3D printing metal and how roughness varies with angles.

Petter Karlow Herzog

3D printing is thought to be one of the technologies that will prosper and drive the oncoming fourth industrial revolution. Using metal in 3D printers is one of the ways for serious production to emerge but there are still a few challenges and one is surfaces finish of the components.

There are multiple possible technologies to produce metal components with a 3D approach, and one of the most promising is selective laser melting (SLM). By using this you can produce components which out perform those produced by traditional methods both in terms of strength and in density. By only adding the material needed, being able to design for less material usage and that a laser is rather efficient, SLM can be a sustainable technology. All of this in combination with the possibility to design complex and customized components, 3D printing of metals is a sought after technique.

High performance industries such as aerospace, automotive and medicinal implants have been looking into 3D printing of metal for a few years. By constructing the whole component in one piece it is possible to design things which are impossible today such as a single piece gear box. There is still some challenges before this can be an alternative in production, production times are rather long, and only batch production is possible today but the biggest problem is surface roughness. To determine and understand this have been the main objective of my thesis.

Why is surface roughness bad, one might ask. First of all, after printing the roughness have to be removed in order to achieve the same result those from conventional methods and after treatment is expensive. Secondly the roughness decreases lifetime and the corrosion resistance of a components. Lastly in order to be able to apply these methods in medical applications, sterilization is of the greatest importance, and to be able to sterilize something very low roughness is necessary.

The reason for this high roughness in SLM production is not that well understood but it is thought to be due to how the molten metal cools. One thing that is very special in roughness is that it is not the same in all directions and how this varies is one of the questions I have tried to answer. By designing a test component and creating a method to measure by I hope that this work can make it easier to understand and predict the roughness in SLM produced components.

I chose to focus on finding a way to relate the roughness of a surface to the angle at which it was produced. To measure this, four different test objects was designed.

The general idea was to use polygons with thin walls, and a six, eight, ten and twelve sided polygon was produced. By measuring the different objects in different orders, a method to get the best results was determined. The object and measurement scheme was to measure each side of the twelve sided object three times using a focused variant microscope. We found that the best surfaces are on horizontal surfaces and the second best surface is on vertical surfaces.

The data from the measurements can then be used to simulate and predict the value of several different roughness parameters. By understanding this and being able to predict the roughness a designer can hopefully be able to design to reduce surface roughness. This can also allow us to investigate how different materials and process parameters affect the roughness at different angles.

During this work the most important thing I found is that the roughness depends on the angle and to be able to discuss this a new way to mark roughness is needed. This because a value can be great at on angle and very poor at another. By using this new notation researchers and engineers will be able to describe surface roughness much more accurately.