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Additive manufacturing of fixture for automated 3D scanning – case study

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Abstract

Additive technologies have their place in process of making new parts, from idea to final product. First step in all additive manufacturing is the development of a 3D CAD model which can be made by 3D modeling in any CAD software or 3D scanning and reverse engineering. When scanning parts in automated measuring cell on rotation table, some kind of fixture or jig is needed to keep part in place. Thin-wall plastic parts tend to deform under effect of their own weight or if they are pressed to tight in fixture. This paper shows case study of developing of 3D CAD model of fixture that holds parts during automated 3D scanning for large number of same parts. Also this special fixture that holds part with its geometry in place is made with additive technology, which enables production of complex geometry with lower costs of production because you need for each product special fixture, which in most cases is impossible or difficult to produce using conventional methods.

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Keywords: 3D modeling, additive manufacturing, scanning, special fixture

1. Introduction

More and more complex geometric shapes, including freeform surfaces, are adopted for the design of products to emphasise styling or aesthetics. Modelling of these products is extremely difficult, and often impossible. Reverse engineering is an emerging technology that can resolve this problem by generating CAD models from the physical mockups or prototype models. [1]

The purpose of reverse engineering is to manufacture another object based on a physic and existing object for which 3D CAD is not available. When the product has free formed surfaces, 3D scanning technology can be used to obtain point cloud of existing object. With the help of the point cloud, 3D CAD model can be developed, which will be used for manufacturing. Reverse engineering is a kind of engineering which takes advantage of an already created object. The final purpose is to create another object similar to the existing object. Getting this is essential to get information about the physic object. Reverse engineering can be applied in different fields and industry. [2, 3]

For reverse engineering based on a discrete scanning point cloud, CAD models must be generated which not only represent the original parts approximately, but clearly reflect the underlying structure of the object. The most important thing is to apply the reverse engineering technology of 3D scanning. [4]

3D scanning is a method which allows us transferring scanned points from space to CAD software and to utilize them. There are more types of digitizing devices that allow this transfer. Main types are: optical, laser, contact, destructive. Fastest and in machine industry most used are laser and optical 3D scan devices. These devices allow us to scan shapes of the real parts with machine industry precision demands. [5]

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2. Additive manufacturing

When it comes to scanning products with large dimensions, but also small products with complex geometry it need to be scanned from several positions. When scanning parts in automated measuring cell, this is achieved in some cases on rotation table, but it is necessary to have a special fixture to hold product and that allow scanning without deformations in the scanned model. This deformations are especially noticeable in the thin-walled products. Such fixture can be used for multiple scans of the specific product.

There is more than one way of using fixtures: as a measurement fixture, checking fixture or climate fixture for both tactile and optimal measurements. [6]

But the question is how to produce such specific fixture in short time with a small cost of production. In the case of polymer fixture, when using conventional processes, in most cases we need mould. But when we need only one fixture with specific geometry costs are too high if we use a conventional process.

Thanks to additive manufacturing production it is possible to produce complex functional products in short time (Fig. 1). Principles of additive manufacturing processes enable easy production of even the most demanding geometric shapes without a substantial increase in production costs. It can therefore be concluded that the justification for the application of additive manufacturing processes increases with the complexity of the product. [7]

The task of every manufacture is to produce items of highest possible quality, with the best possible performance characteristics, lower price, appealing design and realizing maximum yield.

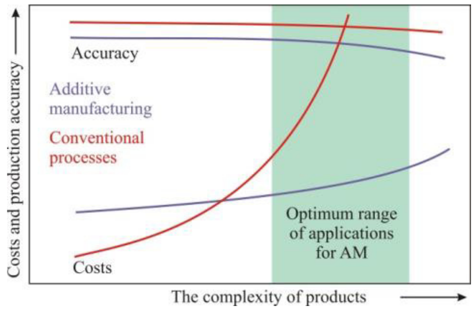


Fig. 1. Justification of additive manufacturing application [7]

Since the production processes significantly change the initial material properties, an essential criterion for the selection of the material is technologicality. Structural design, selection of material, and selection of the production processes are inseparable and related activities. The production must ensure the desired quality for the given material, shape, dimensions, surface quality, tolerances of the product at minimal costs and time of production. For the production of the fixture PolyJet processes have been selected.

PolyJet (mesh of nozzles) procedure combines the upsides of stereolithography (SLA) and 3D printing. [8] (Fig. 2).

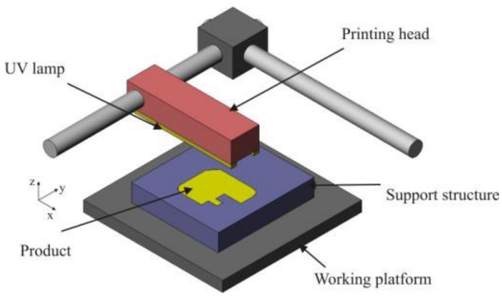


Fig. 2. PolyJet process [9]

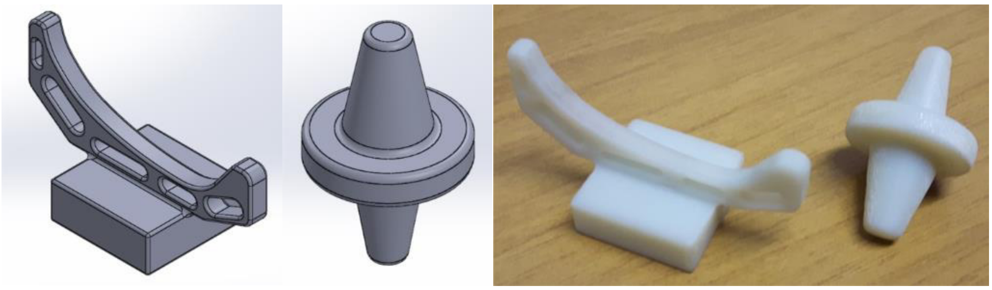
The mesh of nozzles slides back and forth in the direction of y – axis and applies / prints the layer of photosensitive polymer material on the working platform, of 16 μm thickness, which is about 1/5 of the thickness of the stereolithographic layer. Every layer of the photosensitive polymer solidifies under the action of UV light, immediately upon printing, creating a completely cross-linked product, without subsequent crosslinking. Two different materials are used: one for the model and the other as supporting structure, i.e. half of the nozzles applies the material for the model and the other half for the supporting structure. After having completed the first layer, the working platform is lowered for the thickness of the next layer and the print head starts the production of the next layer. After producing the products the supporting structure (gel-like material) is easily removed by water under the pressure of 40 bar or manually, depending on the shape of the product. The thin-wall and small products are cleaned at lower pressures, whereas robust ones at high pressures thus shortening the time of cleaning. [8, 10, 11, 12]

Small thickness of the layer insures the production of products with very smooth surface which makes the finishing unnecessary. Finished products can be processed by a jet of particles, polished, ground, painted, etc. The products can be applied as models for the production of silicone moulds for vacuum casting using special model combustion chambers. [12]

The advantages of the procedure are: high quality (because of very thin layer the products are very precise and they have very smooth finished surface), possibility of producing tiny details and thin walls, application in offices (no contact with resin and the supporting structure is removed with water), the procedure is fast, no need for subsequent crosslinking and it is possible to use different *FullCure* materials that enable different geometry, mechanical properties and colour. [11]

3. 3D modeling of fixture

Drill cover is the part that needs to be scanned automatically. For good scanning without any deformation of cover it is necessary to make a device which holds cover during scanning. With additive technologies we can manufacture different versions of complex model in short time with a low cost, because we do not need to modify the mould, only CAD model and print again. First version of fixture for drill cover is shown in Fig. 3. First version of fixture is print with material Gray20 (combination of VeroWhitePlus and TangoBlackPlus). The material consumption for the model is 25 g and the time of production is 100 min.



a) b)

Fig. 3. First version of fixture: a) CAD model, b) 3D printed fixture

In order to get good fixture, drill cover has been scanned. Fixture should hold drill cover in place by shape and that is achieved by extruding three support pillars up to surface of drill cover.

3D scanning was performed on *David SLS-3* 3D scanner and *David TT-1* automatic turntable (Fig. 4). Same system will be used as a test setup for automated scanning with 3D printed fixture.

Fig. 4. Equipment: 3D scanner and automatic turntable

Result of 3D scanning is STL file or mesh and it is oriented freely in space. To make good orientation of mesh free version of *GOM Inspect V8 SR1* was used which is shown in Fig. 5. Also *GOM Inspect* was used to reduce number of points in point cloud to reduce file size.

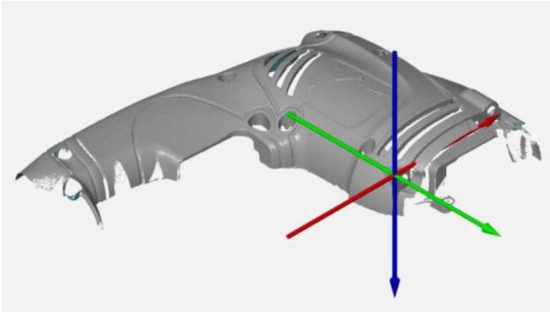


Fig. 5. Result of 3D scanning – mesh of drill cover

After orientation, STL is imported to *Catia V5R20* to model surfaces. Three created surfaces are enough to make solid CAD model of fixture with three support pillars so it holds part in three locations. Comparison of created surfaces and result of 3D scanning or mesh was made in *GOM Inspect.* That comparison shows analysis of surface deviation to STL and it is shown on Fig. 6. The deviation is only in one case +0.39 mm and in other surfaces within +0.04 and -0.08 mm.

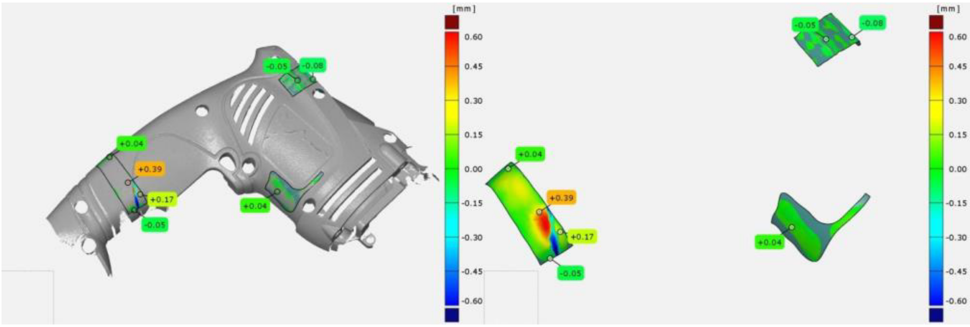


Fig. 6. Analysis of surface deviation

Then surfaces are imported to *SolidWorks 2015*. In *SolidWorks* support pillars are made by extruding sketches up to imported surfaces. The rest of fixture is made to fit *David Automatic Turntable* and to connect pillars into one solid body. CAD model of fixture is shown in Fig. 7 and in Fig. 8 3D printed part. Final fixture is print with material VeroWhitePlus. The material consumption for this fixture is 100 g and the time of production is 6 h.

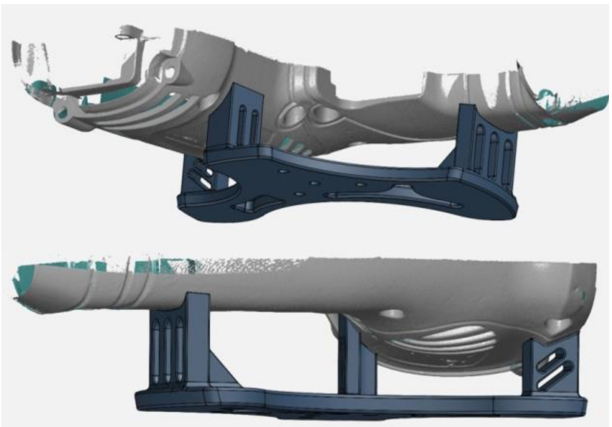


Fig. 7. CAD model of fixture

Fig. 8. Final fixture made by additive manufacturing

4. Test setup for automated scanning

Automated 3D scanning is often used for quality control of large production series and for control of manufacturing processes. With development of automated measuring cells and integration of robots in 3D scanning time of 3D optical measuring is significantly reduced. So there is a need for jigs and fixtures that holds every measuring object in same place and enables higher repeatability. Fixtures for automated measuring must not deform or affect the shape and dimensions of measuring object. Additive technologies allow rapid and cheap production of fixtures of complex shape and with characteristic surfaces that fit to surface of measuring object.

In this work *David SLS-3* 3D scanner and *David TT-1* automatic turntable were used as test setup for automated scanning. 3D printed fixture is mounted on turntable with 3 screws and drill cover can be easily put on fixture for scanning. These principles of fixture making can be applied with every other automated measuring system with or without rotation tables. Fig. 9 shows test setup with fixture and measuring object.

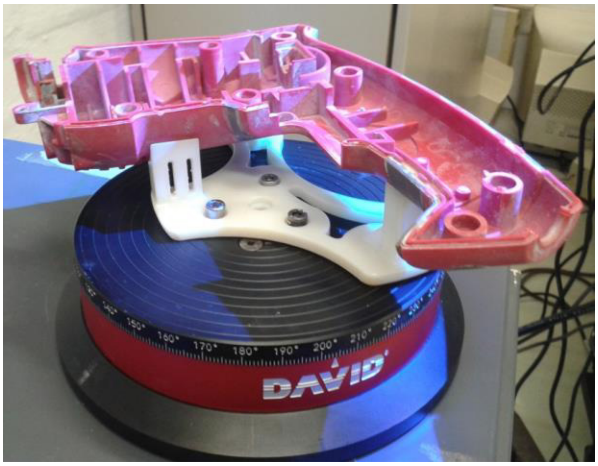


Fig. 9. Test setup with fixture and measuring drill cover

5. Conclusion

As the requirements for accuracy of reconstructed CAD models the preprocessing of scanned data has become a crucial part in reverse engineering. Thin-wall plastic parts tend to deform under effect of their own weight or if they are pressed to tight in fixture, so the design of a fixture is a complex and intuitive process.

Additive Manufacturing offers an incredible level of design freedom used to create fixtures impossible to realize through traditional methods. Fixtures with integrated functionality can be designed to overcome common limitations of traditional fixtures such as locating and releasing snap fits and clips. This, in turn, allows for increased repeatability.

Fixtures are used to place every same part that is measured in same position and orientation.

In this case study it is shown modelling of fixture for drill cover and production with PolyJet technology. Fixture is made with pillars which have holes that save the time of production and material consumption. After being placed on rotary table and rotation of fixture and cover, there has been no movement of scanned object.

Acknowledgements

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