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Maja BAIER, Rafał BOGUCKI, Andrzej BAIER *

Institute of Engineering Processes Automation and Integrated Manufacturing Systems,
Faculty of Mechanical Engineering, Silesian University of Technology, Gliwice, Poland

* andrzej.baier@polsl.pl

REVERSE ENGINEERING AS A TOOL IN PROCESS OF GEAR RECONSTRUCTION

Abstract: The aim of the project was to create a 3D model based on a real gear which has been damaged. The model could be availed to further process of reconstruction. The program used in the project was Solid Edge and its Gear Module.

1. Introduction

With the purpose of transforming a physical object into a digital model, reverse engineering is widely applied. Engineers often avail this method in order to reconstruct the whole technical documentation, build a replica, reconstruct a damaged element or to recompile a production process. Mainly employed tools in reverse engineering could be three-dimensional scanners or traditional measurement methods using a caliper, an altimeter, a measuring machine, etc [1].

The presented paper depicts how reverse engineering could be used in reconstructing a documentation of a damaged gear relying on an original element and a gear which works with it (Fig. 1). The primary tool in the process was CAD system - Solid Edge.

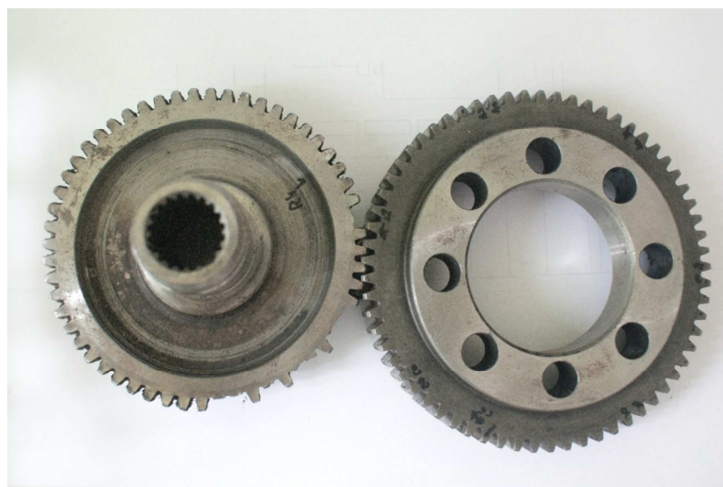


Fig. 1. Two gears working in tandem

Certain stages of gear reconstruction can be named:

1. Measurement of essential dimensions of the gear and verification if they are compatible with other elements and prevailing norms [4, 5]
2. Calculations connected with gear parameters [2, 3]
3. Modeling the element in Solid Edge using Gear Module [6]

2. Measuring stage

In the world of today, widespread digitalization allows for a rapid reconstruction of technical documentation using advanced 3D scanners [7] which, to some extent, facilitate and accelerate a designing process. However, exorbitant prices of the devices lead many to remain staunch in using traditional measurement methods, especially as far as job-lot or individual production are concerned [1].



Fig. 2. Measuring external diameter of a roller

The first step in the project was to measure main parameters of internal and external teeth which were employed in further calculations. Lead of a screw thread was identified with a thread profile templates (Fig. 3) and then verified with the standard [5]. Teeth parameters were measured using an advanced measuring machine since these are the most important and accurate part of the element. The rest of the geometric features was measured with a caliper taking into consideration a tolerance dependant on the use of a surface (e.g. bearing).



Fig. 3. Identifying the lead of the screw thread

3. Calculation stage

Before the usage of CAD program gear module, transmission ratio and clearance have to be calculated. In order to find gear module m the measured pitch point p and the equation (1) were used:

$$m = \frac{p}{\Pi}, \quad \text{where: } m - \text{module, } p - \text{reference pitch} \quad (1)$$

The received value had to be adjusted to normalized modules enclosed in the standard PN-78/M-88502 [4]. In case of external teeth depicted in the paper the module amounts to 2. Pitch diameter d of the gear is equal to:

$$d = z \cdot \frac{p}{\Pi}, \quad \text{where: } d - \text{pitch diameter, } z - \text{number of teeth, } p - \text{pitch point} \quad (2)$$

However, this equation was solved only in order to verify program's calculations. Outside diameter d_a and root diameter d_f were also generated automatically. Subtraction of these two values amounts to whole depth h which is the distance from the top of the tooth to the root. Gear ratio i is equal to number of teeth (65) of the bigger gear divided by the number of teeth (56) of the smaller gear, that amounts to 1,161 in analyzed case. Clearance c for the external teeth was assumed as tenth part of the module, which is 0,2. Pressure angle changes depending on the fact whether the gear is external or internal, the specific value is normalized [2-4].

4. Modeling stage

Solid Edge was availed to create the gear model using the accessible application for cylindrical gears. To generate the gear the following parameters were filled in module window (Fig. 4):

- z – number of teeth
- m – module
- i – transmission ratio
- α – pressure angle
- β – pitch angle

In addition, if power, energy conversion efficiency and velocity are given, the program automatically makes strength calculation and inform whether the gear would endure applied load or not. The Gear Module is also able to make geometric calculations which seem to be essential if physical accomplishment is planned.

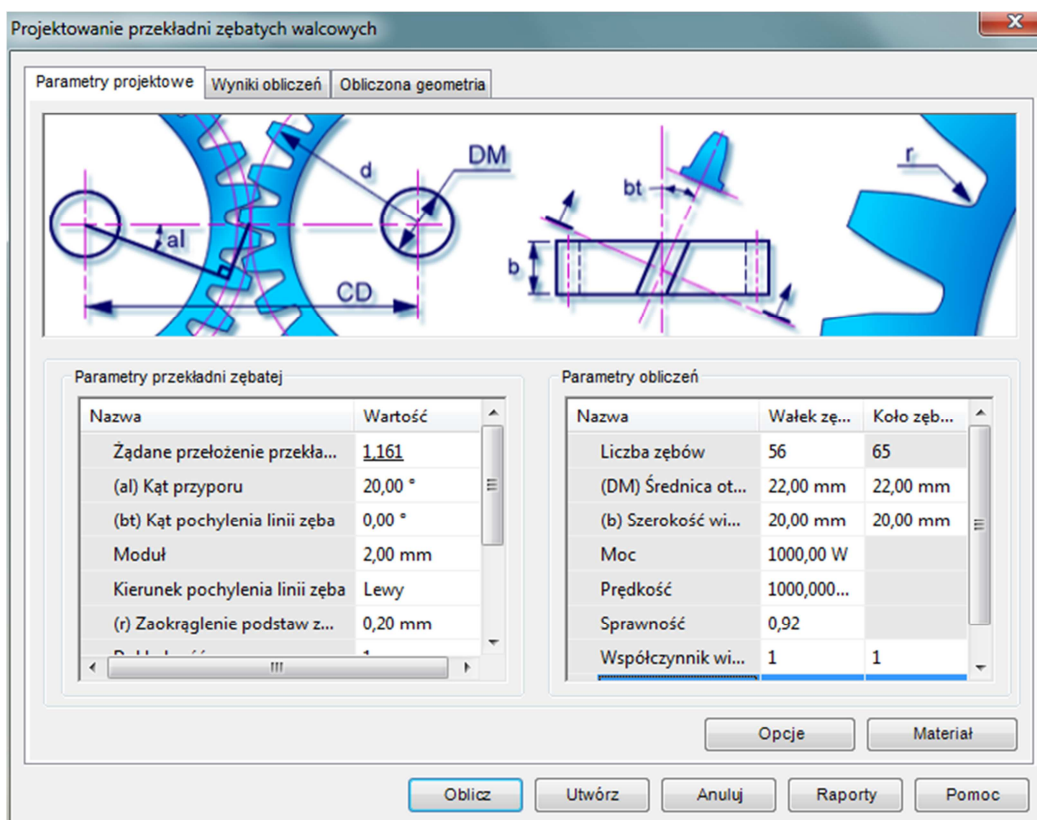


Fig. 4. Window with project parameters

The effect of using the application is the gear (Fig. 5) which had to go through the further stages of modeling to make a perfect image of the real element. Although it was labour-consuming, the module accelerated whole process and reduced the risk of errors in teeth modeling.

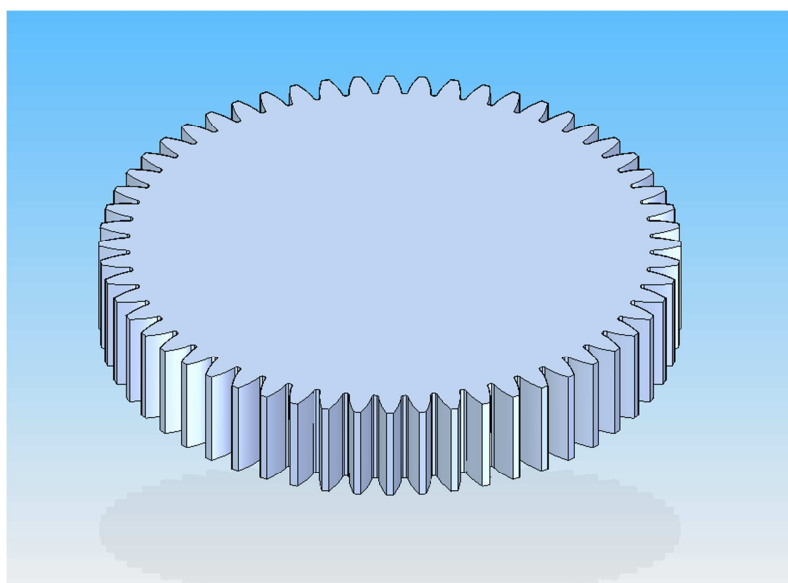


Fig. 5. First phase of modeling

Afterward, the whole modeling process of gear reconstruction is accomplished in the form of 3D model (Fig. 6). It could be transformed into two-dimensional documentation (Fig. 7) using one of the Solid Edge functions called **Drafting**. Putting the function into use allows to add dimensions and technological features which are necessary to produce the gear [6].

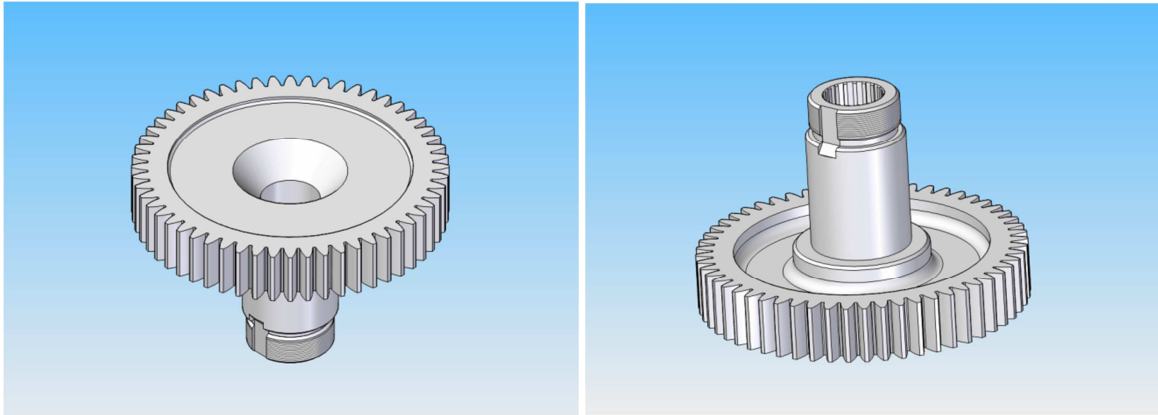


Fig. 6. 3D Model in two views

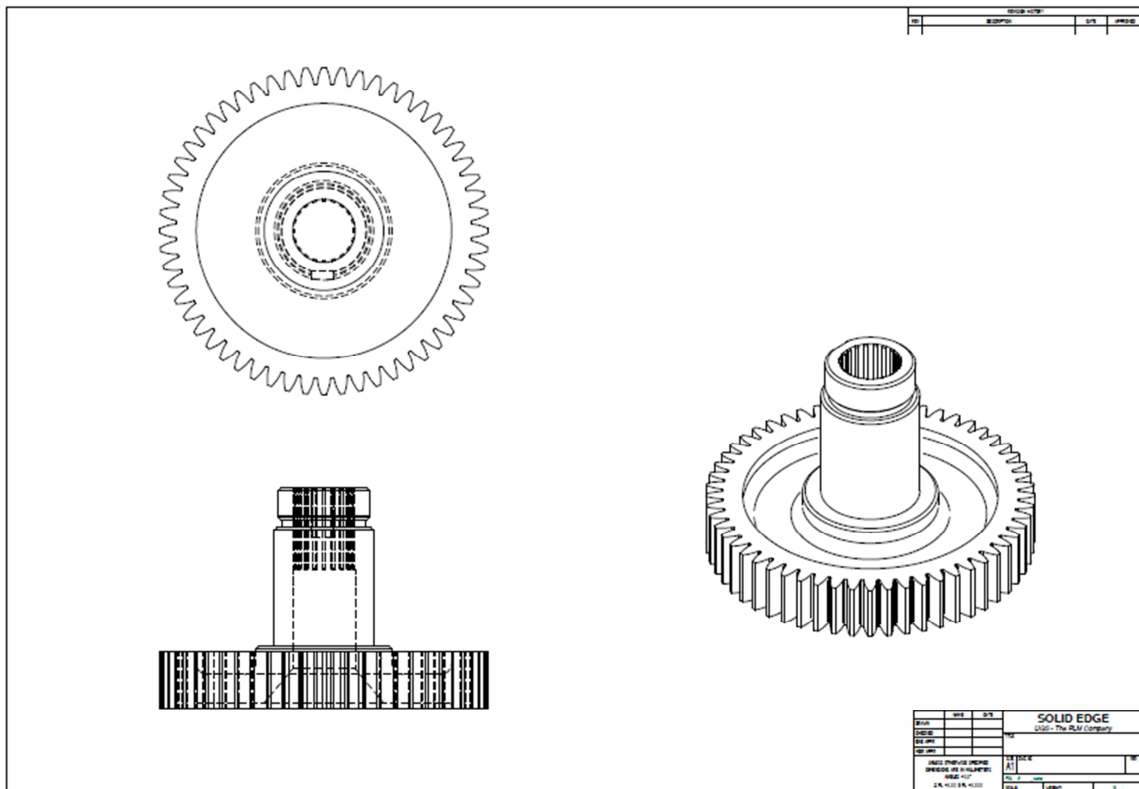


Fig. 7. View of a model after using Drafting function

5. Conclusion

Taking into account digitalization of a physical object in job-lot or individual production, reverse engineering appears to be the most effective designing tool. Laborious measuring and keying parameters in proper CAD program guarantee perfect image of every individual feature of the element. Thanks to advanced programs and their approachable modules process of engineering design became much more convenient.

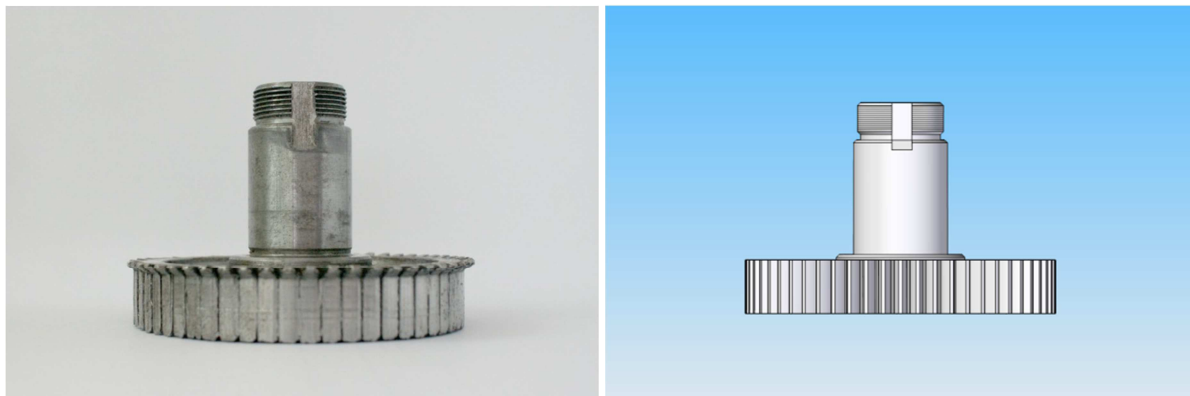


Fig. 8. Damaged gear compared to its model

References

1. Chlebus E.: Technika komputerowa CAx w inżynierii produkcji. Warszawa: WNT, 1995, (In Polish).
2. Kurmaz L.: Podstawy konstrukcji maszyn. Projektowanie. Warszawa: Wydawnictwo Naukowe PWN, 1999, (In Polish).
3. Podstawy konstrukcji maszyn. Aut.: J. Dietrych i in. Warszawa : WNT, 1971 , (In Polish).
4. Polska norma PN-78/M-88502: Koła zębate – Moduły, (In Polish).
5. Polska norma PN-83/M-02013: Gwinty metryczne ogólnego przeznaczenia o średnicach 1 do 600 mm. Wymiary, (In Polish).
6. Solid Edge – Help system.
7. <http://www.3dlasertracker.com/3d-scanning-and-reverse-engineering.html> (29.07.2012)