

Casting Molding of PDCPD Material for Purpose of Car's Power Steering Body

Ł Grabowski, A Baier and M Sobek

Silesian University of Technology, The Faculty of Mechanical Engineering, Institute of Engineering Processes Automation And Integrated Manufacturing Systems, ul. Konarskiego 18a 44-100 Gliwice, Poland, Email: lukasz.grabowski@polsl.pl

Abstract. The growing industry of polymer and composite materials is facing new challenges posed by the automotive industry. In this industry, traditional materials such as steel and aluminum are widely replaced with plastic materials, including polymers. In the past, such behavior concerned design and interior elements, but more and more often plastics are used in the case of load-bearing elements, i.e. those that require high strength and durability nowadays. This kind of materials are also often used in safety systems or driver assistance systems. Therefore, the aim of the activities described in this article are to carry out an innovative process of injection of cold polymeric material, PDCPD (Polidicyclopentadiene), polymerizing with the use of Metathesis reaction, which in 2005 was awarded the Nobel Prize. This injection applies to the worm gear components of the system, supports the power steering system of the passenger car. Also the process of selecting the appropriate parameters to carry out this process, guaranteeing the best quality of the obtained elements is necessary. The aim of the activities was to achieve a fully useful power steering support system, using a polymer body, which is replacing the aluminum. These activities were aimed at reducing the costs and weight of the final product. The injection process and the way to achieve the finished product were carried out in an innovative way, never used in industry before.

1. Introduction

The growing industry of polymer and composite materials is facing new challenges posed by the automotive industry. In this industry, traditional materials such as steel and aluminum are widely replaced with plastic materials, including polymers. In the past, such behavior concerned design and interior elements, but more and more often plastics are used in the case of load-bearing elements, i.e. those that require high strength and durability nowadays. This kind of materials is also often used in safety systems or driver assistance systems. Therefore, the aim of the activities described in this article are to carry out an innovative process of injection of cold polymeric material, PDCPD (Polidicyclopentadiene), polymerizing with the use of Metathesis reaction, which in 2005 was awarded the Nobel Prize. This casting were applied to the worm gear components of the system, supports the power steering system of the passenger car. Also the process of selecting the appropriate parameters to carry out this process, guaranteeing the best quality of the obtained elements is necessary. The aim of the activities was to achieve a fully useful power steering support system, using a polymer body, which is replacing the aluminum. These activities were aimed at reducing the costs and weight of the final product. The casting/injection process and the way to achieve the finished product were carried out in an innovative way, never used in industry before [1, 2, 3, 4].

The casting process was carried in the way showed in Figure 1. Monomer A (3a, 4, 7, 7a-tetrahydro-4, 7-methanoindene mixed with Trichlorophenylsilane) and Monomer B (3a, 4, 7, 7a-



tetrahydro-4, 7-methanoindene mixed with 2, 6-Di-tert-Butyl-p-Cresol) was mixed in a ratio of 1 to 1 directly, at the time of molding or immediately prior to the injection operation. The polymerization process took place inside the mold. Depending on the material manufacturer, the amount of activator used and the temperature of heating the casting mold, the polymerization time could be ranged from 2 to 25 minutes. The samples thus obtained were compared with each other and conclusions were prepared [2, 4, 5, 6, 7].

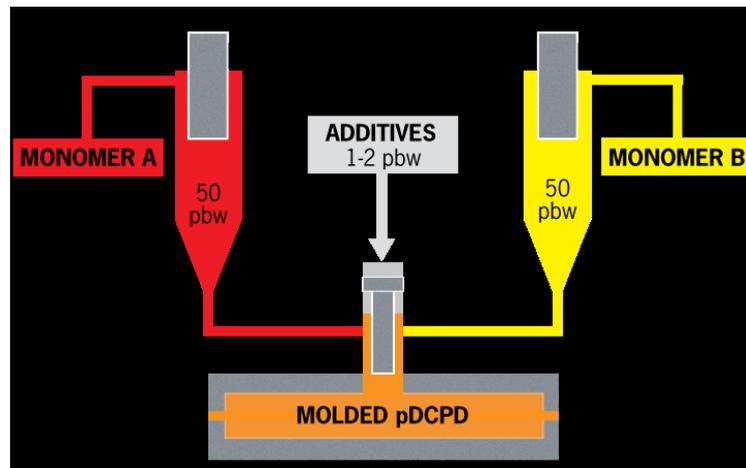


Figure 1. The process of casting using PDCPD material [11]

2. Conducting Preliminary Analyzes

The first step in the process of performing the casting of the PDCPD polymer material was to cast samples, through which it was possible to determine the strength parameters of the material. These activities are described in detail in the publication *Molding of strength testing samples using modern PDCPD material for purpose of automotive industry* [2]. Injection took place using the TELENE PDCPD material. The material lifetime was 2.5 to 4 minutes. The obtained values of tensile strength were achieved at a level similar to some aluminum alloys. All samples were characterized by similar tensile strength; the value of tensile strength “Rm” parameters was close to 40-41 MPa. The temperature of the mold did not affect the material strength values achieved, only the quality of the obtained surface and the number of air traps occurring. The samples could be seen on Figure 2. This was the reason for moving to the next stage of work.



Figure 2. Molded samples (paddles) for tensile strength analysis made of PDCPD

After the process of verification of the mechanical properties of the material, the casting process was started for elements included in the worm gear mechanism. The analysis of the casting of the

bearing sleeves, included in the worm gear of power steering mechanism. These sleeves should be made in a way that eliminates the need for machining, i.e. dimensional tolerances and fits should be kept in relation to the aluminum basic model [8, 9, 10].

3. Casting Of the Worm and Worm Wheel Bushing

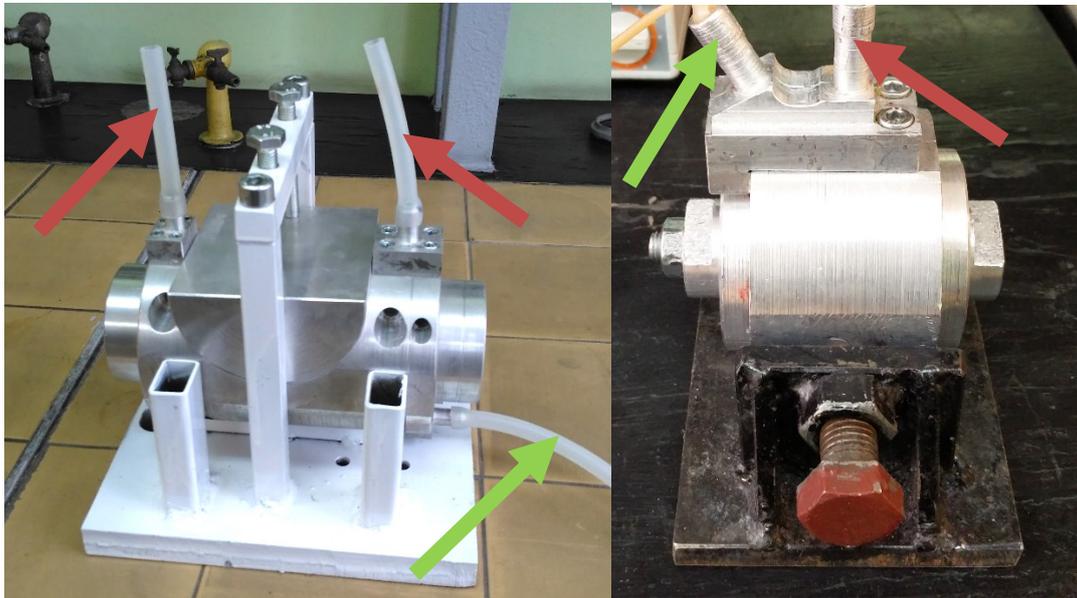


Figure 3. Bushing molds, a) of worm, b) of worm wheel, prepared for PDCPD casting

Two aluminum molds were prepared for the injection molding of the bushing. Aluminum, as a mold material, was selected on the basis of very good anti-adhesive properties. Mold cores and molds have been milled and turned. Previously milled molds were subjected to the Loctite Frekote liquid coating process. On the part a) of Figure 3 mold of the worm bushing were shown, and on the part b) of the worm wheel bushing. By green color arrows, the PDCPD injection hoses were marked, while the vent hoses were marked by red arrows. Ventilation hoses at the same time were used as the type of revision (access eye). The venting elements were placed in the highest part of the mold to drain all the air, which could lead to the occurrence of defective places. The cast was carried out with heating the external parts as well the internal parts of mold. Based on the information obtained in the case of injection of samples for tensile strength analysis (paddles), the temperature of the mold was chosen at the level close to 70°C as appropriate. The casted elements made were subjected to visual and dimensional evaluation.

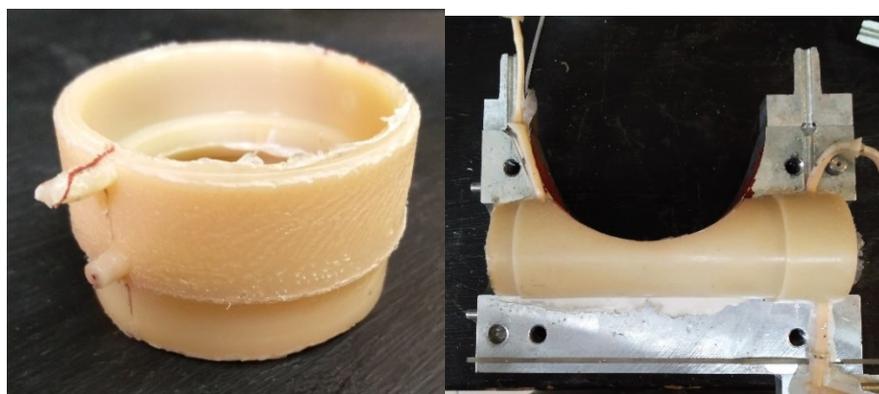


Figure 4. The archived shapes of the bushing: a) the worm wheel, b) the worm of PDCPD

On Figure 4 the obtained shapes in the molding process made of PDCPD material, manufactured by TELENE material were showed. Subsequent tests were carried out on the material from which the target elements of the power steering system manufactured by Apeiron Synthesis are to be created. This material is characterized by a brown color with a transparent structure .



Figure 5. Worm wheel bushing: a) having defects on the outer and inner surface, b) having defects only on the inner surface

In Figure 5, molded elements with defects are shown. Defects resulted from the use of inadequate heating of the mold. In the case of elements visible on parts a), mold preheating had not been applied. In the case of the bushing, visible in part b), heating to a temperature of about 70°C of the outside part of the mold was used, the cores remained unheated. This has significantly affected the quality of the surface obtained; the surface in contact with the core has defects, while the outer surface is characterized by a perfect mapping of the outer surface (heated) form. Also the dimensions on part which was heated are on the level of assumed dimensions



Figure 6. Bushings of worm wheel, free from defects - the correct parameters of the injection process

While in Figure 6 could be seen views of bushings having a perfect surface quality, accurately describing the shape of the cores and outside parts of mold. Gas bubbles and other surface defects were not occurred. In the casting process, heated cores and the outside of the mold were used. This lead to conclude that correct heating of mold is necessary.

4. The Use of Molded Elements in the Body of Power Steering Construction

By achieving a high quality of the worm wheel bushing, it was possible to start the injection of the worm bushing with the use of analyzed parameters of the casting process. Then, the whole system was prepared, equipped with the above mentioned components. The purpose was to mold the geometry of the power steering gear body. For the previously molded bushings, worm wheel and worm assemblies were made, equipped with compensators and bearings. Then these were placed in the appropriate cups,

which resulted in initial, correct positioning of worm gear axis. Then the axes were fixed on the test stand, which allows the axis to be restrained in the system depicting the axis positions in the traditional, base aluminum body. Then the bushing was connected together with the cup, which were permanently connected to each other using a polymer adhesive. The next stage is building the mold on the system and conducting the casting. The use of such a system results in proper mutual positioning of the axes. The casting process was carried out.

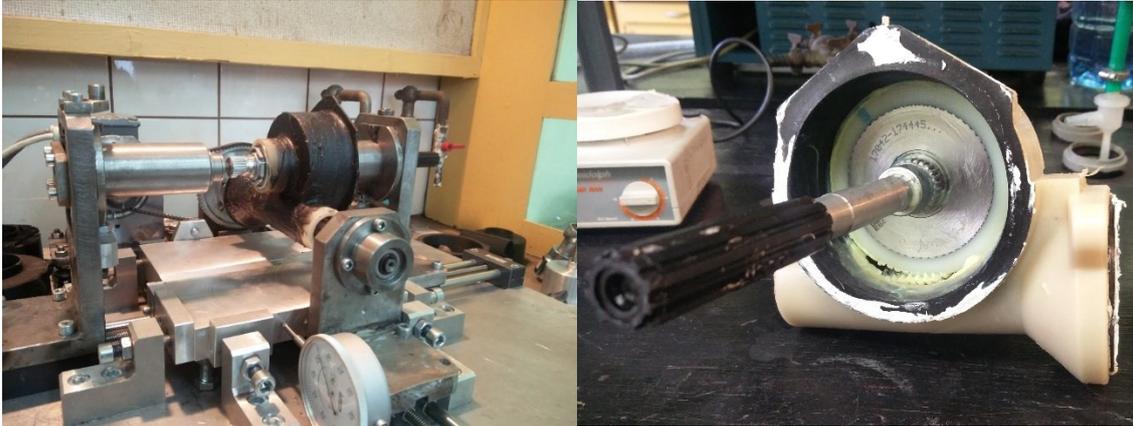


Figure 7. a) Test stand, including worm and worm wheel bushes; b) body of car's power steering casted using the PDCPD

5. Conclusions

The tests have proven the need to heat the mold. Lack of proper core or external elements temperature results in the formation of damaged structures, produced without the required accuracy and with a large number of gas bubbles. This gas can be formed in a rapid polymerization process, but if the mold is heated it is faster and better exported to the outside. The application of heated elements, besides aesthetic values, also affects the achievement of appropriate geometric shapes of the injected elements. Obtaining the appropriate geometric form of the cast body and its components affects the achievement of the proper quality of the final component, because in this innovative process it is not expected to carry out the machining process. The further analysis must be performed to archive correct process of molding car's power steering body using PDCPD material.

6. Acknowledgments

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7. References

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