

Comparison of cooling simulations of injection moulding tools created with cutting machining and additive manufacturing

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1. Introduction

Nowadays injection molded products are gaining ground worldwide. The reason of this is that their production time is relatively short, and during the lifetime of a tool it can even produce hundreds of thousands of products. The manufacturing speed depends on the injection molding cycle, which is one of the most time-consuming parts of the cooling time [1]. As a consequence, the primary aim of the manufacturers is to minimize the cooling time within the injection molding cycle. We investigated whether the cycle time of an injection molding can be reduced by using an additive manufacturing instead of traditional machining.

2. Preparations

When selecting the product to be examined, some important aspects had to be set up. Since it is not our intention to completely replace conventional injection molding tools, it is not recommended to choose a simple product geometry. However, the simulation time would considerably increase if we chose a complicated and large product [2]. The geometry of the chosen product is not so complicated, but it has a sufficient depth to make using of a deep tool insert. Additionally, the technology sheet of the product was available, the simulations are compared with the real production conditions.

The simulation of the process was created with the tool and the cooling circuit of the selected product. After that the cooling circuits of the tool inserts have been modified so, that those can not be

formed by machining anymore, only by additive manufacturing. Simulations were also made of the new cooling circuit thus formed.

3. Simulations

The simulations were run both in standard and in transient mode. Because of the transient simulation has stopped after two cycles, the standard run resulted the same realistic picture of the process. Comparison of standard and transient results also confirmed this [3].

During the simulations, the temperature of the product and the tool, the degree of warping of the product were examined. The cooling time is determined: if 95% of the elements reached the ejection temperature was given on the technology sheet, the product can be removed safely.

4. Results

According to the collected data, it is possible to manufacture injection moulding tools by additive manufacturing. Using this technology, 100% compactness is available [3], [4]. After a proper heat and surface treatment, the mechanical properties of the tools will be even to the tools created by cutting machining.

Based on the results obtained, the 21 second cooling time originally dropped by one second, representing a nearly five percent improvement of cooling time. Using the previous experiences on the cooling circuit, the injection molding tool was further upgraded. Thus, the required cooling time decreased to 19 seconds.

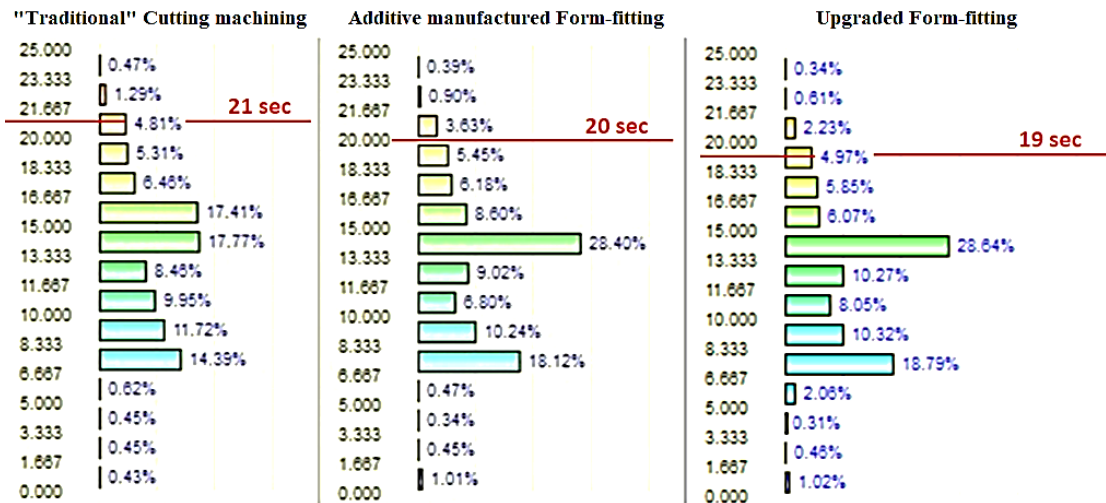


Fig. 1. Cooling time of the elements until they reach the ejection temperature.

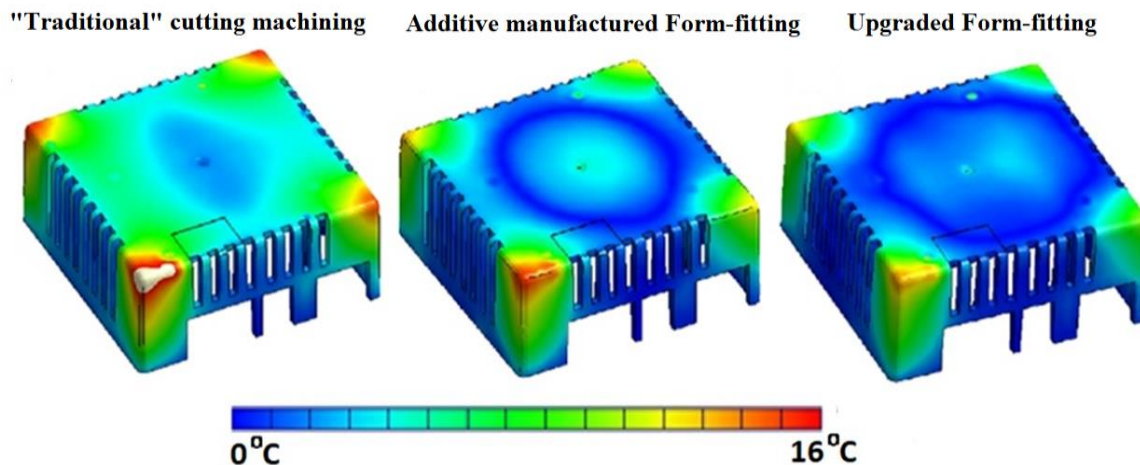


Fig. 2. Thermal difference between inside and outside surface of the product at the moment of ejection, which is proportional to the degree of warping.

5. Summary

The following conclusions can be made:

- Injection moulding tool created by additive manufacturing is possible and has even attributes as tools created by cutting machining.
- In the case of simple product geometry, the use of additive manufacturing tools is not necessary
- In the manufacture of high-complexity products, the form-fitting cooling system (which is not possible with traditional manufacturing methods) can greatly increase productivity, due to more efficient heat shift and shorter cycle time.

References

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