A Review on Selective Laser Sintering Process on CL50WS Material

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Abstract— This paper describes a variety of fundamental research of Selective Laser Sintering Process on CL50WS (Hot Work Steel) Material which the authors have recently performed. Rapid Prototyping (RP) can be defined as a group of techniques which is used to quickly fabricate a scale model of a part or assembly using three-dimensional computer aided design (CAD) data. The Selective Laser Sintering (SLS) is a one of the rapid prototyping (RP) technology by which physical objects are created directly from CAD model using layer by layer deposition of extruded from material. The quality of SLS produced parts is significantly affected by various parameters used in the process. SLS produces higher strength and surface finish metal parts. In this present work two important process parameters of the SLS process such as layer thickness, Orientation. Influence of each parameter on responses such as change in Tensile Strength and Surface roughness of the build part are essentially studied. The effect of process parameters on responses are studied by Taguchi Method. Then optimization of process parameters is made by ANOVA analysis.

Key words: Selective Laser Sintering, Process Parameters, Optimization

I. INTRODUCTION

The "selective laser sintering" process was originally developed at the University of Texas at Austin and then commercialized by DTM corporation (U.S.) The laser selectively fuses powdered material by scanning cross-sections generated from a 3-D digital description of the part on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered b y one layer thickness, a new layer of material is applied on top, and the process is repeated until the part is completed. Compared to other methods of additive manufacturing, SLS can produce parts from a relatively wide range of commercially available powder materials.

II. LITERATURE REVIEW

P.S.Panchal, N.R.Patel, H.J.Patel (2014)[1] has been emphasize on basic and advanced materials used for realization of parts by SLS. In this paper use CL20ES material and measure output parameter (Tensile Strength, Yield Strength, Elongation, SR) for influence of input parameter layer thickness and orientation. Generally SLS materials are available in powder form. SLS machines can fabricate objects in a wide range of materials, such as plastics, glass, ceramics and metals.

SLS basic materials are Carbon-Fibre, Glass Filled Polyamide, Nylon 11 derivative, Fine Polyamide, Nylon 12, Alumina-ammonium phosphate. Metal objects can be fabricated by Direct Metal Laser Sintering and materials are Aluminium, Cobalt Chrome Alloy, Nickel Alloy, Maraging Steel, Stainless Steel, and Titanium Alloy for variety of structural, electro ceramics and bio-ceramics applications.

Rishi Ganeriwala, Tarek I. Zohdi (2014)[2] has been discussed material for the modeling and simulation of selective laser sintering. Such processes involve harnessing optical energy to heat and fuse powdered materials together in an additive process. Selective laser sintering allows for the rapid manufacturing or prototyping of parts with complex geometries. In order to simulate such a process in a rapid manner, the approach pursued by the authors is to develop a computational tool by assembling relatively simple, physically meaningful, models at the small scale, for many interacting particles. This allows for much more refined estimates of the resulting overall system temperature and, ultimately, its change of phase from a solid, to a liquid, and possibly even to a gas. a basic framework has been set up to model the deposition and heat transfer involved in the process of selective laser sintering. it is easy to see the effect of particle size on its temperature. Smaller particles heat up much quicker and will subsequently melt first. After the laser has passed over a section of particles, conduction will cause the temperature of the particle bed to become more uniform. The laser power and scan rate greatly affects the rate at which the particles heat up.

Fangxia Xiea, Xinbo He, Shunli Cao, Xuanhui Qu (2013)[3] has been analysed processing parameters on pore characteristics and mechanical properties. The results indicate that the porosity of green body is mainly depends upon laser energy density, while the pore features and mechanical properties of sintered specimens are largely dominated by sintering the temperature. After sintering at 1100–1300 °C, the average pore size and porosity are 160–35 µm and 58–28% respectively. The pore structural parameters and mechanical properties of the assintered porous 316L SS can be controlled readily to match with those of cancellous bone by modification of SLS processing parameters and subsequent sintering temperature. Based on the investigation of the influences of processing parameters on the pore features and mechanical properties, it is found that the pores of the as sintered porous 316L SS are characterized by an average pore size of 35–160 µm and a porosity of 28–58%. In addition, the elastic modulus and compressive yield strength are found to be 1.58–6.64 GPa and 15.5–52.8 MPa, respectively.

Anish Sachdeva & Sharanjit Singh & Vishal S. Sharma (2013)[4] has been investigates surface roughness (SR) of parts produced by SLS process. The empirical models have been purposed to predict the feasibility of different process parameters viz., laser power, scan spacing, bed temperature, hatch length, and scan count on SR. Further, these parameters have been optimized using facecentered central composite design with response surface methodology. The optimized parameters have been verified by conducting confirmation experiments.

Laser power is the most significant parameter, which reduces the SR when it increases from middle level (28 W) to higher (32 W). Increase in scan spacing from low level toward up to central level (0.2 mm), the SR decreases, but with the further increase in scan spacing up to (0.3 mm) results in increase in SR value. Middle level, i.e., the center level (175°C) in case of bed temperature, is the best optimal level for minimum SR value with optimal sintering conditions. SR decrease with increase in hatch length.Strong interaction has been observed between laser power, scan spacing, and bed temperature.

Ratnadeep Paul, Sam Anand (2012)[5] has been mathematical analysed of the laser energy required for manufacturing simple parts using the SLS process. The total energy expended is calculated as a function of the total area of sintering (TAS) using a convex hull based approach and is correlated to the part geometry, slice thickness and the build orientation. The TAS and laser energy are calculated for three sample parts and the results are provided. a cube, a cylinder and one functional part were virtually manufactured and their laser energies were calculated for different sets of slice thicknesses and part orientations. Slice thickness is inversely proportional to the total laser energy for building the part, and the effect of part orientation on laser energy is dependent upon the geometry of the part. An optimization model was also developed to calculate the minimal TAS and laser energy by varying the slice thickness and part orientation. This technique will also allow the SLS user to choose the optimal slice thickness and part orientation for producing the part with the minimum energy expenditure thereby reducing the "energy footprint" of the SLS pro-cess. The methodology for energy calculation presented here can also be easily extended to other AM processes such as SLA, FDM, and 3DP with minor modifications. only the SLS laser energy has been analyzed while other energy components such as the platform energy, energy for heating the bed, etc. have been neglected.

Mike Vasquez, John Cross, Neil Hopkinson, Barry Haworth (2012)[6] has been scientific research collaboration between Loughborough University and Burton Snowboards to identify, characterize, develop, and test a new elastomer laser sintering material. Polymer characterization tests were completed at Loughborough University and laser sintering processing trials were performed at Burton Snowboard's Rapid Prototype laboratory. Most common material polymer material used in laser sintering are Nylon-12 or Nylon-11.
The development and implementation of a strategic material selection process for laser sintering will have implications beyond the snowboarding industry. one of the inherent benefits of additive manufacturing is the potential for highly customizable parts. With this new materials development process the range of materials will only expand and thereby offer designers more creative freedom to improve their products.

I. Yadroitsev, I. Smurov (2011)[7] has been analysed effects of the processing parameters such as hatch distance on surface morphology. Selective Laser Melting (SLM) is a powder-based additive manufacturing capable to produce parts layer-by-layer from a 3D CAD model. Currently there is a growing interest in industry for applying this technology for generating objects with high geometrical complexity. To introduce SLM process into industry for manufacturing real components, high mechanical properties of final product must be achieved. Properties of the manufactured parts depend strongly on each single laser-melted track and each single layer, as well as the strength of the connections between them.

S. Kumar, J.-P. Kruth (2010)[8] has been emphasised of the present work is on the methodology of composite formation and the reporting of various materials used. Composites have been fabricated using RP techniques mainly for mechanical applications while its utility for other inter-disciplinary applications namely, optical, electronic and thermal, barring few exceptions, has not yet been extensively investigated. There is need to develop either existing RP techniques (such as increasing the capacity of UC/SLM machine, etc.) or search for a new RP technique (such as based on plasma welding, etc.) in order to enhance the application domain. SL and LOM have vast potentials for the fabrication of continuous fibre- reinforced composites.

III. CONCLUSION

Many researchers have worked on different type of materials with various types of Rapid Prototyping technology. Researchers have used varieties of design of experiment (DOE) technique like as full factorial design, Taguchi method, Box-Behnken design and different types of techniques for optimization like GLA technique, Grey relational technique, anova analysis. Some studies conducted on various behaviours like effect of process parameters on different types of material like CL20ES, 316L SS and output parameters like Tensile Strength, Yield Strength, Elongation, Surface roughness.

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