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A FUZZY SET BASED ENERGY CONSUMPTION MODEL OF SELECTIVE LASER SINTERING

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ABSTRACT

Additive manufacturing (AM) has gained enormous attention in the present digital era of sustainable manufacturing. It is commonly known as 3D printing and is one of the foundations of Industry 4.0. This article presents a fuzzy set based methodology for the estimation of energy consumption of a common AM process, viz., selective laser sintering (SLS). SLS is a powder bed fusion AM process that uses raw material in the form of a polymeric powder to fabricate prototypes as well as end-usable parts made of plastics. The energy estimation of SLS is important for the comparison of its efficiency with other manufacturing processes and the assessment of its sustainability. The various energy consumption elements of SLS process are described. Initially, a deterministic energy estimation model comprising necessary parameters is presented. The deterministic model is then converted to fuzzy set based model for handling uncertainties in the energy estimation. For this, the uncertain parameters are considered as fuzzy and suitable fuzzy arithmetic operations are performed. For simplicity, linear triangular fuzzy numbers are used in this work for uncertain parameters. Construction of fuzzy membership functions for input parameters is based on the low, most likely and high estimates of experts. As a result of computations using fuzzy arithmetic, energy consumption can be obtained as a fuzzy number. The developed energy consumption model is demonstrated by examples of two different parts fabricated by SLS. Energy consumption is obtained for a single quantity as well as for multiple quantities of the same part. Full utilization of the machine chamber yields the minimum energy consumption per quantity. For example, energy consumption reduced by 80% for a part, when 18 quantities were made instead of just a single quantity.

Keywords: Additive manufacturing, Energy consumption, Fuzzy set, Selective laser sintering, Uncertainty