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ScienceDirect

Procedia Manufacturing 13 (2017) 732–737

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevedra), Spain

Innovative advances in additive manufactured moulds for short plastic injection series

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Abstract

A study on the preparation of mould prototypes was carried out by polymer additive manufacturing techniques as stereolitography (SLA), laser sintering (LS) and resin photo-polymerization (3D-polyjet) for their use and validation in injection molding technique. Furthermore, a study with different materials was performed to evaluate the most suitable for injection mould in terms of mechanical properties. Mould prototypes include different difficulties (e.g. different vertical channels) in order to evaluate all the parameters during injection cycles done.

Peer-review under responsibility of the scientific committee of the Manufacturing Engineering Society International Conference 2017.

Keywords: Prototype, injection moulding, additive manufacturing.

1. Introduction

Currently, one of the methodologies used for plastic parts fabrication is based on injection mould production using metals moulds. In this sense, the development and manufacturing on injection moulds is a well known complex processing technology. An injection mould, when seen as a production tool, is expected to perform well both mechanically and thermally, to replicate the surface finish required for the part and to produce moulds with dimensional accuracy [1].

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2351-9789
Peer-review under responsibility of the scientific committee of the Manufacturing Engineering Society International Conference 2017.
10.1016/j.promfg.2017.09.124

However, time to market has increasingly become the key differentiator for success in the consumer product market place. The bottleneck of the process is metal injection mould tooling due to the fact that is the most time-consuming and costly part of the design process [2]. Creation and production of a mould with a volume of 300cm3 by conventional techniques, such as machining or EDM, would lead a time of 1 to 3 weeks and a total material cost ranging from $4.000 to $15.000 depending on volume and materials [3].

Focusing on short series production, the manufacturing of a new injection mould and validation is the turning point because of time consuming and high cost. With the aim to reduce the conventional techniques shortcomings, plastic producer´s demand new technologies that can help in the manufacturing of prototypes mould to test and produce short series of new products, previously to manufacture a final injection mould. Thus, AM technologies spring up as alternative technology which permits to fabricate layer by layers different parts starting from a CAD model in a short period of time and without shape limitation. According to Upcraft and Fketcher [4], these processes allow direct and rapid tooling production. “Soft” tooling can be used for low production volumes can be made and, for example, “soft” injection mould tools can be made from polymers, for example, that allow up to several hundreds of injected parts. Subsequently, “hard” or volume production tooling can also be made using metal AM processes that allows over one million shots.

Among all the AM technologies available to produce “soft” tooling for plastic injection moulding, three technologies emerged to reach the final objective, to obtain injection plastic mould for short series. The first one is SLA, using liquid resins, with a good surface finish (minimum layer thickness 0.025mm). Complex geometries can be obtained with good accuracy but with the limitation that models needs supports and some materials suffer from warp. The second one is Laser Sintering (LS), using powder polymers, that does not need additional supports and post-curing processes as SLA but surfaces are porous producing a poorer surface finish (minimum layer thickness 0.08mm). The last technology is 3D printing using a photo-polymeric resin (3Dpolyjet) with a good surface finish and low printing times.

In reference to production times a cost of the production of injection moulds, the production of a 300cm3 of mould with the same characteristics as exposed before for a metal mould performed with conventional techniques [3], 3Dpolyjet needs 5h (500€), SL requires 10h (400€) small SLA printer needs 30h (100€) and industrial SLA works during 3-5 days (700€) to produce a final mould of 300cm3. Therefore the use of additive manufacturing techniques to validate a new design or to produce injection moulds for short series productions is a promising alternative.

This paper is based on the search and development of new innovative polymeric materials for Additive manufacturing to produce prototype injection moulds. Three different moulds were obtained by means of different technologies and they were evaluated by injection moulding to asses that these AM technologies can cover the necessities of the plastic producers.

Nomenclature

AM	additive manufacturing
EDM	Electrical discharge machining
MWCNT	Multiwall carbon nanotubes
SLA	Stereolithography

2. Methodology and experimental procedure

2.1. Materials and manufacturing techniques.

Three different technologies were used for the preparation of injection mould prototypes, SLA, SL and 3Dpolyjet.

Firstly, a selection of materials to be used in each technology was carried out. In the case of SLA technique, though (THO) and high temperature (HT) resins were evaluated. In second place, polyamide 12 filled with 50% of