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Design and Development of a Hybrid Machine combining Rapid Prototyping and CNC Milling Operation

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Abstract

Nowadays, two most important processes, namely rapid prototyping (RP) and CNC machining are being used to produce prototypes. CNC machining (subtractive method) is relatively more precise and accurate, but it is tough to create stuffs with complex features. RP (additive method), by contrast, is able to form parts with sophisticated features, that consents materials to be utilized more efficiently. But its entire automation emanates with conciliations in the qualities of material and geometry. Combining both subtractive and additive process on a single platform has significant advantages. However, this has several challenges such as control system integration and maintaining accuracy of alignment during the change over process. This research attempts to assimilate both of these processes and propose a new design of hybrid machine with the purpose of overcoming the drawbacks related with different control panel and misalignment issues. Fused deposition modeling (FDM) is considered as the RP process in this study. A CNC cutting spindle and an FDM heat extruder has been designed to be placed respectively in front of a rotary stage which will be used to overcome the misalignment with the help of IR sensors. The proposed design allows CNC milling and FDM process in a single setup thus attaining the benefit of decreasing expenses for additional actuators.

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Keywords: Hybrid machine, CNC, Rapid Prototyping, FDM, Rotary Stage, IR sensors

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1. Introduction

Rapid Prototyping (RP),as well known as ‘Layered Manufacturing’ (LM) and ‘Additive Manufacturing’ (AM) is the “basic term for several technologies that allow components to be made without the need to involve the services of expert model-manufacturers”[1]. This technology has pinched significant attention due to its capability to overcome many drawbacks of old-fashioned manufacturing techniques. Its ability to form almost any geometric feature or shape is a great advantage of AM[2]. However, some new limitations have been introduced, which come out from its manufacturing methodology. CNC (Computer Numerical Control) machining process is the perfect way out to the downsides which occur in the RP process. Although high-precision, high-flexibility, high-accuracy and high-speed and so on desired properties are offered by modern CNC technology, the flexibility of the final products obtained from CNC machining is quiet pretty imperfect as paralleled to the RP process.

Among the vast area of RP, a number of methods are used: Stereolithography (SLA), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Selective Laser Sintering (SLS), Multi-jet Modelling or Solid Imaging (SI), Selective Laser Cladding (SLC), 3D Printing (3DP) or Selective Binding, Laser Engineering Net Shaping (LENS) [3,4].The basic technology of any RP system is LM technology that permits the production of three-dimensional parts layer-by-layer [5]. The principle of RP is that the original three-dimensional geometrical part is firstly disintegrated into two-dimensional profile layers. After that material is adjusted layer-by-layer until the completion of the final part of most RP systems whereas material is removed in machining processes. Without the assistance of any tooling, RP process allows parts to be manufactured directly from CAD descriptions [6]. Based on using various forms of raw material the Rapid Prototyping process is classified as solid base, powder base and liquid base. A light source is used layer-by-layer in the liquid-based RP Process for solidifying the liquid polymer, till the product is manufactured. The main difference between the powder-based RP process and liquid-based RP process is that powder is used as a raw material instead of liquid, and a glue ejector takes the place of the light sources. There is no need of support material in the powder based RP process for manufacturing the overhang feature since the powder is able to act as the support material itself. Among various solid-based RP processes FDM is extensively used [7].

FDM has the outstanding geometric capability as like as other RP processes and comparing to other RP processes it is quite simple and has relatively higher accuracy, but it is not capable of handling any metallic product as like as machining processes. In the FDM process, a plastic material (ABS or PLA) is extruded through an extrusion nozzle layer-by-layer to buid a product. Usually, this material is supplied in the form of a filament. Resistive heaters are contained by the nozzle that help to keep the temperature of the plastic just above its melting point. So, the plastic can easily flow through the nozzle and create the layer. After that, it hardens instantly and bonds to the previous layer. This procedure is continued till the shape of the prototype is being created is shown in fig.1

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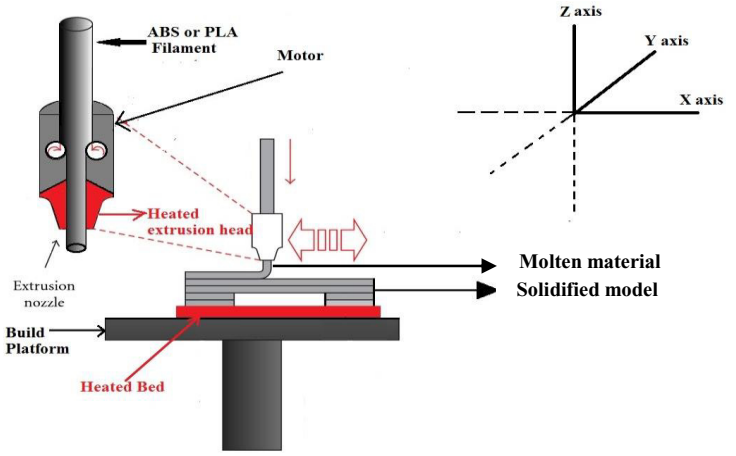

Fig. 1. Illustration of FDM process