COMPUTER AIDED DESIGN AND PRODUCTION ANALYSIS OF VANE PUMP

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Abstract. This article represents an approach for CAD/CAM-based development of technological, constructional documentation of a rotational pump regarding its assembling. An approach for computer-based designing and assembling of the pump has been invented on the basis of pre-created 3D geometrical models of the compound details and the assembled unit as well as on a basis of a virtual, technological analysis of the pump. A constructor can demonstrate his/her skills and knowledge in the process of development of the compound details by using the already generated, summary drawing of the pump. In order to provide full exchangeability of the main, compound details, an analysis has been made as it concerns manufacturability of the dimensioning and assembling of the details on the basis of computer-made simulations. All of the results that have been obtained are required for the purpose of Computer Aided Manufacturing that is to be performed by the technologists. They are also useful for the purpose of training of students and specialists that have to acquire knowledge and skills through the work with contemporary CAD/CAM software products.

Keywords: CAD, geometrical models, vane pump, documentation, technologic manufacturing, analysis, assembling

1. Introduction

In order to create technical products and to establish their development, one has to apply certain methods of innovation [1, 2]. These methods must be developed on the basis of the experience which our universities from the EU zone have accumulated [3]. This would yield an opportunity to achieve mobility throughout the professional training which is to be exchanged between the countries of the EU and Bulgaria. At other hand, the presented issue is related to improvement of the quality of professional training which takes place in the Universities [4, 5]. These predispositions necessitate contemplation on the issue in question. The establishment of a structure of a summarized method for technical product development derives from the experience in the field of '*Methodology of construction*' that has been gathered so far [5, 6]. Also, it should be stressed that the 3D geometrical modeling of real objects becomes more increasingly endorsed both in the industry and in the training process of constructors, technologists and specialists that work in the field of advertising [7, 8]. According to these arguments, one could say that computer laboratories and technological parks provide the following opportunities:

- virtual construction of technical objects and utilization of prototyping machines for the purpose of prototype development of 3D geometrical models of designing objects;
- 3D scanning and dimensional analysis of the final, real model that is obtained;
- automated assembling of a mechanical product via a special software.

Animation-simulation, dynamic models become more widely used throughout the designing process. They present an opportunity for searching of collisions between the compound details within the assembled unit as well as an opportunity for exploration of the functionality of the product. This is particularly relevant throughout the process of designing of mechanical, hydraulic, pneumatic and electrical drives [7, 9].

Suitable methodologies, tutorials, means of training and applicable software products must be developed in order to create, synthesize and transfer the developed method.

These works and products must be tested in order to investigate their functional congruity and effectiveness during their usage [10, 11].

The purpose of the present work is to develop working drawings of the main, functional details of a mechanical product by the use of a preliminarily created 3D geometrical model, and to propose technological versions for their accurate, mutual treatment and automated assembling.

The object of our investigation is a rotor pump as was done performed a virtual, technological analysis of it which is shown on [7].

The main goals of the present investigation are the following:

- development of a 2D assembly drawing of a designed, mechanical product, i.e. a rotor pump;
- rationalization of a version of treatment of the main, compound details: a cap, a body, a flange and assembling of the pump.

2. Geometrical modeling of mechanical product

A graphical AutoCAD system and catalogue materials have been used in order to execute an assembly drawing of a wing, rotor pump. Figure 1 shows main and additional images as well as written information which are required for the purpose of composition of the constructional document.

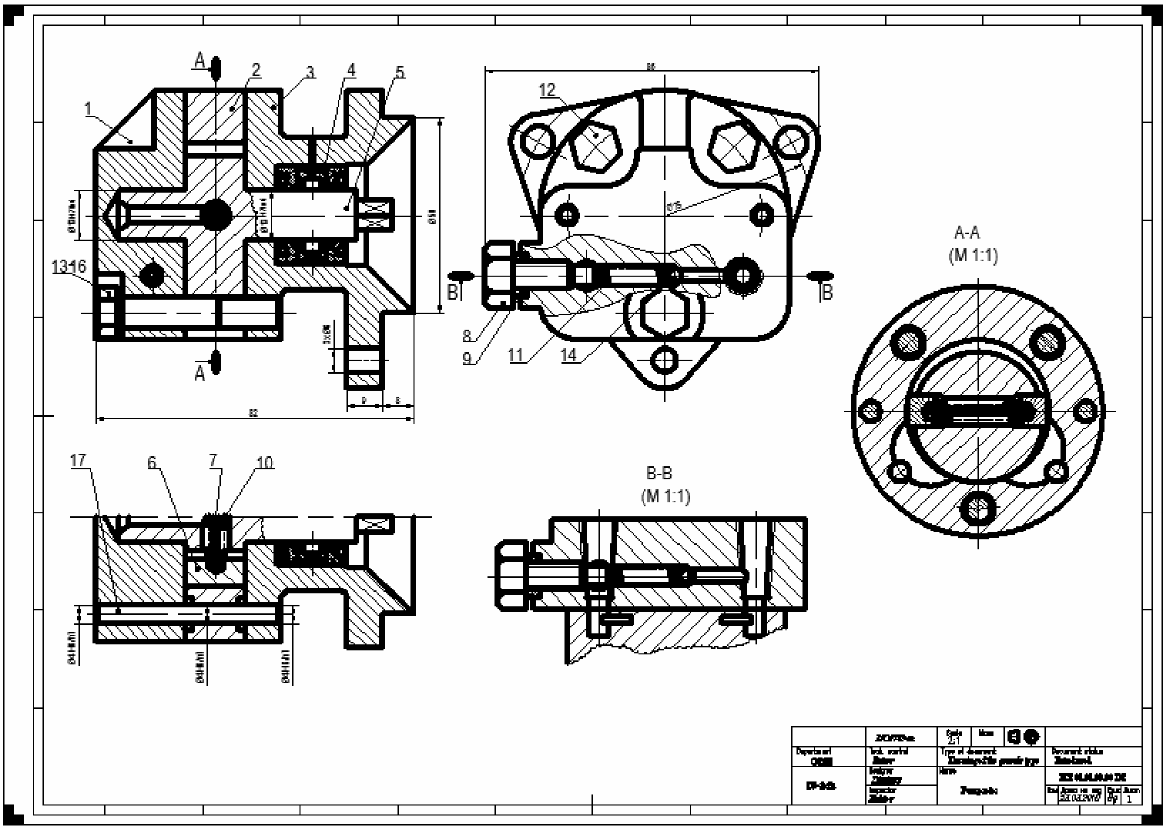

Figure 1. An assembly drawing of a rotor pump

3. Analysis of the technology of dimensioning and assembling

The technological research of geometrical shapes of details represents a basis for the process of dimensioning. One of the most frequently used methods of dimensioning is the method of technological dimensioning that incorporates definition of the dimensions by determination of reference surface which also includes a certain strategy of their mechanical treatment [10, 12]. The technological process of mechanical treatment of mutually connected surfaces from different details of a designed product, that provide exact accuracy of their assembling, can be performed via a precise analysis of the equipment.

The most important issue refers to determination of the basis of the details in order to achieve the predicted characteristics of accuracy within the created geometrical models [13]. Figure 2 represents geometrical models of four main details from a rotor pump: a cap, a body, a flange and pins. These details are to be aligned on the basis of the layout of their openings by the usage of the two pins that are shown. One of the important problems for enhancement the accuracy of assembly of constituent parts in precise assembly units is the selection of designing and technological section bases. This means that the specified from the constructor tolerance zones allows the technologist to choose the most rational technological operations and equipment for the production of the designed product [7].

The pins will be attached to the body by the use of a static assembly Ø4 P8/h8. They will be attached to the flange and to the cap by mobile assemblies Ø4 H8/h8. Thus formulated problem can be illustrated by created simplified assembly drawing, which is given in Figure 3.

Provided the joints of assembling of the pump have been specified according to Figure 1, it is required that the option of assembling of the rotor with the flange and the cap is to be analyzed in order to realize the planned assemblies Ø13H6/h5. In this respect, it is assumed that one should investigate the deviation of coaxiality of the openings for the bearing pins within the cap and the flange. This is the presumed deviation that accompanies the method of alignment of the details. It should be less than the deviation of joints Ø13 H6/h5.

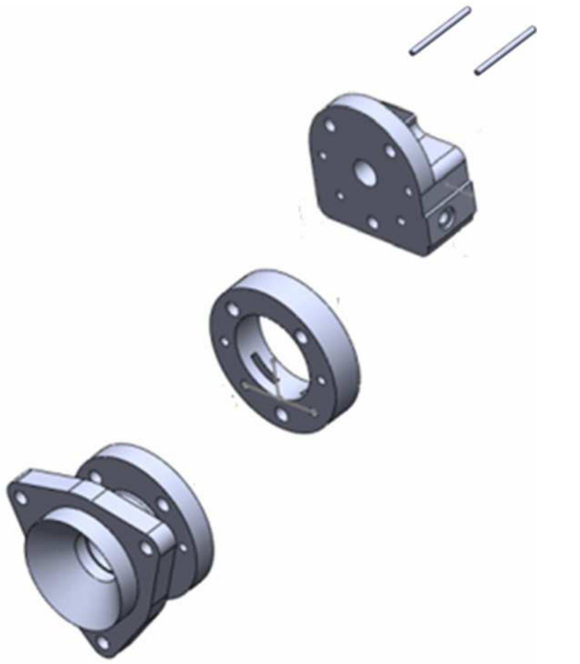

Figure 2. Pictorial shaded exploded models for assembling

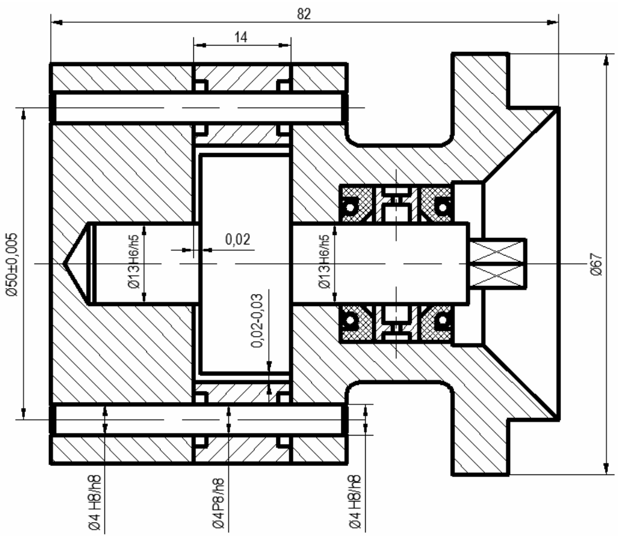

Figure 3. Tolerance dimensioning of the vane pump

Considering the top deviations of allowance fields H6 and H5 (for size Ø13), it is ascertained that the maximum coaxiality deviation of the mentioned openings is equal to the maximum gap within the joint, i.e. 0.019 mm.

In order to perform the dimensioning analysis, one has to use simplified 3D-Solid models of the rotor pump details that have been developed within the confinement of a Solid Works environment. The details which participate in the dimensioning analysis (a body, a flange, a cap and a pin) have to be dimensioned by the use of a Dim Expert module by Solid Works as one has to utilize the capabilities of automated dimensioning along with the corresponding types of dimensional, geometrical allowances (Figures 4, 5, 6, and 7).

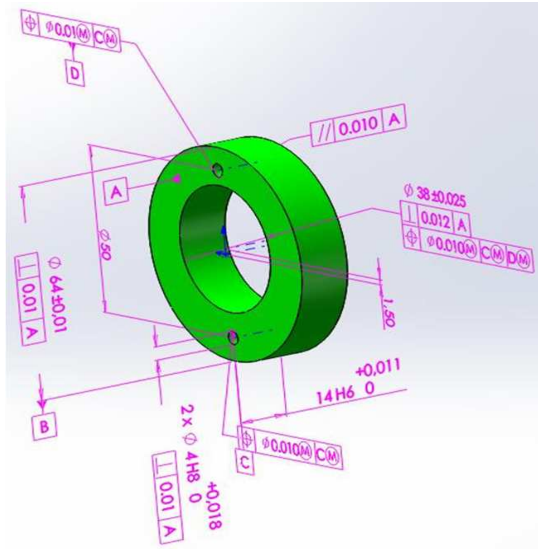

Figure 4. Part „Body“

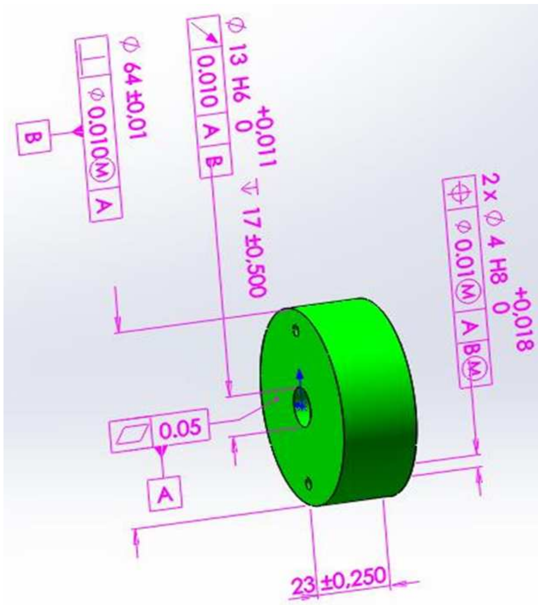

Figure 5. Part “Cap“

Since the alignment of the cap to the body is identical with the alignment of the flange to the body, it is satisfactory to review only one of the two instances.

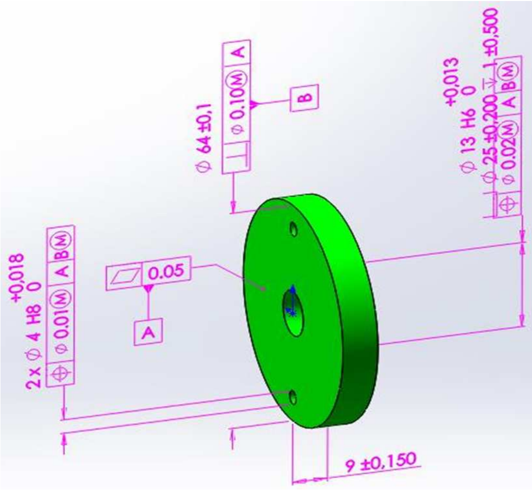

Figure 6. Part „Flange“

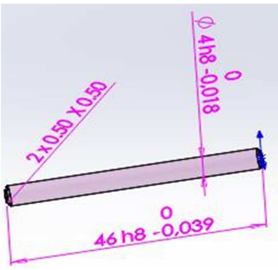

Figure 7. „Pin“

To that end, one has to compile a simplified assembled unit which is to be made of the body and the cap as they are to be centered one to another by the use of the pins. One has to investigate the distance between the central axis of the body and the axis of the opening Ø13 H6 in the cap along the layout of the pins as that distance has a zero nominal value (Figure 8).

An analysis of allowance is to be performed by the use of the Toll Analysis module by Solid Works. The results which are obtained from the analysis (concerning the assemblies given on Figure 1) show that the maximum allowable deviation that is obtained according to the method of full exchangeability is of 0.090 mm, and, according to the static method, it is of 0.064 mm (Table 1, no. 1).

This kind of deviation is too big and allows considerable misalignment of one detail to another, that is to say, the alignment of the body and the cap is relatively inaccurate.

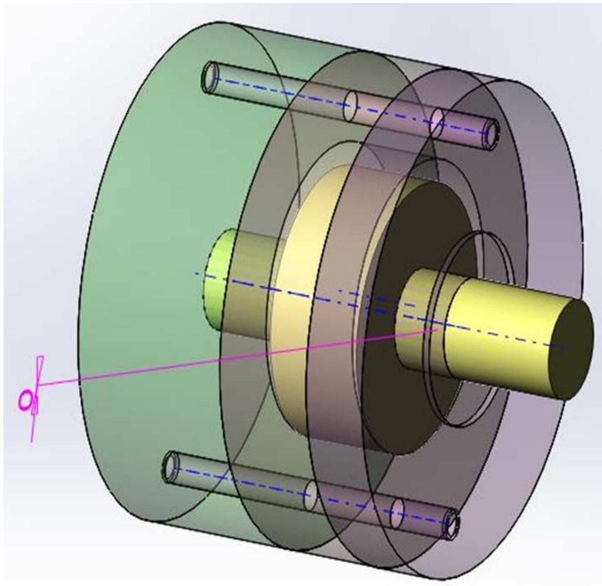

Figure 8. Simplified model of assembly unit of vane pump

Table 1. Results of tolerance analysis

№	Part	Dimensions [mm]	Geometric tolerances (Figures 5, 6, 7, 8) [mm]	Min. & Max. worst-case conditions		Root Sum Squared Min & Max worst-case conditions	
				Xmin [mm]	Xmax, [mm]	XRss min, [mm]	XRss max, [mm]
1	Body	Ø4 P8	Position Ø 0.01	– 0.045	0.045	– 0.032	0.032
	Cap	Ø64 ±0.01	Perpendicularity 0.01				
		Ø4 H8	Position Ø 0.01				
	Axel pins	Ø4 h8	none				
2	Body	Ø4 M7	Position Ø 0,01	– 0.035	0.035	– 0.025	0.025
	Cap	Ø64 ±0.01	Perpendicularity 0.01				
		Ø4 G7	Position Ø 0.01				
	Axel pins	Ø4 h6	none				

In order to improve the precision of alignment (according to recommendations [14], is picked the following joints for assembling: for the body: a static joint Ø4 M7/h6; for the cap (and for the flange): a mobile joint Ø4 G7/h6. Thus, consequently, the maximum allowable deviation of alignment along the pins is reduced with 0.020 mm, according to the method of full exchangeability, and, according to the static method - with 0.014 mm (Table 1, no. 2) precision assembling of vane pumps.

The alignment of the flange to the body is to be performed similarly.

This approach allows finding the most suitable technological decision, high quality and precision assembling of vane pumps.

4. Conclusion

The topology of geometrical modeling of the rotor pump, the development of a set of constructive documents and the exploration of technological solutions are based on a preliminary, virtual analysis of the mechanical product. All these achievements are suitable for performance of simulative, engineering analysis of the assembled unit throughout the process of its designing and assembling within the confinement of certain conditions of manufacturing.

According to the assemblies that are planned in the assembly drawing and according to the geometrical allowances between the main details that are centered by a pin joint, it was done an analysis of the technology of dimensioning and assembling of the rotor pump. An analysis of allowance has been performed by the use of the Tool Analysis module by Solid Works as this analysis corresponds to the full exchangeability method and to the static method. Consequently, are obtained the most optimal deviations for alignment of pins: 0.020 mm for the full exchangeability method, and 0.014 mm for the static method. This approach allows finding the most suitable technological decision, high quality and precision assembling of vane pumps.

The obtained results are required both by constructors and by technologists as they could serve for the purpose of Computer Aided Manufacturing. They are useful for training of students studying engineering subjects and for specialists who work in that field as they improve certain skills and knowledge in the usage of contemporary CAD/CAM systems and in the utilization of new IT technologies within the field of mechanical engineering.

References

1. Jayaprakash, G., Sivakumar, K., Thilak, M. (2010) *Parametric Tolerance Analysis of Mechanical Assembly by Developing Direct Constraint Model in CAD and Cost Competent Tolerance Synthesis.* Intelligent Control and Automation, ISSN 2153-0653, vol. 1, no. 1, p. 1-14, doi:10.4236/ica.201.11001
2. Srihari, S.N. (1989) *Applications of Expert Systems in Engineering: An Introduction*. In: Tzafestas, S.G. (editor) *Knowledge Based System Diagnosis, Supervision, and Control*. Plenum Press, ISBN 978-1-4899-2473-5, p. 1-10, DOI: 10.1007/978-1-4899-2471-1_1
3. Yordanova, D., Ivanov, V., Barzev, K., Kolev, I., Mitev, G., Bratanov, D. (2009) *Encouragment of the Relationships Science – Business Through Establishment of Centers for Technology Transfer in Bulgaria (The Case of the University of Rousse)*. European Integration Studies, ISSN 1822-8402, Vol. 3, p. 23-29
4. Dinev, G. (2011) *Principles of Mechanical Design*. AVANGARD PRIMA
5. Dinev, G., Popa, L., Lepadatescu, B. (2012) *Computer design and precision control for assembling of mechanical assembly unit*. Academic Journal of Manufacturing Engineering, ISSN 1583-7904, Vol. 10, no. 3, p. 32-37
6. Popa, L., Lepadatescu, B. (2012) *Virtual enterprise and product development.* Proc. of International Conference “Challenges in Higher Education &Research, CHER2012, Sozopol, Bulgaria, Heron Press, Vol. 10, p. 132-136
7. Dinev, G., Angelov, P., Chalakova, E. (2014) *Virtual Analysis of Manufacturability of Vane Pumps*. Journal of Applied Mechanics and Materials, ISSN 1662-7482, Trans Tech Publications, Zurich, Vol. 555, p. 479-484, doi:10.4028/www.scientific.net/AMM.555.479
8. Dinev, G., Malakov, I., Dotsev, D. (2012) *CAD Optimal Design, Documentation and Automated Assembly of Mechanical Product*. Advanced Material Research, ISSN 1662-8985, Vol. 463-464, Trans Tech Publication, Switzerland, p.1202-1205, doi:10.4028/www.scientific.net/AMR.463-464.1202
9. Dinev, G. (2012) *An approach for simulation design of mechanical assembled unit*. Advanced Material Research, ISSN 1662-8985, Vol. 463-464, Trans Tech Publication, Switzerland, p. 1085-1088, doi:10.4028/www.scientific.net/AMR.463-464.1085
10. Clinciu, M,. Clinciu, R. (2012) *Illustrating the dimensioning process of a part by using the machining operations plan.* Proc. of International Conference “Challenges in Higher Education & Research, CHER2012, Sozopol, Bulgaria, Heron Press, Vol. 10, p.202-203
11. O’Connor, P. (2012) *Practical Reliability Engineering*. Willey, 5 edition, ISBN 978-0470979815
12. Chih, W-h., Fu, J.C., Wang, K-j. (2007) *A neural Network based approach for Tolerance Analysis.* Journal of Chinese Institute of Industrial Engineers, ISSN 1017-0669, Vol. 24, no. 5, p. 366-377
13. Montgomery, D.C. (2012) *Design and Analysis of Experiments*. Willey, 8 edition, ISBN 978-1118146927
14. Koriikov, Tz., Sotirov, B., Petrov, M. (2003) *Manual of a laboratory metrology and measurement equipment. Tolerances design.* Publishing house of University “Angel Kanchev” of Rousse, Bulgaria (in Bulgarian)

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