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RESEARCH ARTICLE

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DESIGN OF MACHINE PARTS IN THE AUTOMOTIVE INDUSTRY USING 'CAD/CAM'

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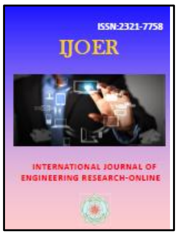

ABSTRACT

This work deals with strategy in designing machine parts using CAD in terms of their historical development. It explains the basic concepts related to the use of CAD systems. The theoretical part summarizes the issue of production models, CAD / CAM technology and milling technology. The practical part is elaborates engineering design of machined parts focused on the specific requirements for application in the foundry. For designing of milling technology was used CAM system. Technological preparation for production on the CNC machine will be implemented with using CAD / CAM software. In conclusion will be assessed technical economic evaluation of production this component.

KEYWORDS: Machine part design strategy, CAD system, over-the-wall engineering, concurrent engineering, prototype, simplex.

Introduction

Basic classification of the CAD system according to the dimension for which it is primarily intended. They are 3D CAD modelling software, which is hard to do without a design office today. They accelerate the development of machine part design, analysis, simulation and technology[1]. The programs are designed as a platform for add-on applications where we create a 3D model and then edit the drawing in a 2D CAD system. It is a very effective way of creating technical documentation.

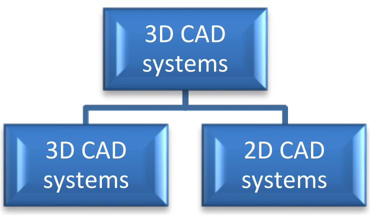

Figure 1: Basic classification of CAD system

Example of 2D CAD system are a) AutoCad by Autodesk Inc. and b) eDrawings by Dassault Systems SolidWorks Corp. In a computer environment, an object is perceived as an object to be portrayed. In my work I will deal with rendering of machine parts using CAD software. It is necessary to draw the machine parts and then realize the volume virtually[2]. Work in CAD software begins snapping the datum to the base point of the program with coordinates [0,0,0]. These coordinates determine the origin of the Cartesian coordinate system. Then we draw the base profile to the plane from which we will start. We dimension it and then create a 3D object by rotating it around an axis, pulling it out of the plane, or doing other operations. An important problem, for example, is that it is simply not possible to work with points at infinity (so-called step points). Although the drawings are usually finite, improper points may arise when displaying 3D objects (for example, in a very common centre projection on a planar projection, the projection of some points of the scene may be infinite) as in AutoCad Inventor. The problem is that the vector representing the improper point in space should have one or more components equal to ± ∞. As you know, the value of, cannot be simply represented on the computer. Moreover, this value should also be the result of arithmetic operations, which again is simply not possible. Therefore, this problem is solved in CAD systems by a set of fixed programmable points to choose from for our specific problem[3].

The model in the context of foundry production is a major part of the modelling device that serves to create an active cavity in a metal casting mold. The model itself has a shape corresponding to the shape of the casting, but with larger dimensions that take into account the shrinkage of the metal during casting. The model can be made of different materials. Nowadays, new production technologies of model production using CNC (Computer Numerical Control) machine tools are often applied. This technology ensures fast and accurate production of very complex models[4]. Production of models using CNC machines is very closely connected with CAD (computer-aided design) and CAM (Computer-aided manufacturing) technologies. Thanks to the possibilities of CAD technology it is possible to quickly create a model, verify the functionality of the model and eventually modify the model and drawing documentation. The follow-up CAM technology enables the progressive programming of machining technology and pre-production adjustment of machining parameters. The result is efficient production that is less time-consuming than manual and, moreover, makes it possible to detect a number of shortcomings at an early stage and thus improve the quality of production[5].

CAD SYSTEMS

CAD systems, i.e., Computer Aided Design, are tools that use computer technology for the initial stages of the production process. They are used mainly for the development of new products, design or construction modifications and as a basis for technical preparation of production. The CAD area belongs to a group of computer-aided technologies collectively called CA (Computer Aided) Technology. CA technology creates a tool structure suitable for the various phases of the product cycle[6].

CA technologies can be divided into areas:

- CAD - Computer Aided Design.
- CAP - Computer Aided Programming.
- CAPE - Computer Aided Production Engineering.
- CAE - Computer Aided Engineering.
- CAPP - Computer Aided Process Planning.
- CAQ - Computer Aided Quality.
- CAM - Computer Aided Manufacturing.
- CIM - Computer Intergarted Manufacturing.

In CAD software it is possible from the beginning to design a part, model it in exact dimensions, test its functionality and create drawing documentation. Thanks to the use of this computer technology there is a significant increase in productivity and quality of drawings. Furthermore, thanks to the extensive possibilities and interconnections of these technologies, it is possible to design the production completely and reduce the amount of prototypes produced[7].

Classification of CAD systems

CAD systems can be divided into 3 categories:

- lower class,
- middle class,
- upper class

Representatives of lower-class software are typically modeled in 2D (two-dimensional) only. The best known representatives are AutoCAD, TurboCAD Delux. These software allow the creation of surface models and drawings and are suitable for easier work (Freibauer et al, 2010)

CAD system options

Modeling in middle and upper class software has much in common and differs only in advanced modeling functions and add-on modules for more complex design design (Freibauer et al, 2010).

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Vol.7., Issue.5, 2019
Sept-Oct

SolidWorks 3D CAD system modeling

The first step in modeling in 3D CAD systems is to create a model of the part, followed by drawing documentation for this part. Software also allows assembly of more parts into functional units, so-called assemblies. Again, it is possible to create drawing documentation.

Modelling of parts

When creating a model in all 3D modeling software, including SolidWorks, the default step is to create 2D or 3D sketches. This sketch can be placed on any plane or space in the case of a 3D sketch. After the sketch is created, the surface model is converted to 3D. This is enabled by a number of functions such as extruding a sketch into space (Fig. 2), rotating around an axis, etc. Each such step is saved with all parameters in the command tree, which clearly shows the progress of the part design.

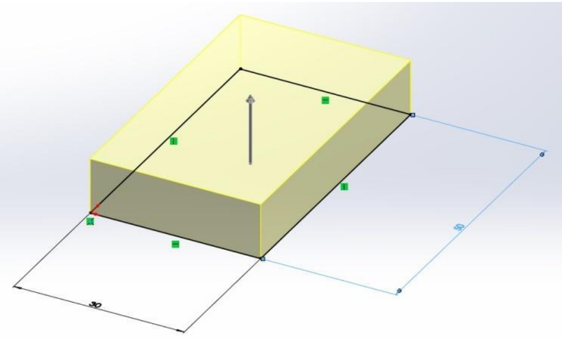

Figure 2: Creating a model in Solidworks

For modeling complex parts, the command tree is necessary. The structure shows clearly the individual steps that can be changed retroactively and at the same time shows the parametric sequence of individual modeling operations. It is precisely by using the parametric continuity of individual modeling operations that it is possible to modify the seemingly large part of the model in a very short time. It is possible to assign the material characteristics color and many other properties to the modeled part so as to correspond as closely as possible to the finished product.

Creation of reports

An important modeling option is the creation of reports. The assembly consists of several interconnected parts. The first step in creating an assembly is to import the parts into the assembly builder. For joining these parts is used so-called bond, which ensures mutual placement of parts or allows their movement only in a certain way. Basic types of links include.

- unification,
- parallelism,
- perpendicularity,
- tangential connection,
- Concentration
- offset by distance,
- tilt by angle.

By combining these constraints, it is possible to assemble the parts into an assembly in a variety of ways so that they can move as the designer intended. If necessary, it is also possible to use some special bonds that are used in engineering. These include: cam, pin, gearing, rack and bolt.

Drawing documentation

Creation of drawings comes up to the last. This is because all geometry is transferred to the drawing from completely modeled parts or assemblies. Along with geometry, user-entered part and setting information is transferred to the drawing. In the drawing, part volume, material, and weight are automatically added to the title field. The relationship between model, assembly, and drawing ensures that changes made to the model are reflected in assemblies and all drawings in which the part is represented .

Additional modules

Modern CAD programs offer, in addition to a wide range of features for part modeling and drawing documentation, add-on modules that partially replace specialized software. These include, for example, the simulation of stress under the finite element method, or the graphical rendering of modeled parts for presentation purposes. An important module for large companies and large projects are programs to manage production documentation. These modules allow controlled access to files with information about recent changes, their author, etc. For large projects, they make it easier to navigate the data and make it possible to clearly check the status of work.

CAM

CAM, or Computer Aided Manufacturing, are systems for the preparation of programs for numerical control of production machines. These systems use the geometry created in the previous design phase in the CAD system. Many programs offer a combination of both CAD software and CAM software, so these systems are often referred to as CAD / CAM technology. CAM systems allow machining programming and offer the possibility to simulate technological operations during production. These programs are suitable for milling, drilling, turning, electroerosive machining, laser or waterjet cutting. The output is a program for CNC machine control in production[8].

Production process in CAD / CAM systems

Production using CAD / CAM technology includes several interrelated stages. These stages range from the design phase to the final production phase.

The application of this technology allows a systematic approach to the development and production of a new product. The whole process includes design, production verification, and correction of found errors and modification of the production process. CAD / CAM systems are mainly used in the production of molds, models, dies and other complex components in the machine industry[9].

Experimental

Creating a model in CAD

To facilitate the creation of NC code in CAM, it is good to create a CAD part model. One of the best software for this work is Solid works, which works on the principle of solid modelling. The drawing is then created from the model and can be further worked, eg in assemblies. The basket modelling shown in Figure 3

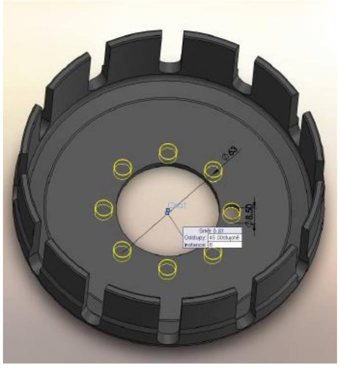

Figure 3: Solid works modelling.

Design of technological process using GibbsCam software

The GibbsCam Technology Support Software (Figure 4) is an effective tool for creating individual operations and subsequently creating NC codes for CNC machines. It supports turning operations with milling cycles of 2-axis to 5-axis milling and wire erosion.

At the beginning of the work we create a geometry or model. CAM also supports importing the model from CAD. We define tools and cycles for individual operations, which are checked by a graphic simulation, which monitors the collision of the tool with the workpiece. The final part of the work is the generation of paths by postprocessor for individual types of machines.

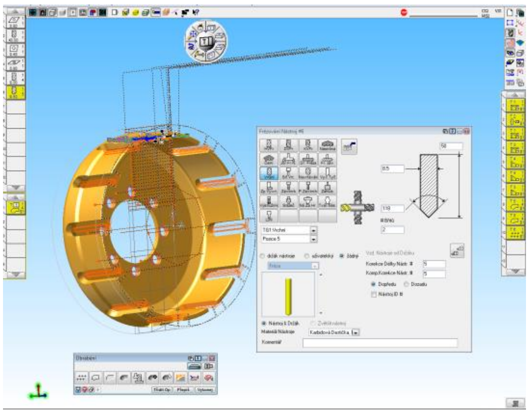

Figure 4: Working with GibbsCam

The individual operations of the basket are shown in the following tables, where individual operations with their description are shown.

International Journal of Engineering Research-Online
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Vol.7., Issue.5, 2019
Sept-Oct

Table 1: Roughing of the forehead.

Graphical representation of the operation	Description of work
	Front roughing with 0.1 mm allowance. Cutting speed 220 m / min, cutting width 0,8 mm and feed per revolution is 0,2 mm.

Table 2: Drilling a central hole.

Graphical representation of the operation	Description of work
	Drilling a central hole. It is important to choose the largest possible tool to save time when turning, but we are limited by the power of the machine, therefore the choice of a 35 mm drill bit. Drilling speed 363 rpm and feed per revolution is 0.35 mm.

Table 3: Roughing outside

Graphical representation of the operation	Description of work
	Roughing of outside diameter with 0.2 mm addition to diameter. The main reason why this section was not associated with the roughing of the face is due to the bending of the workpiece by the drilling pressure. Cutting speed 220 m / min, grip 2.5 mm and feed per revolution is 0.35 mm.

Table 4: Roughing of the interior.

Graphical representation of the operation	Description of work
	Roughing of inside diameters with 0.2 mm addition on inside diameters and 0.1 mm on jaws. Cutting speed 145 m / min, grip 2,5 mm and feed per revolution is 0,3 mm.

Table 5: Finishing of external surfaces

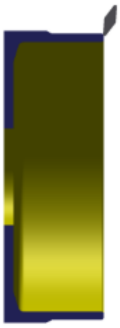
Graphical representation of the operation	Description of work
	Finished forehead and outside diameters to complete. Cutting speed 170 m / min, feed per revolution is 0.15 mm and grip according to material addition

Table 6: Finish the internal surfaces.

Graphical representation of the operation	Description of work
	Finish the inner faces and inner diameters to complete. Cutting speed 120 m / min, feed per revolution is 0.12 mm and grip according to material addition.

International Journal of Engineering Research-Online
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Vol.7., Issue.5, 2019
Sept-Oct

Table 7: Roughing of grooves.

Graphical representation of the operation	Description of work
	Roughing of all grooves with 0.1 mm wall addition. Tool speed 6,764 rpm, 541 mm / min feed rate and 1.5 mm stroke. The last engagement is important, where there is a possibility of collision of the tool and the rest of the material;

Table 8: Finish grooves.

Graphical representation of the operation	Description of work
	Finish all grooves to complete. Tool speed 5,570 rpm, feed 1,005 mm / min and total groove dept

Table 9: Drilling holes for screws.

Graphical representation of the operation	Description of work
	Drilling holes for 8.5 mm screws on a finished tool. Drilling with short solid carbide tools is not required. The tool speed is limited to 3,000 machine speeds and 167 mm / min.

Table 10: Complete roughing of the other side

Graphical representation of the operation	Description of work
	Complete roughing of the other side with an addition of 0.2 mm to the diameter and 0.1 mm to the face. Cutting speed 220 m / min, cutting width 0,8 mm and feed per revolution is 0,2 mm

Table 11: Complete completion of the other party.

Graphical representation of the operation	Description of work
	Complete completion of the other party. Cutting speed 170 m / min, feed per revolution is 0.15 mm and engagement material addition.

Investments invested in a computer production support program are worthwhile. Programming NC codes in the intuitive programming systems of CNC machine manufacturers and workshop programming are lengthy programming methods and prolong production times. In the programming of shaped parts such as molds, we cannot even do without CAM. The main benefit for production preparation is in the fast determination of machining times, which is important for pricing the part. For the basket part, the total cutting time in the CAM was calculated to be 32.3 minutes.

Design of gauges

Micrometre length gauges and digital callipers will be used to measure the basket length and outside diameter. The groove width will be measured using Johansson gauges.

Jawa 50 engine cylinder design

Before designing the Jawa 50 engine's own cylinder design, it was necessary to carefully think through the entire modelling structure. The main question was how the modeling would be most effective in terms of time and complexity of some structural elements. First, half of the cylinder was sketched, see Figure 5, including fins that have the cooling function.

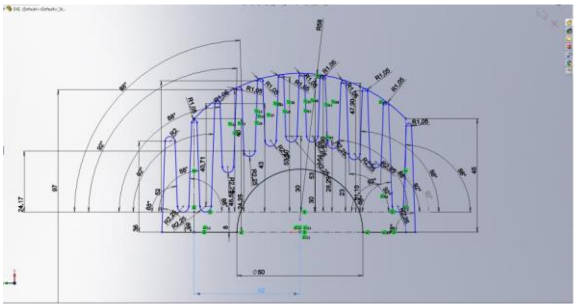

Figure 5: Jawa 50 engine cylinder sketch.

Several sketches, such as circles, a straight line, and a tangent arc, were used from the Sketch panel to sketch. Easy handling when removing wax patterns from the silicone mold for further processing was ensured by the correct dimensioning of the passive cooling fin angles. After dimensioning all the necessary dimensions such as radii, pitches, and rib angles, the sketch could be considered fully determined and worked on. The Extrude Add feature was used to convert from 2D to 3D model. To use this feature, the sketch had to be fully enclosed. In this case, it was closed using an axis that was intentionally used. Furthermore, the program itself offered the possibility to enter the length in millimeters to which it was necessary to extend the pink-colored area, see Figure 5 and 6.

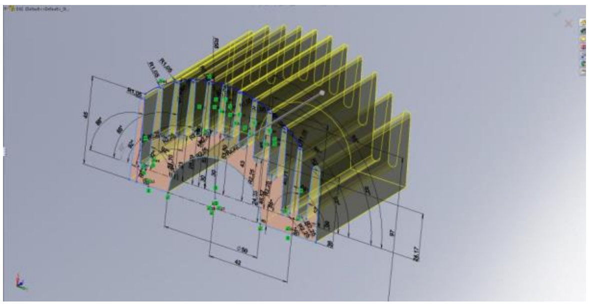

Figure 6: Convert 2D sketch to 3D model

By confirming the choice, half of the cylinder was extended to the required length. Subsequently, another element, Mirroring, was used to complete the second half of the cylinder. When selecting this element, it is necessary to determine what area or total produced elements are to be mirrored. It is also necessary to select a plane or surface that determines the imaginary boundary of the mirroring. The mirror plane was selected as the Right plane, which also ran through the imaginary axis of the Jawa 50 engine cylinder, as can be seen in Figure 7

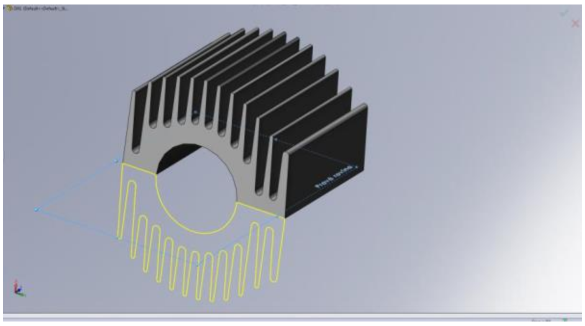

Figure 7: Mirroring half of the Jawa 50 engine cylinder

After making a rough model of the engine cylinder, the individual channels were further modeled. As the first were modeled internal overflow ducts of the engine cylinder. The transfer ducts were sketched from the side where the cylinder head is screwed. First of all, it was necessary to lay out the spacing and placement of the holes for the connecting screws, the so-called " four " because of the easy assembly of the final product of the Jawa 50 engine cylinder. Several sketch fillets, tangent constraints, and center arcs were used in the design. This created approximately the same shape, which was 2 mm wider than the original, which was the intention. Then the Add Extrude element was used and the sketch could be extruded to the appropriate length.

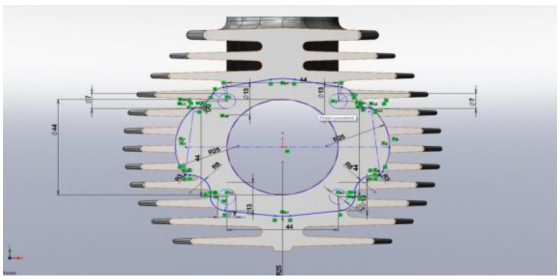

Figure 8: Jawa 50 engine cylinder duct boundary.

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Vol.7., Issue.5, 2019
Sept-Oct

Further, the resulting internal shape of the transfer channels remained to be modeled. The shape was retained from the factory, however, the fillet and overall width were increased by 2 mm compared to the original design. Enlargement could only be done to certain dimensions, as the adjustment would not produce any positive effects. This would cause undesirable wear on other components inside the engine (gaskets), resulting in leakage of transmission oil into the combustion chamber and a large fuel consumption difference. After the final dimension, see Figure 9, the Extrude Extrude feature was used.

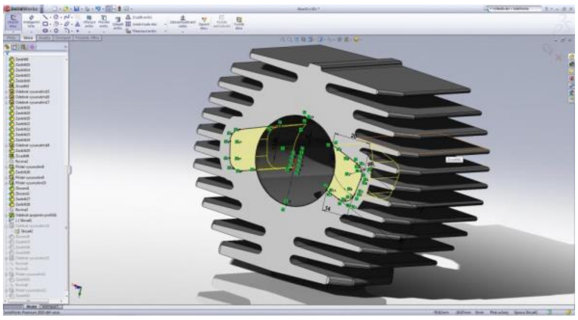

Figure 9: Jawa 50 engine internal duct sketch.

TECHNICAL-ECONOMIC ASSESSMENT

There are companies on the market that are involved in the technical improvement of individual motorcycle and automobile mechanisms. It manages to improve and design functionally better mechanisms than those suggested by the manufacturers. The market has also been found for manufacturers of worn parts who are able to supply parts of the same quality as a large car manufacturer, but often at a significantly lower price. The production of the basket has confirmed that secondary production of parts for the automotive and motorcycle industry makes sense and will feed small and medium-sized businesses. The cost of the basket includes the cost of materials, production costs of the machines, cooperation (alkaline blackening) and overhead costs (construction and technological preparation, logistics). Prices are without VAT.

Total sum of costs in Table 12

Incurrence of costs	Costs without VAT [LYD]
Material	16.3
Material division	6.6
Machining on CNC machine	52.5
Cooperation	2.49
Overheads	40.1
Logistics	27.6
Total	145.59

The price of the basket in offers on the Internet ranges from LYD 180 to 300 without VAT. The differences are due to the material used, the production technology and functional improvements. Prices of the whole mechanism of these types of clutches range from 1516 to 3030 LYD. We produced the basket part at a cost of approx. Repeatability of production would lead to cost reduction, mainly overhead costs. In multi-piece basket production, more efficient machine tools could be considered.

The material used was 1.7225, which has above-average mechanical properties, compared to the parts offered by various manufacturers. Manufacturing dimensional tolerances and surface quality tolerances have been observed. Thus, a long service life of the component can be assumed.

CONCLUSION

There is no denying the rapidly increasing importance and development of machining technologies that have become an important part of the engineering industry worldwide. The technical sophistication in the design of automated machine tools and the advancement of technological production support software have a large share in the increasing importance of engineering technology and thus the share of the engineering industry in the world economic situation is increasing. It is possible to assume a constant increase in the needs of machined parts, the future of workers and companies in this field is more certain than in other manufacturing fields. This project presents a comprehensive proposal for the basket production process. Modern methods of technological process design were used. The design of part production was practically verified by production of a basket on a modern CNC machine. The economic evaluation has shown that the production of the basket is economically worthwhile using the present technologies. This paper also deals with design of 3D model of Jawa 50 engine cylinder and its possible production realization. A suitable additive and cast material was chosen for the production of the Jawa 50 engine cylinder.

As a result of this work was created a cross-platform application for 2D drawing with computer-aided design orientation. The program enables to perform basic tasks, which are characteristic and crucial for CAD drawing, which was the basic aim of this work. The resulting application cannot be considered as a complex real-world CAD system, but rather as a design study of this type of program and a core for further expansion. The whole project was particularly beneficial in terms of new knowledge and experience gained during its implementation.

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