# INVESTIGATING THE IMPACT OF BMD PROCESS VARIABLES ON THE MECHANICAL PROPERTIES OF 316L ALLOY

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## Abstract

In today's world, most industries are focusing on increasing productivity with effective and modern techniques in the manufacturing process. In this regard, the building of the new components for R&D purpose and for the prototype Bound Metal Deposition will be the effective way to build a component. In these sectors industries mostly use wood or pattern for manufacturing a component or prototype. The scope of the present work is on study on effects of the Bound Metal Deposition (BMD) process parameters on tensile properties of 316L material using design of experiments

**Keywords:** Bound Metal Deposition, 315l Stainless steel, Tensile testing

## 1.0Introduction

This paper mostly speaks about the bound metal deposition process which is an additive manufacturing technology. Bound metal deposition (BMD) is similar to 3D printing technology. BMD is a process where components are manufactured layer by layer. Raw material for BMD could be any metal which will be in the form of powder filled thermoplastic media. In this case we took stainless steel 316L as raw material. Components have been manufactured using BMD and differentiated by three parameters. Components built by gyroid structure. This gyroid structure deals with infill methods. Infill is a method where the layer thickness can be adjusted as required. By using infill method 6 components in which 3 parameters are manufactured. Components were heat treated for strengthening. Once the heat treatment process was done all components were taken for the tensile testing area. Each parameter has two components. In total, 3 parameters 6 components were taken. Each parameter tested for tensile strength and the values obtained are noted.

## 2.0 Literature Survey

Alexander Watson et. al (2020) Bonding mental depression is reducing the lead time of selective laser sintering and Electron beam melting, geometric freedom is increased more cost of the operational and high capital of the plagued of SLS and EBM.with the cost of approximately is 60%-80% less than other processes. [1] Chengshan Zhou et. at (2020) compared the effect of various heat treatments on the microstructural characteristics and passivation behaviour of SLM (Selective Laser Melting) 316L. Compared to the SS316L sample heat treated at 1100 °C showed a lower corrosion resistance and lowest current density. [4] Jinghao jiang et. at (2019) The support material can also be a significant cause of long part production time and higher energy during manufacture. An added support generation method is proposed based on the feature of printable threshold overhang angle and longest printable bridge length. [9] Saereh Mirzababaei et. al (2019) Binder jetting of SS 316L was reviewed in this article for the first time. Mono-size of 316L gas atomized powder with spherical shape and average particle size of 22–30 µm is an optimal feedstock to achieve the full density.BJ manufactured parts exhibited higher or equivalent hardness compared to conventionally manufactured parts. Maximum strength and elongation at break increased with final density. [13] Bikas H et. al (2019) Functional parts can be printed directly in specific metal powders using similar layer-by-layer techniques. The redesigns became more than 30 times more expensive to manufacture than the original design. Whether a performance increase can allow an increased manufacturing cost.[2] Saeidi et. al (2017) 316L fabricated using selective laser melting (SLM). Tensile test is done at 800-degree Celius's a result this 316L stainless steel can store substantial amounts of energy and undergo high level stress up to 400 Mpa than conventional 316L. [12] Montero Sisti Aga M L et. al (2016) This works studies the influence of different heat treatments applied to 316L stainless steel produced by SLM. Tensile, Charpy and hardness tests were performed on the as built and heat-treated samples. 316L stainless steel processed by SLM results in much higher yield and ultimate strength. [11] Riemer A et. al (2014) Three samples powder are taken with 316L ss. Following processes are carried out by each sample. First sample gives good fatigue strength as well as crack growth threshold values. [8] Kurgan N et. al (2010)316L material is in powdered condition and it is cold pressed under a pressure of 800 mpa. pressed samples are taken to the sintering process at temperatures of 1200, 1250 and 1300 degree Celsius. as a result, the mechanical properties of a sample which is sintered using 1300 degree Celsius found to be more suitable for 316L stainless steel. [10] Blandford R. K et. al (2007) To give a quasi-static tensile testing for304L and 316L stainless steel. A370-03a standard tensile testing under ASTM procedure was conducted on both materials at -20 degree to 600-degree Fahrenheit. 304L is slightly higher than 316L. [3] Dadfar M et. al (2006) Corrosion behaviour tested at 37 degrees Celsius. Corrosion behaviour of BM and WM compared together. Corrosion result of WM is better than BM.Heat treatment improves in WM 316L stainless steel. [5] Gil L, Brühl S et. al (2006) the corrosion performance of a 3l6L stainless steel was in a 0.9% sodium chloride solution by using electrochemical. Surface characterization before and after corrosion testing was performed using scanning electron microscopy with an energy X ray analysis [6] Hong S G et. al (2005) Material used is the study is cold worked.

Material given is solution treated at 1100 degree Celsius for 40 min.DSA is analysed for different temperature and as a result strain rate is observed. [7]

## 3.0 MATERIALS AND METHODS:

### 3.1 Work material 316L Stainless Steel:

316 L Stainless steels are manufactured with silicon, nickel, carbon, nitrogen, and manganese alloys in addition to chromium. For example, nitrogen enhances tensile qualities such as ductility. Austenitic steel is made more flexible by adding nickel. It is widely utilised in the chemical and petrochemical industries, as well as in food processing, pharmaceutical equipment, medical devices, drinkable water, wastewater treatment, maritime applications, and architectural applications near the beach or in cities.

**Table 3.1** 316L Stainless Steel Chemical Composition

| | C | Mn | Si | P | S | Cr | Mo | Ni | Fe |
|---|---|---|---|---|---|---|---|---|---|
| **316L SS** | 0.0-0.03 | 0-2.0 | 0.0-1.0 | 0.0-0.05 | 0.0-0.02 | 16.50 - 18.50 | 2.00-2.50 | 10.00 - 14.00 | Bal |

**Table 3.2** Mechanical properties of 316L Stainless Steel

| | Tensile stress (Mpa) | Elongation (%) | Melting point (°c) | Density (g/cm^3) | Modulus Of Elasticity (Gpa) |
|---|---|---|---|---|---|
| **316L SS** | 450 | 40 | 1400 | 8 | 193 |

### 3.2 Bound Metal Deposition:

Bound Metal Deposition (BMD) is an extrusion-based metal additive manufacturing (AM) technique that involves the extrusion of a powder-filled thermoplastic media to create metal components. Heating and extruding bound metal rods—metal powder held together by wax and polymer binder—onto the build plate, layer by layer, shapes a part. After printing, the binder is removed via the debinding process, and the metal particles are sintered, causing them to densify.

### 3.3 Infill pattern:

The structure and shape of the material inside a part is known as the infill pattern. Infill patterns can affect a part's strength, weight, print time, and even flexibility. They can range from basic lines to more complicated geometric designs. There are a variety of infill patterns available in different slicer programmes. When paired with the outside shell, infill-based structures give excellent stiffness at a low weight. The shape of the infill geometry affects both the effective modulus and the degree of anisotropy of structural properties. The Studio Printer employs triangular infill, which has a few advantages over hexagonal or square infill geometries. In the triangular infill, the elastic modulus is constant. X-Y plane, ranging from 18 to 28% of the solid substance's elastic modulus

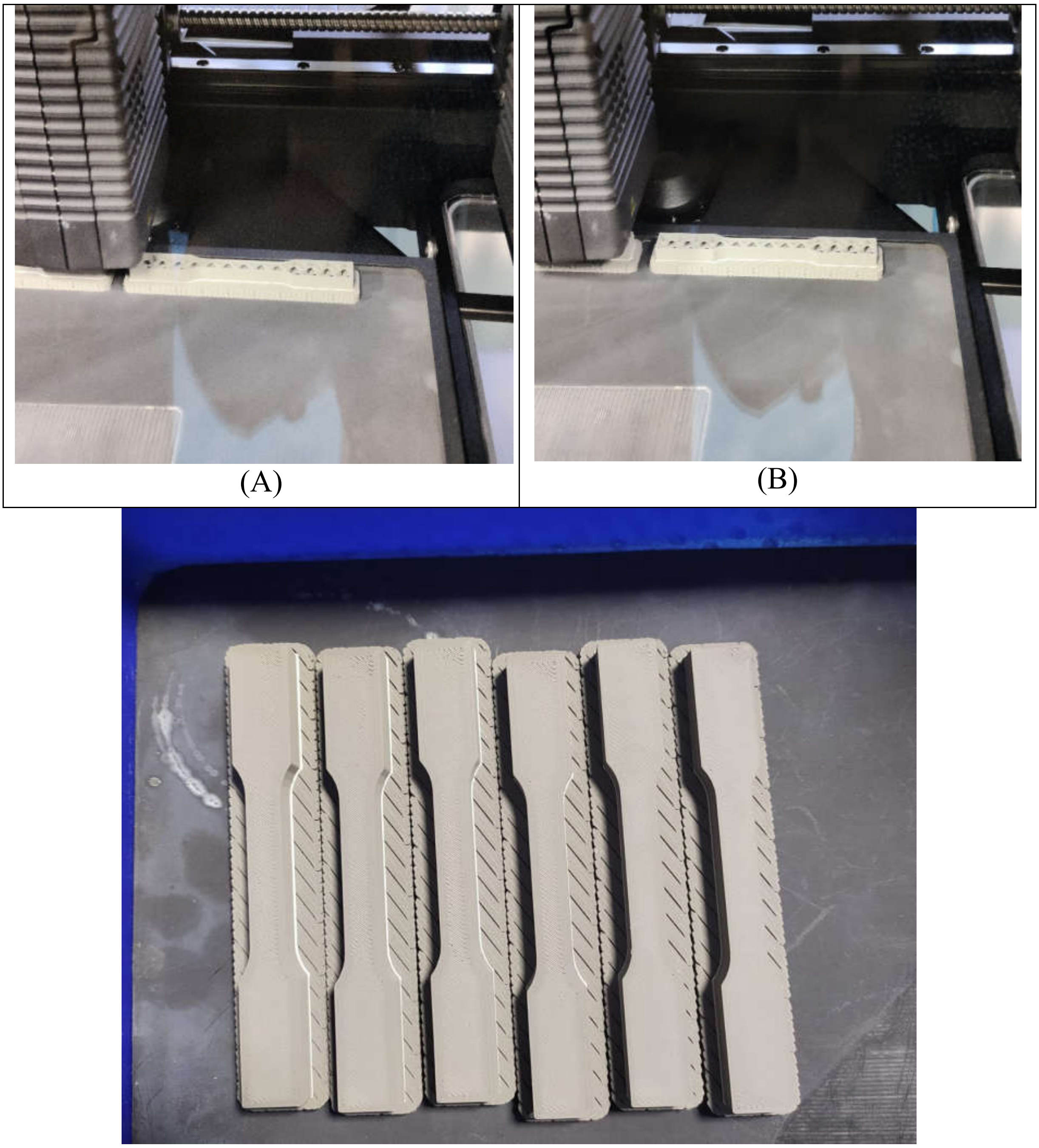
### 3.4 Gyroid Structure:

A gyroid structure is a triply periodic morphology that is made up of minimal iso-surfaces with no straight lines.

**FIG: 3.4.1- Gyroid structure**

**4.0 Manufacturing process:**

Bound metal deposition is a manufacturing technique where components are built. It is an additive manufacturing technology. Stainless steel is coveted into an extrusion metal rod for the purpose of BMD. This metal rod is melted and formed to the required shape layer by layer. The process involves in building a component is said to be infill method. This infill method is used to change the wall thickness, which is used to change the weight and strength of the component. 3 set of components were made by changing their infill properties. The structure involves in the process is said to be gyroid structure. This gyroid structure and infill method are the main process involve in building the component.




**(c)**

**Fig A, B & C – specimen building**

## 5.0 Tensile Testing:

Tensile testing involved in all 3 sets of components and results are noted. Tensile testing is a destructive test method that determines the metallic material's tensile strength, yield strength, and ductility. It determines how much force is required to break a composite or plastic specimen, as well as how far the specimen stretches or elongates to reach that breaking point.

## 6.0 Result and Discussion:

The experimental work carried out with the 3 sets of different parameters and tested using tensile testing method. Results for different parameters are obtained and found the maximum tensile strength that could withstand

| SPECIMEN | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| ID | A | B | A | B | A | B |
| THICKNESS | 1.2 | | 1.6 | | 2 | |
| TENSILE STRESS ($N/mm^2$) | 308.72 | 372.89 | 371.99 | 370.12 | 420.70 | 418.60 |

Fig 6.1 - Tested component

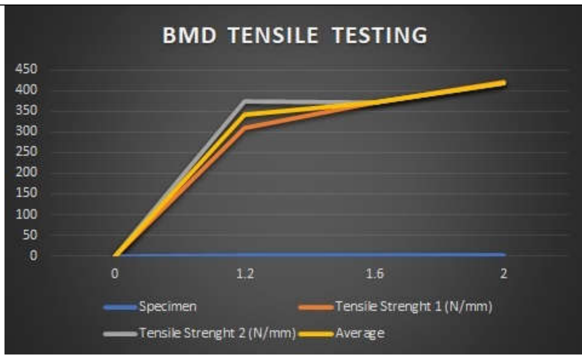



Fig 6.2 - Tensile tested graph

## 7.0 Conclusion:

The components have been manufactured using bound metal deposition and tensile testing results are obtained. In the analysis found that the parameter 3-A gives the high tensile strength while comparing to other parameter. Parameter 3-A has a similar value of tensile strength while comparing to conventional way of stainless steel. So, we conclude that infill of 2.0 thickness gives the high tensile strength and it can be compared to conventional method.

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