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Study on Influence of Scanning Speed on Mechanical Properties of AlSi10Mg Produced by Selective Laser Melting

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ABSTRACT: **Manufacturing is one of the oldest processes. Due to development in technology there had been many advances in manufacturing processes as well. One of such advances is 'Additive Manufacturing'. Unlike the conventional type of manufacturing additive manufacturing specimens are built layer by layer, which reduces the wastage of the material as well as brings more strength to the specimen. SLM is an additive manufacturing method in which it uses high power laser fused into the metaled powder. It melts the powder to bind them together. The SLM process has the capability of melting the whole metal just to bind it into a solid 3-D model.**

keywords— Selective Laser Melting, AlSi10Mg, Tensile Strength

1 INTRODUCTION

- Additive manufacturing is one of the advanced technologies of manufacturing.
- Selective laser melting is an additive manufacturing process which uses high power laser to melt the metaled powder into a solid geometrical shape.
- AlSi10Mg specimens are manufactured using SLM method by varying scan speed.
- The specimen is tested for tensile strength, density, low cycle fatigue and Vickers microhardness.
- Then the results are evaluated.

Selective Laser Melting (SLM) is one of the very few 3D printing techniques that can directly create metal part from the 3D model. This technique is an advancement of Powder Metallurgy (PM) a metal molding technology that avail heat and pressure to form powdered metal parts. An additive manufacturing layer technology, SLM entails the utilization of high-power laser (like carbon dioxide laser) to fuse small particles of plastic, metal, ceramic, or glass powders into a mass that has a required 3D shape. The laser selectively fuses powdered material by scanning cross sections kindled from a 3D digital description of the part (for example from a CAD file or scan data) on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one-layer thickness, a new layer of material is supplied on top and the process is repeated until the part is completed.

1.1 Description of material

The material that is used in the project is $AlSi_{10}Mg$. it is a quintessential casting ally with good casting properties and is normally used for cast parts with thin walls and complex geometry. It renders a good strength, hardness and dynamic properties and is also used for parts that are exposed to high loads. Parts in EOS Aluminum $AlSi_{10}Mg$ are exemplary for applications which need a combination of good thermal properties and low weight. They can be machined, spark-eroded, welded, microshot-peened, polished and coated if required. $AlSi_{10}Mg$ is mostly used for AEROSPACE, AERONAUTICAL components. It is also utilized in automobiles. Processing of aluminum powder is done at high temperatures of 200 ^{o}C that helps in reducing the internal stresses, which are characteristic for SLM parts. The laser-sintering process works by extremely rapid melting and re-solidification. This creates more strength in the produced parts. Due to the layer wise building technique, the parts have a certain anisotropy. Aluminum has a low density, which means it is lightweight and easy to move. For this reason, it is preferred metal choice when building aero planes. While being lightweight, the material is also very strong and easy to shape, making it the perfect choice for manufacturing. Another impressive property of aluminum is the fact that it can be recycled 100%. This makes aluminum an environmentally friendly metal and also saves its ore from being depleted. Aluminum is twice as a good a conductor as copper. It is an excellent conductor of heat and electricity and so commonly used in most major power transmission lines. Aluminum is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation.

2 LITERATURE REVIEWS

1. In paper [1] the author explains about Additive Manufacturing. And the over view of applications of additive

manufacturing. Additive Manufacturing (AM) is a valid and economically viable technique to produce fully functional, geometrically complex parts. One such AM technique, Selective Laser Melting (SLM), uses a high-power laser to selectively melt layers of metal powder. Selective Laser Melting can be compared to a repetitive welding process, stacking thousands of welds next to and on top of each other to produce a 3D geometry. The difference lies in the fact that the purpose of welds is to join two or more separate geometries into one, while in SLM, the welds itself are the geometry. Moreover, the process takes place on a much finer scale compared to commercial

While AM is a disruptive technology, it by no means has the aspiration to completely replace other manufacturing technologies. To compensate for the additional cost of AM parts, one or more of the advantages that AM offers compared to other technologies need to be exploited. The four main advantages are listed below and all stem from either designing complex structures or the digital nature of the process chain. In AM, it costs almost as much to produce the same part 100 times as it does to produce 100 single different parts. This is called mass customization and is particularly important for the medical sector. Each patient is unique, and bespoke produced implants increase the durability of the implant as well as the comfort level of the patient.

2. In paper [2] the author discusses about the design process that is involved in producing the metallic products using Additive Manufacturing. Using this method helps in reducing the manual work, which results in reducing the labor. Additive Manufacturing was known as Rapid prototyping. The increase in trends and technologies has made it essential to use end-use or produced parts which is often referred to as Rapid Manufacturing (RM). Selective laser melting is an additive manufacturing process which is a furtherance of Selective Laser Sintering. It is widely used to produce the parts which can be directly used as end-use products. The main aim of the particular research was to evaluate the process an find out the limitations of the geometry of the process. To analyze and synthesize the experimental results and to frame first hand design rules for the existing designs. Evaluate the framed design rules and inform the further usage of the rules.

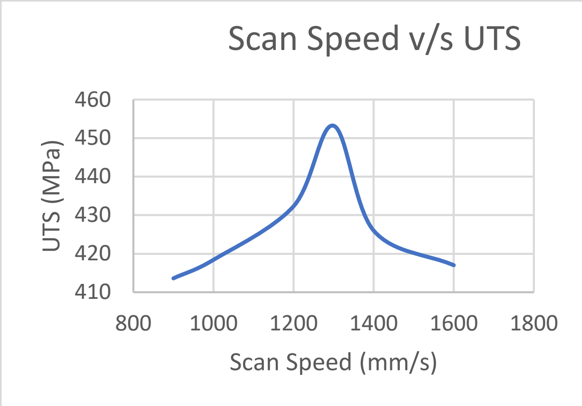
3. In paper [3] the author gives us an overview of development of a two-dimensional Cellular Automata -Finite Element (CA-FE) coupled model after which the prediction of microstructure which is formed when powdered AA-2024 is melted using SLM. The models that are developed play an important role in predicting the final microstructure of the specimens that are manufactured by SLM method. That further helps in predicting melt pool cooling and also the solidification rates. Also the size of the melt pool, how the porosity increases and the increase in the growth of microstructure of specimens produced by SLM can be speculated. This helps in understanding the SLM process and also to manufacture better components with better consistency of their properties and to enhance them.

4. In paper [4] the author speculates the importance of manufacturing light weight parts or components for the increasing trends in manufacturing. As the industries modernized, there is an increase in demand to reduce the cost and time for manufacturing. Currently geometrical manufacturing of complex light-weight structures is in need. This can be done by additive manufacturing (AM) or selective laser melting (SLM). The main objective of SLM is to obtain much cleaner and efficient manufacturing process. SLM helps in achieving upto 50% weight reduction and gives better design performance. So, aluminum specimens had been selected for conducting the experiment. Aluminum is a metal which was being used widely from a long time in aerospace, aeronautical and automobile industries. It is known for its light weight, but it has its own disadvantages. Using Aluminum in SLM means it requires higher laser power compared to other materials. After conducting the experiment, it is observed that at 50 and 100µm hatch spacing, sufficient overlapping b/w adjacent melt pools is observed. The study has also shown that the type of pores formed are dependent on scan speed.

3 RESEARCH METHODOLOGY

- First the material is manufactured by EOSINT M280.
- Scan speed is varied for each specimen.
- The specimens are tested for tensile strength.
- Later followed by density test, Vickers microhardness test and Low cycle fatigue test.

4 Figures



5 RESULTS AND DISCUSSION

Sl.No	SPECIMEN	SCAN SPEED (mm/s)	LOAD (kN)	UTS (MPa)
1	A	900	2	413.6
2	B	1000	4	418.4
3	C	1200	6	432.3
4	D	1300	4	453.2
5	E	1400	6	426
6	F	1600	2	417

6 SCOPES OF PROJECT

AlSi10Mg is a typically casted alloy which has a very high strength, density and good thermal properties which makes it highly demanded in aerospace and automotive industries.
Because of its light weight it can be used to make the spaceships which will be helpful for easier space travel.
This alloy built by SLM offers tremendous strength and also high geometrical freedom for complex parts.
It can also be widely used in electrical appliances due to its high resistivity after the heat treatment.

7 CONCLUSIONS

After a through experimentation it is found out that if the scan speed is 1300 mm/s the manufacturing cost of the material can be reduced as well as the properties of the material. As we know that Aluminum is an abundant material and also light weighted it has its disadvantages. Therefore through this experiment it was found out that the properties of the alloy can be enhanced with the scanning speed.

8 APPLICATIONS

Used in aerospace, aeronautical and automobile industries. Since there is need of light weight products in the latest trends.

9 ADVANTAGES

1. Offers good Strength, Hardness and Dynamic properties.
2. Resists high loads.
3. Thermal properties.
4. Low shrinkage.

10 REFERENCES

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