MACHINE FOR ROTARY MOLDING OF PLASTIC TYPE „MUSSEL“

Ivan SHOPOV[*], Mariana BOTEVA[**]

[*]Technical University of Sofia, Plovdiv Branch, Bulgaria

[**]University of Food Technologies, Plovdiv, Bulgaria

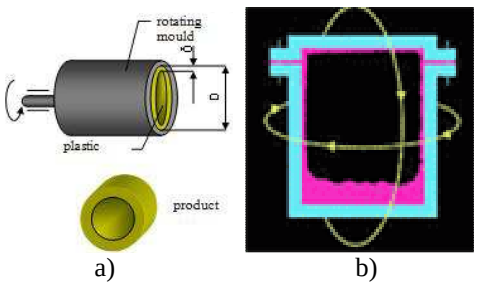
Abstract. Rotary molding has an important place among the main methods of processing of polymeric materials. In recent decades, the rapid development of this method has led to the achievement of high productivity, lower cost products, as well as improvement of the composition of the used polymeric materials. One of the most promising types of machine constructions for rotary molding machines are of type "mussel". The article deals with the technical requirements for the construction of a machine for rotary molding of plastic type "mussel". Characteristics of the design task are done and specified time to solve it by the method of "variation" is shown. 3D model of a machine for rotary molding of plastic was created and its design features were explained.

Keywords: molding, rotary, machine, plastic

1. Introduction

Rotary molding has an important place among the main methods of processing of polymeric materials. In recent decades, the rapid development of this method has led to the achievement of high productivity, lower cost products, as well as improvement of the composition of the used polymeric materials. Hollow products with various shapes and sizes of thermoplastic materials in the form of powders or granules are produced using this method.

The technology of producing of plastic products by the method of rotary molding is based on the distribution of the molten material on the inner surface of a rotary form under the action of centrifugal forces. Depending on the location of the axis of rotation in space, rotating molding is done with the horizontal (Figure 1a), a vertical, oblique or two mutually perpendicular axes of rotation (Figure 1b). In the process of rotation of the molding form with a certain speed of the material besides centrifugal force, gravity and friction force act.



a) b)

Figure 1. Rotary molding with one horizontal axis (a) and two mutually perpendicular axes (b) [1]

Rotary molding process is relatively simple, allowing influencing the entire production cycle and the production of a high quality product with low cost and good properties. The process itself can be divided into four stages, Figure 2.

Figure 2. Stages of rotary molding process [3]

During the first stage dispensing the polymer in the molding form is carried out. The most commonly used is powder polymeric material. Its particle size should be in the range of 50 to 200 μm. Usually the material is overdosed from 10 to 15% due to the need for subsequent machining. In the second stage, the molding form is closed and placed in the heating chamber, and during heating the form is rotated with two axes, and the molten polymer adheres to the walls of the molding form. The heating of the form may be conducted in isolated cells, either directly through the use of gas burners. Working temperature usually does not exceed 300 °C. In the already melted material occur convection currents circulating in the radial direction. This facilitates the directed crystallization of the castings and it is the better, the bigger is the frequency of rotation of the form. After the material is discharged evenly in the third stage the form is placed in a cooling station. At this point there is focused airflow and / or steam, which cool the form to the

hardening temperature of the material. This is done without stopping the rotation movements so as to avoid deformation of the product. After the cooling phase in the fourth stage the form is positioned in a station where the device is removed [2].

The advantages of rotary molding are mostly in broad technological capabilities, which allow quickly and not costly to master the production of various products with complex shapes and large sizes. Molding technology features high flexibility and manageability. Equipment and technological equipment are cheap, simple and convenient for production and operation [2]. The quality of the wall of the products is very good because of making its shape under the constant impact of the centrifugal forces that promote the crystallization of the material.

The main disadvantages are associated with relatively low productivity, the specific preparation of the starting material, occupation of a large production area of the settings of a "carousel" and "Shuttle" type and the high cost of energy, due to tempering of large volumes.

The question therefore arises for the development of the method of rotary molding of plastics, while keeping its strengths and overcoming the weaknesses. There are two main areas for improvement method:

- Through developing the process;
- Through creating new progressive designs of machines for rotary molding.

One of the most promising types of machine constructions for rotary molding machines is of type "mussel". Their feature is that the heating station closes the machine as a shell, hence the name of this type of machine. Their energy consumption is comparatively smaller and the structure is compact and occupies a small production area. In the specialized literature usually only the most general information about the capabilities of these machines are given, without revealing details of their design features. This article discusses the structure of such a machine, constructed in the Department of Mechanical and Instrument Engineering, Technical University of Sofia, Plovdiv Branch.

2. Formulation of the design task

The machine for rotary molding of plastic parts is semiautomatic. The whole cycle is automated except for the placement of plastic granules in the form as well as basing, tightening, release and downloading the form from the rotor.

It is intended for casting of two pieces in the shape of frustum of cone with a volume of five liters. Such products may be used as containers for storing food products, paints and other chemical substances. The wall thickness should be between 4 and 8 mm.

The form will be of aluminum alloy with easy opening and removal of produced parts and fast loading of the new portion of granules. In order to attain the required productiveness the form is two-nested and convenient for quickly basing and tightening of external surfaces.

The planned output is expected to be around 52,000 parts per year. The machine must rotate around the two mutually perpendicular axes, as rotation speeds are such as to provide uniform thickness and high quality of the wall. The reliability of the machine should be high as it will work in two shifts in continuous operation. In order constructive simplification and synchronization the rotation on both axes will be done by a single engine. To ensure minimum energy consumption the machine will be designed in the pattern of a "mussel".

The development of the final constructive version of the machine for rotary molding is a typical task of designing with known prototype.

A special feature of this case is that prototypes are known only as a principle scheme and there are no details of prior constructions. Companies also do not comment the methods for selecting and optimizing the parameters of individual assemblies of the entity for development.

The method of variation is used, as different assembly options are reviewed and the selection of different possible structures is made. Moreover, the requirements for functionality, reliability, the lowest cost and opportunity for construction are kept.

3. Construction of the machine for rotary molding of plastic type "mussel"

The problem is solved with the construction shown in Figures 3 and 4.

Figure 3 shows the view of the machine for rotary molding of plastics. It consists of a heating and cooling station 4, a housing 3, a chain drive 2, motor-reducer 1.

Figure 4 shows a view from above of the machine with the lid of heating - cooling chamber open. They are seen as 9 for two workpiece form, basing - clamping mechanism 8, hollow shafts 7, called "hands", arm 6, and external hollow shaft 5.

Figure 5 shows a section of the hull at the source of cooling chamber hollow shaft. They can be seen both the bearing and the two shafts mounted

in each other and conducting rotation in two mutually perpendicular axes as well as the chain drive, from which the movement to the shafts comes.

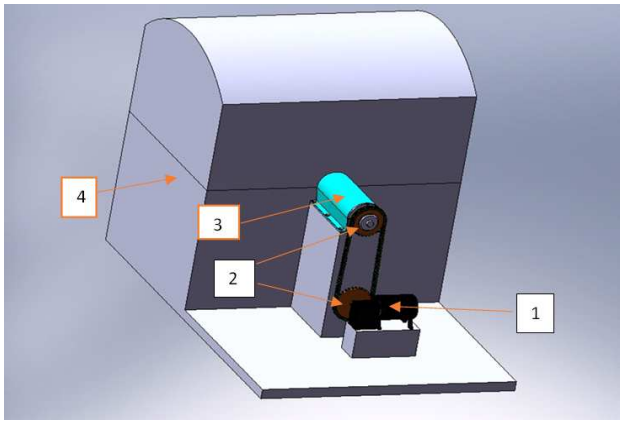


Figure 3. View of a machine for rotary molding of plastics

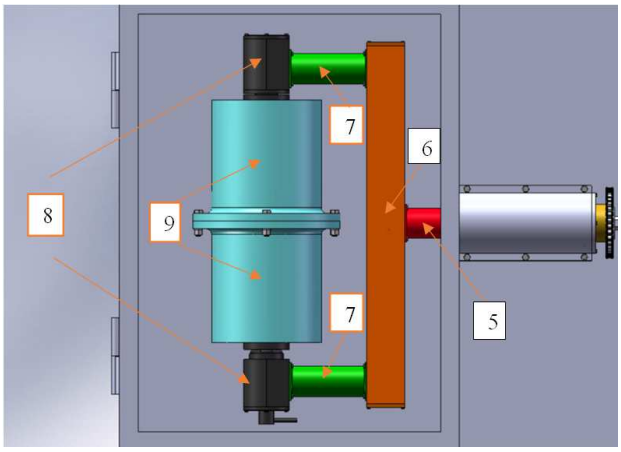


Figure 4. View from the top of the machine for rotary molding of plastics with the lid open

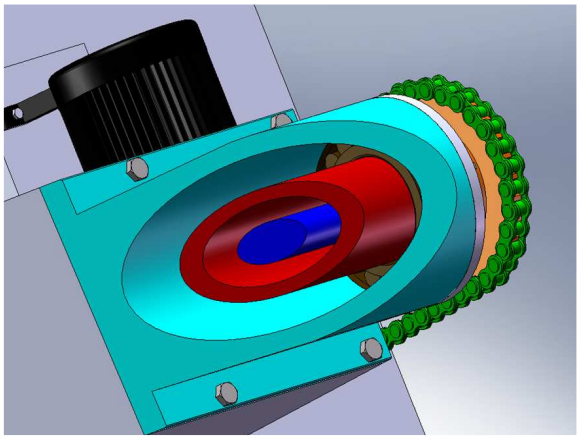
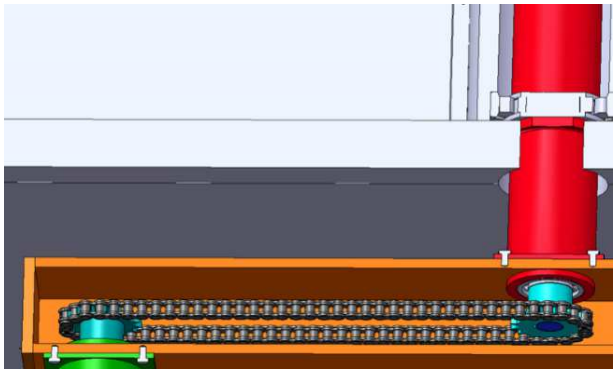


Figure 5. Cross section of the hull at the outer hollow shaft

Figure 6 shows a sectional view of a rotating arm of the machine for rotary molding of plastics. Gear unit is placed in it providing the movement around the second axis. To the right the output sprocket and its engagement with the chain is shown.



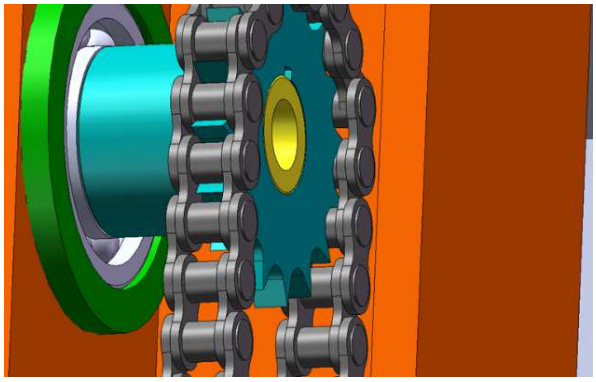


Figure 6. Section of the arm of the machine for the rotary molding of plastics

Figure 7 shows the transmission of traffic to the basing - clamping unit and molding form. It is performed by a pair of bevel gears, mounted in the housing of the basing - clamping unit.

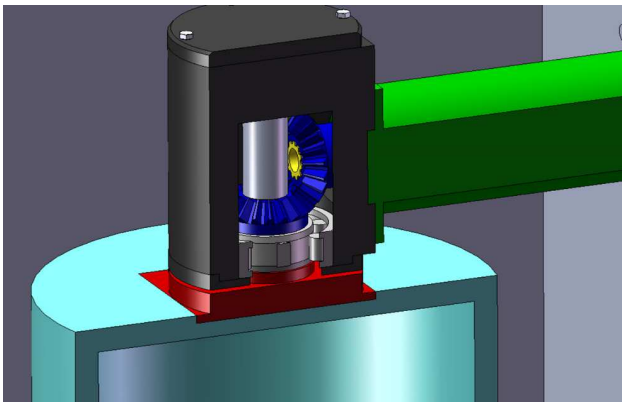


Figure 7. Transmission of movement to the basing - clamping unit and molding form

Figure 8 shows the assembly that performs tightening of the form to the basing plates. It is done by screw - clamping device which is driven by a handle.

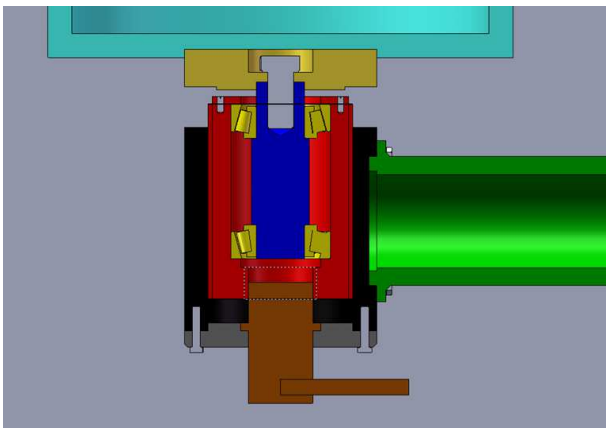


Figure 8. Section of the clamping device

The operation of the machine is as follows: The drive is done by the engine-gearbox and chain gear. From there, the movement is transmitted to the external and internal shafts, as the outer shaft is hollow and the internal one is mounted inside. The outer shaft transmits motion to the arm, which through the arms and the clamping and basing plates carries out horizontal axis rotation. The inner shaft transmits the motion to the chain drive, hidden inside the arm. From there, through the shaft mounted in one of the arms and a pair of bevel gears, rotation of the form along a second axis perpendicular to the first is done.

The discussed construction of the machine for rotary molding of plastics can process simultaneously two parts with volume of five liters and a wall thickness of up to 8 mm. The productivity of the machine is 52,624 parts per year.

4. Conclusions

1. The essence of the process of rotary molding of plastics is described, its advantages and disadvantages, as well as the ways of overcoming the latter.

2. The technical requirements for the construction of a machine for rotary molding of plastics type "mussel" are examined. Characteristics of the design task are done and a way to solve it by the method of "variation" is shown.

3. A 3D model of a machine for rotary molding of plastics is created and its design features are explained.

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