment of being able to forecast the performance characteristics, and it is able to be applied to a variety of machining processes. This was discovered after it was investigated whether or not the method could be used in the employment of being able to forecast the performance characteristics.

This was something that was seen by those present. In addition to ANN modelling, the Monte Carlo approach was used by Madic (2015) in order to optimise the laser cutting parameter settings in order to produce the lowest possible kerf tapper angle. This was done in order to get the cleanest cut possible while working with the material. The ANN model exhibits a high degree of accuracy when it comes to precisely calculating the kerf taper, which is important for many applications. The use of the Monte Carlo approach resulted in the accurate prediction of optimal settings for the parameters that influence laser cutting, which in turn resulted in a kerf tapper angle that was as little as was humanly conceivable. The Preference Index Method was the approach that Madic (2017) chose to use in order to model laser beam cutting operations and achieve the highest possible level of efficiency in those models. This strategy was used throughout the course of the study to gather information. This approach, which is a component of MCDM methods, ranks the available options in accordance with linear and quadratic transformations of the data that are included in the decision matrix. These transformations may be found in the decision matrix. The technique gives the key feature of being able to compute both lower and higher preferred selection index values, which is one of the approach's numerous benefits. Despite the fact that the method is fundamental and advantageous in the manufacturing sector, it may result in a big number of alternative solutions with attribute performances that are pretty comparable to the ones that are picked. This is due of the nature of the procedure.

Components quality (characterization of SLM parts)

This description demonstrates that additive manufacturing techniques have the potential to produce fully functional components with controlled microstructure. Achieving the desired properties and grain structure requires having a controlled microstructure, which can be produced using these techniques. In practically all of the additive manufacturing groups, the analysis of selective laser melting (SLM) components, microstructural characterization, and linkages to the material characteristics have been among the leading subjects that have been the focus of current research.

The quality of the surface and its roughness

Since the items created by additive manufacturing have a high surface roughness, surface quality is considered to be one of the most significant drawbacks associated with the process. In addition to this problem, surface accuracy is one of the other things that customers are concerned about. However, there are a variety of other approaches that can be used to enhance the surface texture that is now available.

According to Senthilkumaran and his co-authors, surface roughness in additive manufacturing is mostly the consequence of the parameters specified by the machine operator during the fabrication process. This is in addition to the powder specification, which is also a factor. This is the case regardless of whether or not a technology known as additive manufacturing is used. Furthermore has proposed that the SLM method as well as other approaches for additive manufacturing include a broad range of parameters that the operator may alter and control. A few examples of these variables include the strength of the laser, the qualities of the powder, the layer thickness, the scan speed, the hatch spacing, and the conditions of the surrounding environment. These parameters cover the whole range from to in their entirety.

During the course of the last few years, this area of study has been the subject of a sizeable number of studies carried out by various researchers. On the other hand, one of the difficulties of using this technology is that it is unable to produce a suitable surface quality in a consistent way. This is one of the disadvantages of utilising this technology. One of the things that presents a challenge is the following: As compared to the employment of coarse powder, the utilisation of fine particles powder leads to outcomes that are superior in terms of the quality of the surface finish and the density of the product. This is because coarse powder has a greater surface area than fine particles powder does. The results of a number of different investigations have led researchers to come to these conclusions. Fine powder is an extremely important aspect that is necessary in every scenario in order to improve the attributes of the component. These properties include the surface quality, the mechanical strength, and the density of the component. Fine powder is essential. In order to improve the item's quality, it is essential that this step be taken.

The relationship between surface roughness and fatigue life

The parameters of surface roughness provide an explanation for each and every characteristic of the surface's texture by making use of a wide range of various elements. The parameter that is used the vast majority of the time is known as the arithmetic average roughness (Ra), which is also referred to as the centre line over the specified sample length. The arithmetic average roughness is one of the names that may be used to refer to the centre line. There are a variety of additional aspects that need to be taken into consideration, such as the average summation of the highest five peaks and lowest valleys across the cut length, which is represented by the value Rz, and (Rt), which is the distance that separates the lowest valley from the highest peak throughout the cut length. These are just two examples of the many additional aspects that need to be taken into consideration. The cut length contains information pertaining to each of these parameters.

Nevertheless, the behaviour of additive manufacturing is currently only partially understood because to the complexities involved in the manufacturing process. It has been demonstrated that the fatigue behaviour of traditional materials may change dependent on the surface polish. In the case of forged metals, for example, localised surface size defects are often seen. It is possible for these dendrites and the growth in surface roughness to bring about quick fatigue failure, and this is especially the case in the zone that experiences high cycle fatigue (HCF). The surface roughness has less of an impact on the way the material behaves in regions that have a low level of cycle fatigue. Also, the outcomes of heat treatment on the forged components might make it possible to lessen the material's hardness while simultaneously increasing its fatigue life. This would be a win-win situation.

It is possible to enhance the fatigue outcomes of a surface finish that has been forged but then left in its initial form. Surface cleaning procedures such as sand blasting and vapour blasting are two examples of such approaches. These treatments will eliminate scale defects as well as a portion of the layers that have been decarburized in order to bring about an improvement in the surface quality. Under some conditions, a compressive residual stress will also be produced near the surface of the material. This is an effect that might be desired under some conditions, especially when it comes to applications dealing with weariness.

Their study includes a literature analysis on the implications of the machined surface topography on fatigue life. Novovic and his co-author analysed a number of roughness parameters as part of their research. In particular, the writers analysed the research that was done on the literature discussing the connection between the two. According to the results of their inquiry, the parameter Ra is the one that is used most commonly when characterising the fatigue behaviour of the material. This was determined by looking at the data collected over the course of their investigation. Yet, results from fatigue tests carried out on specimens with the same Ra value showed an usual dispersion of twenty percent across the board. It was subsequently recommended that the Rt and Rz should be favoured more than the Ra when calculating the fatigue performance. This was done so since the Ra was considered to be less reliable.

During the dynamic fatigue testing, Spierings and his co-authors conducted a comparison study to investigate the differences and similarities in the behaviour of traditional materials and those manufactured using SLM. The goal of the study was to determine whether there were any significant differences or similarities between the two types of materials. Despite the fact that the surface conditions of the two trials were different, the findings revealed that the fatigue life of SLM SS316L samples is roughly 25% shorter than that of conventional materials when the stress was at a lower level. This was the case despite the fact that the overall degree of stress was lower. In addition, it was shown that the endurance restrictions for SLM samples are 20% lower than those of conventional materials when the stress level is lower. This was found to be the case when comparing the same samples to each other. The materials showed the same degree of lifetime stability even when subjected to increased strain, which was assessed by larger amplitudes.

The problem with density

When it comes to the additive manufacturing technique known as SLM, taking into account density is yet another crucial component to take into account. It is widely acknowledged as an important factor in determining the mechanical characteristics of the components. Due to the interplay of factors during the fabrication process and also because to the lack of the mechanical pressure that is used in moulding, it is difficult to manufacture completely dense functioning components using SLM. This is because moulding uses mechanical pressure (which helps remove porosities). Although while obtaining completely dense and functioning components is the fundamental objective of SLM, this objective is notoriously difficult to accomplish.

The results of Kruth and his co-authors indicate that the normal porosity of SLM components is somewhere in the neighbourhood of 0.77 percent; nevertheless, it is conceivable to manufacture components with a porosity of 0.032 percent by the process of re.melting. As a result, laser re-melting is an essential step in the process of reducing the amount of porosity in SLM components. Also, it serves to minimise surface roughness as well as residual stress, indicating a positive influence on the attributes of the component as a whole as a result of its incorporation into the whole.

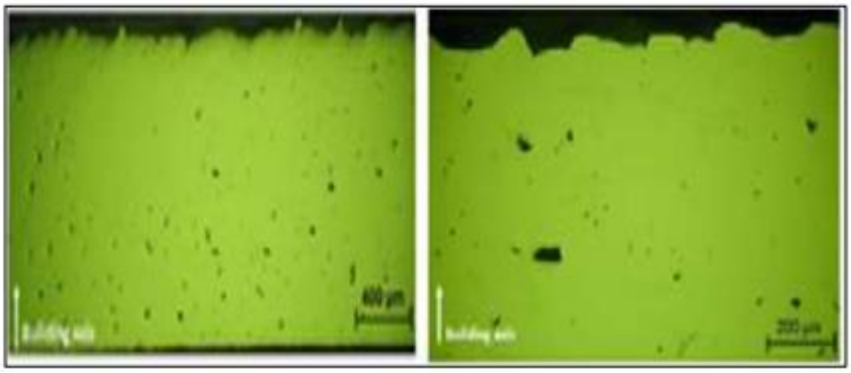


Figure 1 A enlarged cross-section of an SLM part, first at a magnification of 40 times and subsequently at a magnification of 100 times.

A cross-sectional image of an SLM component formed from stainless steel powder and seen via a microscope is shown in Figure 1. The item was created using selective laser melting. It is the SLM method that is to blame for the nonhomogeneously scattered pores or holes that may be seen as black dots throughout the micrograph. These pores and holes can be observed in the image.

Porosity is a very important difficulty with SLM components; in order to alleviate porosity difficulties, post-processing procedures such as remelting may be necessary. Problems with porosity may be brought about by a broad range of different causes, some of which include the density of the laser beam and the characteristics of the surrounding environment, amongst other things.

During the powder additive manufacturing process, there is a need for rapid cooling at room temperature. According to some publications, this is another significant factor that leads to an increase in the total amount of porosity in SLM components.

This method may also be used to SLM components; however, it will not be able to get rid of the open porosities that are already on the surface of the part. Hot Isostatic Pressing, often known as HIP, is a technique that may reduce the amount of porosity that is present in ceramics and metal casting. The abbreviation HIP stands for "hot isostatic pressing."

Another method is called impregnation, and it involves using a different metal with a lower melting point than the base metal in order to impregnate the base metal in order to achieve a particular goal, such as to increase the base metal's mechanical characteristics and to minimise its surface roughness.

Properties relating to mechanics

The fabrication of components using SLM methods is now the focus of investigation by a large number of researchers from all over the globe who are looking into the mechanical properties that can be accomplished using these techniques. In point of fact, the static load capacity characteristics of layer-produced components are well recognised and have been published. This was accomplished via extensive research and documentation. Elongation, tensile strength, and hardness are some examples of these characteristics. With the exception of traits like ductility, which are much lower in SLM generated parts, Kruth and his co-authors reached to the conclusion that the quality of components created by SLM are equal to those of bulk materials in their research. In addition, it has been discovered that the tensile strength of bulk materials is greater than that of SLM pieces.

This was discovered via testing. The presence of contaminants, oxygen in the build chamber, and an absence of pressure are all factors that lead to the production of porosities, which in turn decreases the toughness of additively constructed objects. When dealing with reactive materials like titanium alloys, this is extremely important to keep in mind.

It has been discovered that the mechanical qualities of an object that is created using the technology of additive manufacturing are not only dependent on the composition of the alloy, but also on the amount of flaws that are produced by the process and its parameters when the object is being built. This is the case even though the mechanical qualities of an object that is created using subtractive manufacturing technology are independent of the composition of the alloy. This is something that has not been discovered or understood before.

As a direct consequence of this, there is a sizable amount of work that must be completed in terms of the mechanical characteristics. The relationship between the component's microstructure and its mechanical characteristics is highlighted by the fatigue properties of the component when it is exposed to high temperatures. These qualities provide an excellent representation of this concept and may be seen in the component.

During the SLS process, Wang and his co-authors explored how the impacts of laser settings had an influence on the shrinking of the features. This was done in order to better understand the SLS process. They reached the result that increasing the scanning speed and decreasing the distance that was between the hatches led to an increase in the percentage of shrinkage that had occurred. On the other hand, the rate of shrinkage increases as either the temperature of the object being shrunk or the thickness of the layer being shrunk increases. It has also been revealed that beam offset, placement issues in hatching, and the inertia of the scanning mirror may all contribute to difficulties with shrinkage. Nevertheless, the orientation of the component as well as the exposure procedures that are used might have an influence on whether or not the right size is produced.

It is prudent to be prepared for the fact that the mechanical characteristics of SLM pieces will not be consistent with one another. This is because the mechanical characteristics of SLM components are affected by the presence of many neighbouring melted tracks as well as melted layers that are piled on top of one another. The local solidification in the metal component decides whether or not the parts will have excellent solidification, whilst the microstructure of the solidification affects the strength attributes of the SLM components. Another researcher has posited that the sample component is susceptible to large thermal strains as a result of the rapid temperature drop that occurred as a result of the rapid cooling that occurred during the SLM process. This idea was presented as a result of the quick temperature fall that occurred as a result of the rapid cooling that occurred during the SLM process. The thermal loads may cause the components to undergo thermal strain, which can then lead to buckling deformation. Buckling deformation may cause a decrease in the part's dimensional accuracy as well as the surface accuracy, both of which can be detrimental to the overall quality of the component.

Some researchers have suggested that in order to reduce the temperature gradient, the scanning spot must first be subdivided into a large number of smaller scanning regions. They have also suggested that the rescanning method be utilised in order to reduce the amount of buckling deformation to a point where it can be eliminated. A double scan is performed on the powder layer. The powder in the designated area is completely melted during the first scanning operation, and the rescanning process is carried out in a direction that is perpendicular to the direction in which the initial scanning procedure was carried out. With the assistance of the rescanning strategy, it is possible to prevent the buckling deformation from occurring, and the quantity of residual stress may be cut by around 55%.

It is necessary to achieve homogenization of the non-homogenous residual stresses and surface roughness that are produced by AM techniques. There is a possibility that these pressures and roughnesses might be harmful. Sanz and his co-authors designed and carried out an experiment in which the materials cobalt chrome alloy (CoCr), maraging steel, and Inconel served as the experiment's subjects, respectively. For your convenience, the results of this investigation are laid out in figure 2 for you to review. A variety of heat treatments and mechanical finishing processes, including shot peening, abrasive flow machine (AFM), and a vibratory technique, are used were applied to various parts in order to demonstrate how the various treatments influence the amount of residual stress and how hard the material is. The purpose of this experiment was to show how the various treatments affect the amount of residual stress and how hard the material is.

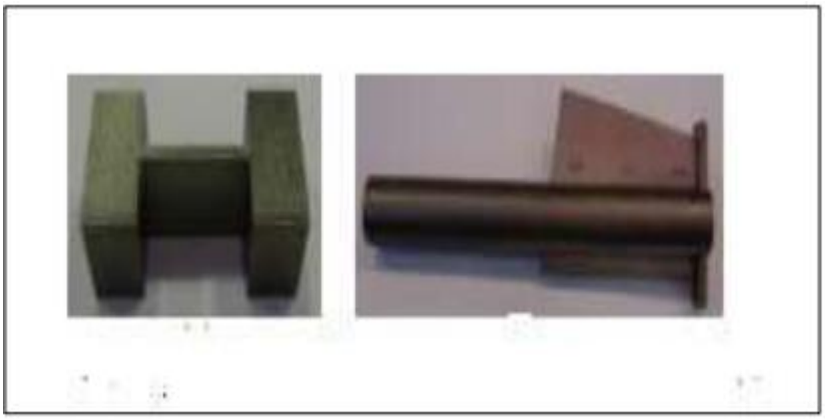


Figure 2Samples produced by DMLS, samples with H geometry, and prototyped guiding vanes

Because of the large number of tests that were performed, it was determined that the typical porosity was not very high, and it became clear that the different treatments could not be compared to one another in terms of their capacity to raise porosity. According to the results, shot peening and other finishing processes that are conceptually similar may be used to create a surface finish that is equivalent to that of the samples. This was found out by examining how similar or unlike the surface finishes of the samples were to one another. Not only do shot peening treatments accomplish a greater decrease of surface porosity than heat treatment does, but they also demonstrate an increase in surface hardness that is on par with the attributes that were there initially. This is due to the fact that shot peening compresses the surface of the material, which in turn lowers the surface's porosity (asmanufactured).

In order to do an examination of the production process, the levels of residual stress were also measured longitudinally on four different places of each sample. The results of the experiment indicated that direct metal laser sintering (DMLS) created nonhomogeneous residual stress on the surface of the maraging steel (H.geometry) samples. The fact that the experiment was really performed is evidence of this assertion. This stress distribution was not due to any extra treatment. Despite the fact that the word "sintering" is used to describe the process, it is actually a selective laser melting (SLM) technique, and the parts are completely melted. DMLS is a trademarked name owned by EOS that is used to represent their SLM technology. Shot peening, when applied, provides homogenous compressive stress, which is a significant benefit that helps reduce residual stress and improves other qualities including fatigue life and hardness. In addition, the same authors found that thermal treatment of Inconel 718 resulted in a lesser improvement in residual stress when compared to shot peening. It is possible that this was due to the fact that compressive stresses were not created as a consequence of the thermal treatment.

Other methods of polishing, such as the abrasive flow machine (AFM) and vibratory polishing, also revealed some compressive residual stress after the process was complete. It would seem from this that the mechanical polishing approach is more essential than the thermal polishing strategy.

OBJECTIVES

1. Carry out tests in the laboratory to investigate the surface roughness, topography, and density of SLM components, as well as the most common construction issues that result in a poor surface finish (in process parameters).
2. To reproduce the output of a machine. The study will evaluate automated post processing approaches to increase surface quality and compare them to in process procedures.

RESEARCH METHODOLOGY

Techniques for polishing the surface

Surface finishing processes are of the highest significance since they have an influence on the overwhelming majority of the mechanical attributes that components possess. It is generally agreed that surface roughness is one of the most severe limitations of additive manufacturing (AM). As a result, these surfaces need improvement work in order to become more desirable. During the manufacturing process of the components, surface improvements can be made to create a better overall finish. Alternatively, several post-processing techniques that are currently available on the market can be utilised to achieve the same goal, and these techniques can be used to create a better overall finish. A significant amount of research and development work has been done on the issue of the quality of the surface finish that is produced by SLM components.

There are a wide variety of various sorts of efforts, but generally speaking, they may be divided into two groups as described above.

- Adjustments to the CAD programme and the machine parameters (in process methods).
- Post processing techniques that can change the surface finish of the product.

Processes Currently Being Carried Out

SLM was only recently put to use for the fabrication of complex metal components that need for little treatment, are created directly layer-by-layer, and are both entirely dense and functional. On the other hand, the components that are manufactured utilising this method still have problems like as surface roughness and residual porosity. The CAD software, the characteristics of the manufacturing process, or the material specification are all to blame for these problems. As a consequence of this, these attributes need to be adjusted in a thoughtful manner in order to produce a result that is acceptable. These criteria are divisible into the four categories that are shown in the following sentence.

1. The parameters of the laser, which include things like laser power, wavelength, spot size, and laser density, among other things.
2. A description of the material, including the distribution of particle size, its flowability, the type of substance, and so on.
3. Environmental characteristics such as the amount of oxygen present, the temperature, and the atmosphere of protective gases, etc.
4. The scan settings, which include things like scan speed, hatching distance, overlapping, layer thickness, and component orientation, among other things.

The powder particle size, the layer thickness, the laser power, the scan speed, and the level of oxidation are the most critical variable factors that have an effect on the surface quality and the properties of the product.

DATA ANALYSIS

INITIALLY, A LABORATORY TRIAL IS CONDUCTED

Experiments were conducted with the objective of analysing the characteristics of the SLM 125 components, including surface roughness (Ra), topography, and density, as well as determining whether or not the machine is capable of producing reproducible results for manufacturing applications. Figure 2 illustrates how the work that was completed during this phase (chapter) was segmented into three separate phases. These stages may be observed in the figure.

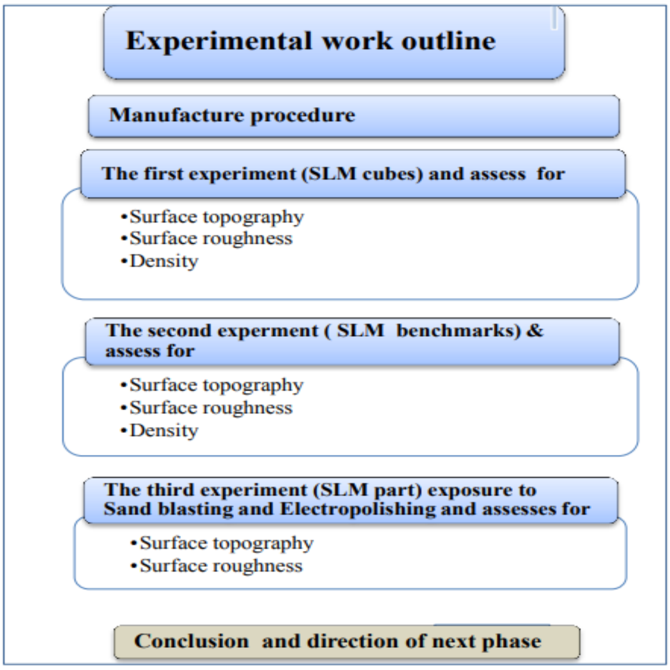


Figure 2demonstrates the overall structure of the experimental method that was used in the first phase.

MANUFACTURE PROCEDURE

The order of the experiments as well as their goals were presented in the chart that was just above it. It is essential to emphasise that each and every one of the experimental components was fabricated using the exact identical set of build settings. These parameters had previously been established on the SLM 125 at De Montfort University. In order to accommodate these criteria, the usage of stainless steel powder with a specific range of particle size, spanning from 15 to 45 m, was required. On is where all of the parameters will be shown. Table 1.

Table 1Laser setup settings. The procedure for producing a three.dimensional printed object using a selective laser melting (SLM) machine

Laser power	200 watt
Scan speed	480 mm/s
Focus offset	0 mm
Point distance	60 µm
Layer thickens	50 µm
Exposure time	100 µs
Powder dosage	90%

The stages involved in the data transition from CAD to AM are outlined in the following paragraphs.

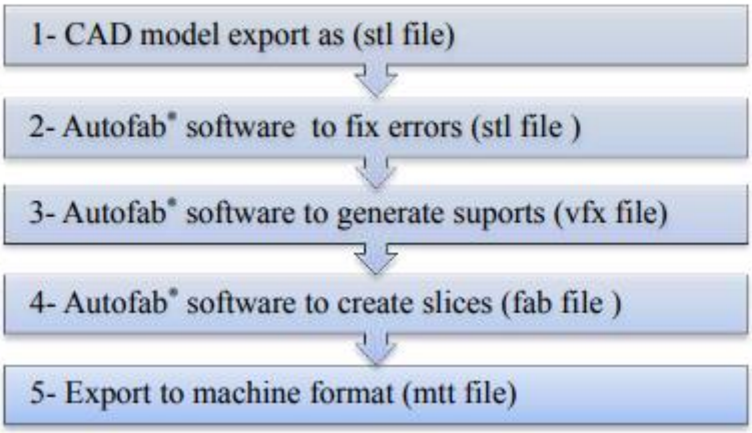


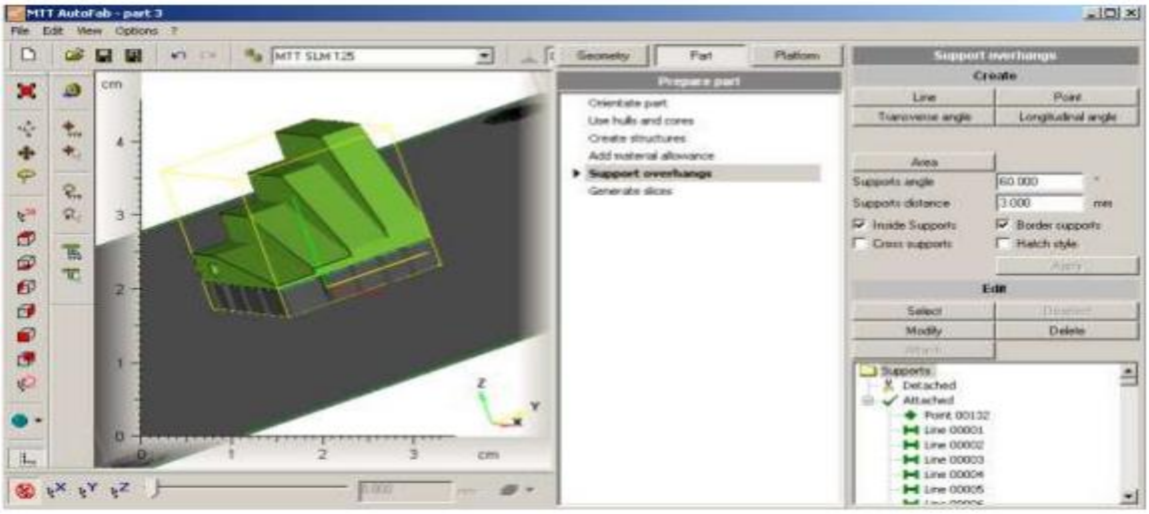
Figure 3The data translation steps from CAD to AM.

- In the beginning, the component that will be printed by SLM is developed by utilising computer.aided design (CAD) software such as Auto CAD, Solid Works, Pro.E, and so on..
- After the component has been developed using CAD software, the file containing the design is then transformed into the.STL format (Triangular representation of a 3D object).

- The Autofab software is well.known for its ability to accurately slice items so that they may be used on additive manufacturing machines. It is important to highlight the fact that the autofab programme processes the file in three distinct steps.

- The.STL file will be put into the Autofab programme in order to correct the fundamental mistakes in the component.

- Once the operator has ensured that all of the faults in the file have been rectified, the next step is to provide supports to the part. Different kinds of supports include a line, a point, a transverse angle, and a longitudinal angle.



Supports angle 60.000 °
Supports distance 3.000 mm
☑ Inside Supports
☑ Border supports
☐ Cross supports
☐ Hatch style

Supports
- Detached
- Attached
  - Point 00132
  - Line 00001
  - Line 00002
  - Line 00003
  - Line 00004
  - Line 00005

Figure 43D model with supports generated in Autofab software

- The supports are chosen based on criteria such as the kind of material, the form of the component, and the orientation of the part. The supports that were connected to the component are seen in figure 4.

- Once the supports have been created, the file will immediately be transformed into the.VFX format (This format saves triangle data).

- Once the component has been successfully saved in the.VFX format, the operator will produce slices by employing the "Meander" hatch pattern inside the programme. After the slices have been created, the component will be automatically stored in.FAB format after it has been converted from its original format.

- The operator is responsible for final adjustments to the part that is positioned in the build chamber. It is extremely vital to position the part in such a way that it makes the most efficient use of the area permitted of the build substrate in order to shorten the amount of time needed to complete the construction.

- Additionally, it may be utilised to construct several test samples in a relatively short amount of time and with precise area allocation on the substrate.

- When the component has been positioned in the appropriate manner, the file is then exported to the MTT format for the SLM Renishaw Machine, and it is loaded onto the computer of the machine through the process of file transfer.
- The machine will determine the process parameters, the cost of the materials, and the amount of time required.

1. Machine process

Every one of the samples was constructed based on the parameters stated in Table 1. The following are the precise actions that were performed to start the construction.

- Open the machine and load the 3D samples, also known as the (mtt), file.
- Activate the equipment, which includes the laser chillier and the argon gas, and let it run for approximately two hours as the pre.heating that Renishaw recommends.
- Place the material in the machine once it has been stuffed into the powder hopper.
- Install the substrate onto the region of the construction platform.
- Make the necessary adjustments to the wiper height on the substrate, and place the substrate's datum at zero.
- Make sure the dose is correct, then use the wiper to apply the initial layer to the substrate.
- Determine the correct amount of powder to use (90%)
- Choose the build file, and then begin the build process.

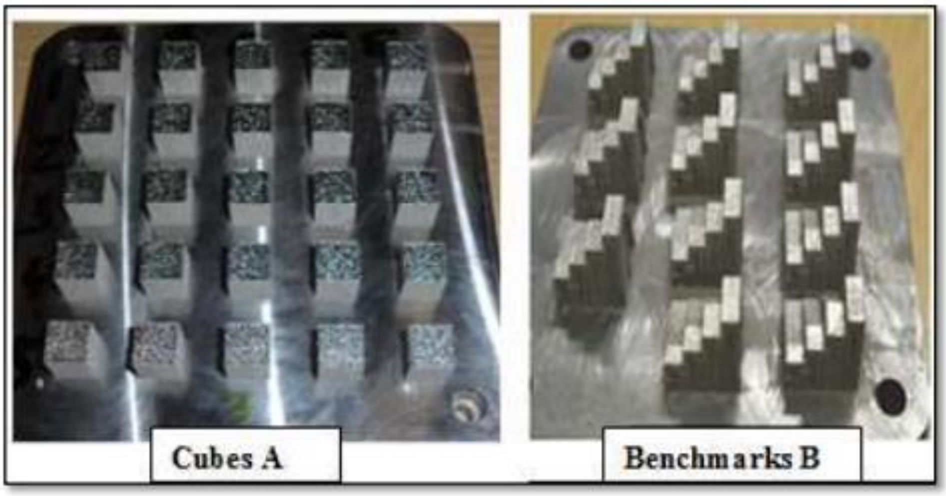


Figure 5The SLM 125 was used to make cubes as well as benchmarks

CONCLUSION

Surface finish enhancement is a fundamental requirement for many applications of additive manufacturing, but it is still challenging to achieve using the majority of traditional processes. One solution to this challenge is to use additive manufacturing. The proper application of post-processing techniques and the decisions made regarding those techniques play an essential role in achieving the intended results. The SLM method has the potential to make completely functional parts that offer a number of benefits. This is possible because of the technology's capacity to generate complex shapes with adequate dimensional precision. On the other hand, SLM products are regarded to have low surface roughness and persistent porosity, which are two of the technology's most significant drawbacks. It is essential to do study on the various surface finishing techniques because each one has a distinct influence on the mechanical and chemical properties of the components.

The primary goal of the research was to improve the surface finish of items made of Stainless Steel 316L that were produced by Selective Laser Melting (SLM) by employing a novel combination of two rounds of optimisation. Because SS. 316L has been through AM material development to set parameters (for a range of particle size 15 to 45 m), it was chosen as the material to utilise in the production of components. Laser remelting and electropolishing are the two processes of optimisation that are performed in order to improve surface roughness while maintaining dimensional tolerance. The most important takeaways can be summed up in one of these three categories.

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