



Title:

Application of a Digitization Procedure Used for a Design of an Old-timer Component

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Introduction:

This paper presents a procedure suitable for improving the shape of an old-timer component within specific tolerances. Firstly, the necessity of such a modification and the function of this component are explained. Secondly, the digitization technique and interpolation procedure are described. Thirdly, detailed technical documentation and tolerances are created in relation to its unique shape. Finally, its precision manufacture is shown.

Various digitization technologies are widely used by design engineers dealing with existing components which either lack technical documentation or which were manufactured long ago. The presented procedure of digitizing neighboring components and the consequent design and fabrication of a made-to-measure component has been performed in the framework of various industrial projects. These are part of a partner company's know-how and therefore could not be present in a paper. Therefore, the workplace came up with a didactic example on which all the steps are demonstrated. The high importance of such an expensive procedure to be applied for a simple insert component is explained in the first section of this paper.



Fig. 1: Prototype of the engine inserting component between cylinders built using FDM 3D printer.

An Inter-cylinder Crankcase Insert:

The inter-cylinder crankcase insert (hereinafter insert) is a part of the crankcase and it seals the center main bearing casing of the crankshaft. Its manufacturing process and assembly using traditional technologies are described here since this component is suitable for the JAWA 350 old-timer motorcycle from the 1960s. A central hole for the insert was drilled in the casting before the precise

shaping of the cylinder recesses. Subsequently, an intermediate product of cylindrical shape was inserted into this hole. Precise holes for the cylinder barrels were machined afterwards and when this crankcase was positioned for the machining, minor deviations might occur. The axes of all these cylinders were parallel but did not lie on the same plane [4]. Therefore, each insert between the cylinders was unique and irreplaceable. The crankcase used for the project is shown in Fig. 1. This unique geometry with its specific axis positions and diameters had to be created using 3D scanning.

The main purpose of this project was to involve students in a real development using modern methods of interpolation of a point cloud. Another important goal was to improve the efficiency of ignition and consequently the whole combustion cycle [3].

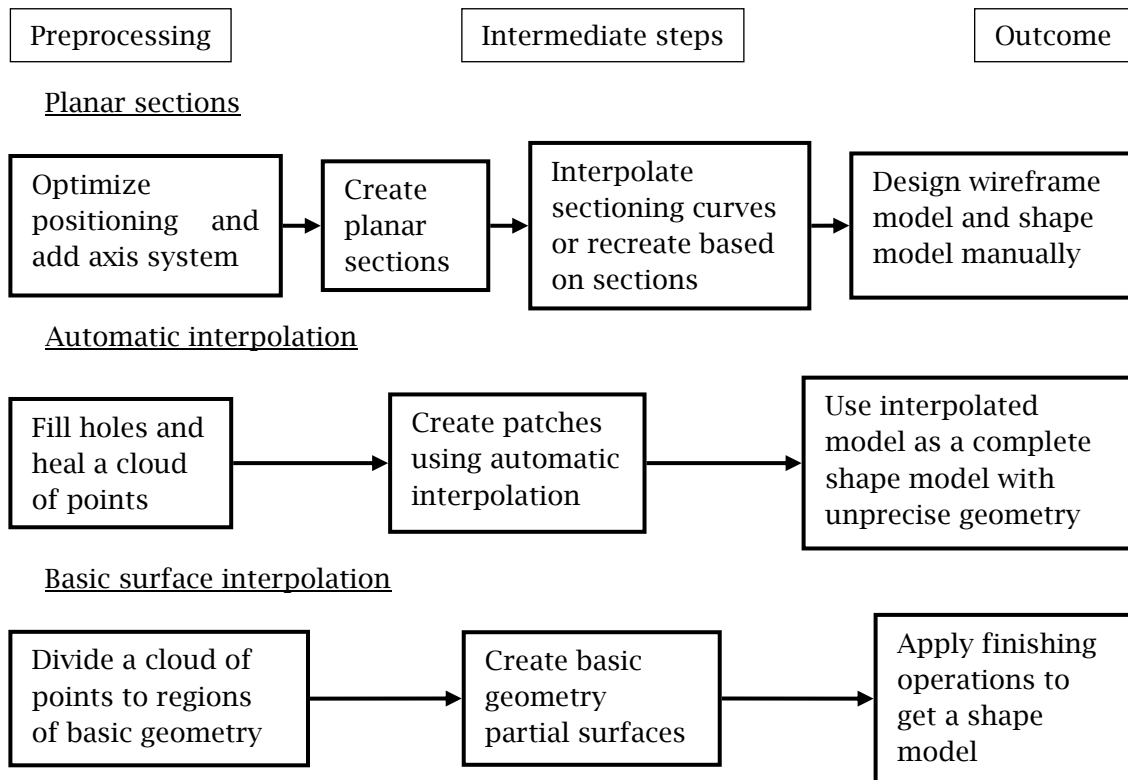


Fig. 2: Scheme of steps of three different interpolation procedures [1].

3D Scanning and Methods of Interpolation:

Students used optical 3D scanning device ATOS Compact scan 2M to obtain digitized data of cylinders. With precision of 0.013 pixel it is widely used for the accuracy mapping analysis [6]. ATOS Compact scan 2M is a non-contact 3D scanner and it utilizes blue light and triangulation. The projector projects a fringe pattern across the part's surface and as the patterns rapidly shift during each scan, the two cameras capture the displacement to calculate the 3D coordinate measurements [2]. The most difficult task for students was minimizing the number of snapshots to deliver the best precision of outcoming data. Calibration of the device was a less complicated task since the regular calibration is necessary only for reference points geometry. This means that a predefined calibration panel with a pattern of dots is scanned several times in a specific position. Here, students improved their understanding of scanner precision and necessity of constant distance from the scanned object. Other settings were part of a maintenance performed occasionally, e.g. when the set of objectives are replaced. Students correctly selected a set of MV500 objectives in combination with reference points of 5 mm diameter.

Depending on specific shape of scanned component, various types of interpolation procedures can be distinguished. At the authors' workplace, four types using the complex CAD system CATIA are known [5]:

- **Planar sections** – utilizing this type of interpolation is not a proper surface interpolation, rather a remodeling the component using precise sections along a selected direction;
- **Automatic interpolation** – a predefined number of random patches are generated in a way that a limiting deviation is reached;
- **Basic surface interpolation** – interpolated are basic shapes such as planar, cylindrical, conical or spherical surface, they are of undivided geometry, cloud of points needs to be split to create every surface in its basic form;
- **Power Fit** – meshed model is divided into segments based on boundaries of different interpolation. Such a procedure is the most similar to class A surfaces creation, however it is time consuming and hierarchical. This method was not demonstrated within presented project, since there was insufficient point cloud data income.

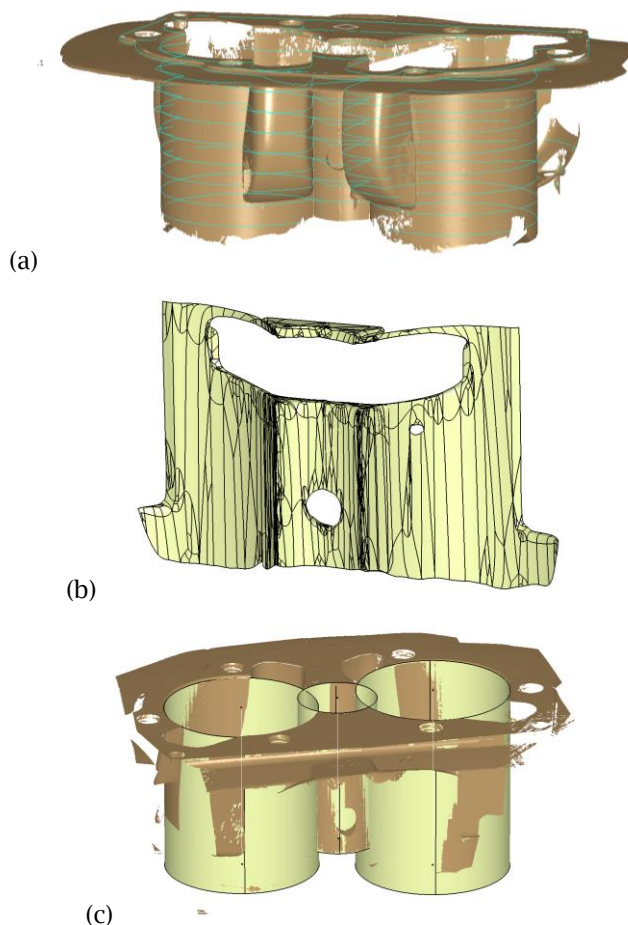


Fig. 3: Interpolation intermediate steps for (a) Planar sections; (b) Automatic interpolation; (c) Basic surface interpolation.

For certain applications, appropriate interpolation method brings the highest precision, specific geometrical tolerances, complicatedness of the data, etc. Therefore, it needs either experiences or a tool for this decision to be made at the beginning of the whole CAD model creation procedure. Fig. 3 shows various CAD interpolation procedures used within this project.

Technical Documentation and Tolerances:

Technical documentation is essential for most of design companies and workplaces, while they create drawings in 2D and store them in document version, either virtually or in paper. It usually means to frequently modify a 2D version of drawing when a 3D model is modified [7]. However current CAD softwares enable 3D GD&T (Geometric Dimensioning and Tolerancing) with updates of these annotations in GUI (Graphical User Interface).

Within the presented project, 3D GD&T were used in a designated tool of CATIA. Design of the insert as virtual model is shown in Fig. 4. Application of 3D GD&T enables better understanding of functional importance of specific dimensions. This model was used as a didactic example for undergraduates. Technical documentation for this project was created in a form of a model, a 2D drawing and a 3D annotation model. STEP (STandard for the Exchange of Product) model was sent to a CNC (Computer Numerically Controlled) machine for a further tooling preparation and a fabrication.

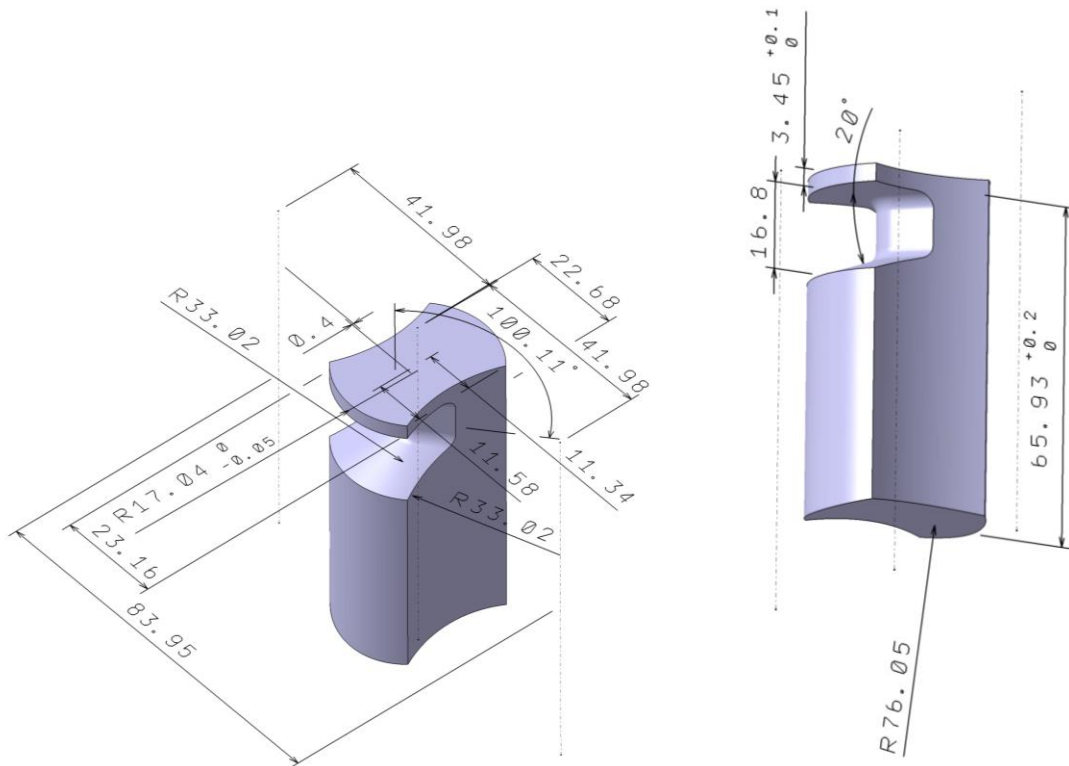


Fig. 4: 3D GD&T model of the insert.

Manufacturing and its Precision:

The insert was fabricated from an aluminum alloy using CNC milling machine. Digitization procedure is simpler for a quality check, since there is no interpolation needed, only direct comparison on cloud point data is done. Final deviation report is shown in Fig. 5. After assembling, insert fit perfectly and it

was proven the engine start efficiency was improved compared to randomly purchased insert of imprecise geometry.

Conclusion:

Future curricula of design-oriented subjects need to be supplemented by case studies such as presented in this project. Students need to learn the process of interpolation is never the same and appropriate tools help to increase the knowledge level of model created. A significant improvement, which should be implemented similarly in the industry is an application of 3D GD&T model. Designers need to involve specific elastic and plastic behavior of material in the designing process. For example, Additive Manufacturing precision is limited along z axis. Quality check via 3D scanning device is performed to verify it. All in all, there is always a difference between comparison of a fabricated component with a man-made drawing or a fabricated component with initial point cloud data. This project has reached sufficient deviations in both kind of analyses.

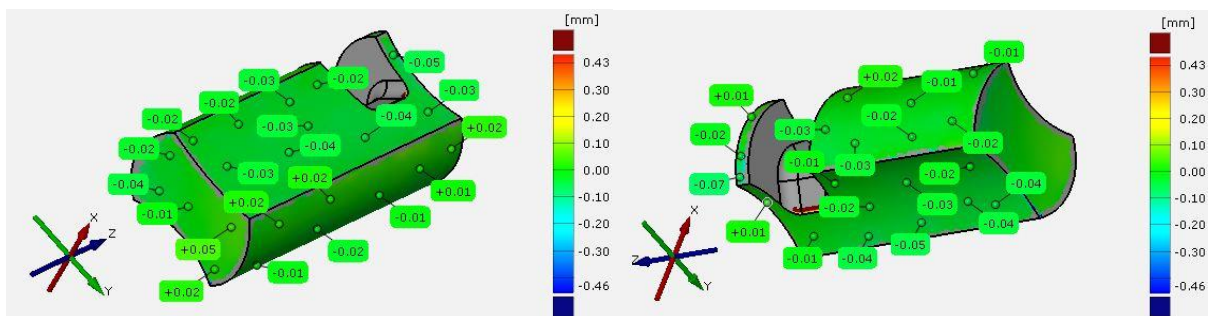


Fig. 5: Deviation analysis of a precisely fabricated insert in comparison to a step model.

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