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THE INFLUENCE OF STRUCTURAL CHANGES OF SINGLE-SCREW-EXTRUDER FOR POLYPROPYLENE COMPOSITES PROCESSING

The influence of construction features of single-screw extruder, namely lengths of screw and amount of ditches of unchanging secant are in the area of feed of extruder, and the number and nature of the filler on the performance extruder in the processing of composites based on polypropylene filled with fiberglass, talc, chalk is investigated. It is established that the use of extruders which supply with seating grooves can influence the extrusion process in general, and change the characteristics of the extruder, depending on the nature of the filler and its amount in composites based on PP.

Key words: extruder, polypropylene, filler, fiberglass, talc, chalk.

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ВПЛИВ КОНСТРУКТИВНИХ ЗМІН ОДНОШНЕКОВОГО ЕКСТРУДЕРА НА ПЕРЕРОБКУ ПОЛІПРОПІЛЕНОВИХ КОМПОЗИТІВ

Досліджено вплив конструкційних особливостей одношнекового екструдера, а саме довжини шнека і кількості канавок незмінного перерізу в зоні живлення екструдера, та кількості і природи наповнювача на продуктивність екструдера під час переробки композитів на основі поліпропілену, наповненого скловолокном, тальком, крейдою. Встановлено, що використання екструдерів, які обладнані зоною живлення з канавками, впливає на процес екструзії загалом, а також змінювати характеристики екструдера залежно від природи наповнювача та його кількості в композитах на основі поліпропілену.

Ключові слова: екструдер, поліпропілен, наповнювач, скловолокно, тальк, крейда.

Formulation of the problem. One of the major zones, which determine the behavior of the extruder, is the feed zone. The efficiency of all other zones extruder, its flow capacity and quality of the products are depending on the correct processing in the feed zone. The main factors, which affect the loading zone, are its design, along with the properties of the processed material. The construction of feed zone determines the conditions of interaction of particles with the cylinder wall and the screw, and thus determines the nature of the movement of particles in it, its flow capacity and energy costs.

Analysis of recent research and publications. As you know [1], the character of material moving in the filling zone determined by the filling degree of screw core, conditions of interaction material with the wall of the cylinder, particle sizes and depth of the channel. Since the particle size and channel depth cutting are not changed during the processing of a material, influence the nature of the movement of material and the work of feed zone can only be provided by changing the interaction of material with the wall of the cylinder.

The material in the screw core moves by moving the screw surface relative to the surface of the cylinder. Efficiency of the material moving determined by forces on the bound material-surface of screw and material cylinder-surface. The material in the screw core may be handled only when the friction of material on the

surface of the cylinder is greater than the friction of material on the surface of the screw. Thus, the friction of material on the surface of the cylinder is the driving force, which provides the movement of material. Change interaction material from the wall of the cylinder material may be due to the increase of surface roughness of the cylinder by drawing on its surface grooves of the profile and the required size. Extruders with vent grooved in feed zone power are well known [2–5]. They are characterized by the following advantages in comparison with the smooth cylinder extruder in the feed zone [6]:

– creater flow capacity of the process;

– better stability of the extrusion process;

– low dependence of productivity from pressure changes.

However extruders with vent grooved in the feed zone has some disadvantages. High friction of the material on the surface of the cylinder leads to a rapid increase in pressure and an increased cylinder wear, which requires the use of higher quality metals. In addition there is a significant loss of energy (up to 30–40 %) due to the necessity of intensive cooling in zone comprising grooves. The loosing of energy can be reduced by increasing the temperature of cooling water – energy efficiency can be increased to 45–80 % by increasing the temperature of cooling water from 5 to 70 ºC. Another drawback of such zone construction is necessity for engines with higher torque than extruders with smooth-walled cylinder. These features lead to the fact that energy consumption for extruders with grooved zone power by 10–25 % higher, than for extruders with smooth cylinder. It's typical disadvantages for cylinder with grooves, which are parallel to the cylinder axis. Using spiral grooves may fix the number of deficiencies, including lower energy consumption for cooling.

We describe the design zone supply although giving a number of advantages for extrusion of polymers remain static and can not be changed during operation of the equipment in order to influence the movement of material, and thus the process of extrusion in general.

A more effective method of influence on the character of the movement of the material is the use of grooves, which allow you to change the depth directly during operation of the equipment. Such construction of feed zone are well known and widely used [2, 6]. The main advantages of this construction are the ability to adjust the power of the area in accordance with the characteristics of the material and mode of operation of the screw; possibility of choosing of the optimum depth of the groove during operation of the equipment, which increases the possibility of managing the process of extrusion in general, automatic process. Adjustable grooves in the feed zone control and optimize the process of extrusion. They promote increasing the range of produced materials by adjusting the characteristics of extruder for material properties.

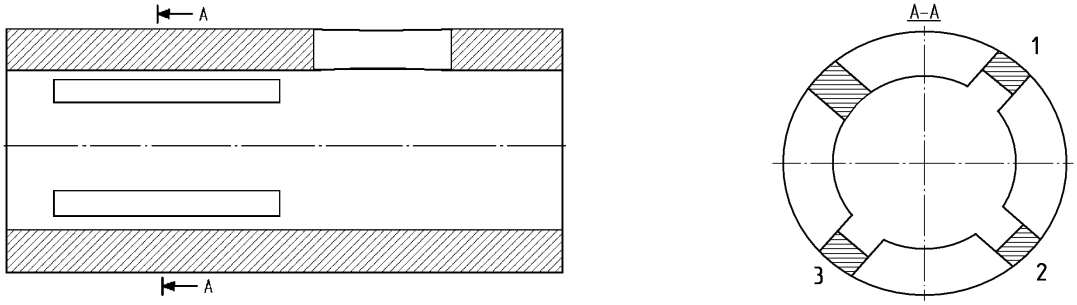
Purpose of work. The purpose of this paper research was to determine the influence of structural features of single-screw extruder, namely the length of the screw and the number of grooves unchanged sectional area of supply, the number and nature of the filler on the performance of the extruder during processing of composites based on polypropylene.

Results and discussion. For this studies was used experimental facilities, which allows changing the number of grooves in feed zone and length screw [7]. Grooves in the feed zone had fixed dimensions (depth 2.3 mm, length 94 mm, width 8 mm) and were located after feed opening (Fig.), the number of grooves can be varied from 0 to 3.

Experimental installation equipped with screws 25 mm in diameter with the ratio l/D 20 and 30 and head to the size of die gap 20×1 mm. Temperature in cylinder zones was I = 160 ºC, II = 180 ºC, III = = 190 ºC, head – 200 ºC speed of screw rotating 25 rot/min. The flow capacity of experimental setup was evaluated by weight of extrudate sampled at regular intervals. Filler content changed within 10-50 wt %. The fiberglass, talc and chalk were used as fillers.

Studies on the effect of grooves, screw length and content of chalk on extruder performance (Table 1) showed that in the case of the screw with the ratio l/D = 20 performance increases with increased content of chalk, and to screw the ratio l/D = 30 passes through a maximum when the content of chalk 20–40 % depending on the number of grooves. This influence of chalk on performance extruder (l/D = 20) can be attributed to the effective viscosity of melts in increased content of chalk, which leads to a decrease

of countercurrent melt and increase of the flow capacity. In the case of the screw with the ratio l/D = 30, maximum productivity caused by the deteriorating conditions of moving material (energy loss along the length of the screw) after reaching a certain critical effective viscosity of the melt.



Location of vent grooves in cylinder of extruder

Table 1

The influence of vent grooves, screw length and content of chalk on the flow capacity of extruder, kg/h

		Numbers of vent grooves			
		0	1	2	3
Chalk content, %	0	2,4 / 2,3	2,6 / 2,5	2,6 / 2,5	2,7 / 2,6
	10	2,9 / 2,5	3,2 / 2,9	3,0 / 2,9	2,8 / 3,0
	20	3,0 / 2,9	3,3 / 3,4	3,2 / 3,1	3,1 / 3,2
	30	3,3 / 3,0	3,5 / 3,3	3,5 / 3,4	3,2 / 3,0
	40	3,5 / 3,0	3,7 / 3,2	3,7 / 3,2	3,6 / 2,9
	50	4,0 / 3,0	4,0 / 3,2	3,8 / 3,1	3,6 / 2,9

The influence of grooves number in the feed zone on the flow capacity of the extruder, in the case of screw ratio l/D = 20, varies depending on the amount of chalk in the composition. For pure polypropylene feed capacity increases with the increasing of vent grooves number. At the same time for the composition with 50 % chalk determined the decreasing of productivity. For compositions with 10-40 % of chalk a maximum of productivity was evaluated in the presence of 1–2 grooves. Using screw with ratio l/D = 30, was saved the dependence of productivity on the number of grooves. For compositions with 10 % chalk, like also for pure polypropylene, have increased productivity growth in the number of grooves and for compositions with 50 % chalk observe maximum that was absent at shorter screw. This dependence of productivity on the number of slots can be explained by better conditions in the area of material moving power of grooves, but this is observed only for pure polypropylene (l/D = 20) and 10 % of the composition of chalk (l/D = 30).

When tested polypropylene compositions in which an ingredient used talc obtained results generally similar to compositions with chalk (Table 2).

For screw ratio l/D = 20 growth talc content, as in the case of chalk, increases the effective viscosity of melts and productivity. For screw ratio l/D = 30 productivity growth observed only 30 % talc content, further increasing the filler content causes a drop in productivity. Effect of grooves in the power zone on the extruder performance is the same for the two screws and manifests itself in increased productivity growth in the number of grooves. Only compositions with 40 % talc used in screw with the ratio l/D = 30 can be observed lack of dependence of productivity on the number of grooves.

Glass fiber as filler for polypropylene, unlike chalk and talcum powder has less impact on the productivity of the extruder (Table 3), and for the auger to the ratio l/D = 30, a decrease of productivity with the increase of fiberglass.

Table 2

The influence of vent grooves, screw length and content of talk on the flow capacity of extruder, kg/h

		Number of vent grooves			
		0	1	2	3
Talk content, %	0	2,4 / 2,3	2,6 / 2,5	2,6 / 2,5	2,7 / 2,6
	10	2,9 / 2,6	3,1 / 2,8	3,0 / 2,7	3,0 / 2,8
	20	3,1 / 3,0	3,3 / 2,9	3,2 / 2,8	3,3 / 3,2
	30	3,3 / 3,4	3,5 / 3,5	3,5 / 3,8	3,4 / 3,3
	40	3,4 / 2,9	3,8 / 3,3	4,0 / 2,6	3,9 / 3,0

Table 3

The influence of vent grooves, screw length and content of glass fiber on the flow capacity of extruder, kg/h

		Number of vent grooves			
		0	1	2	3
Glass fiber content, %	0	2,4 / 2,3	2,6 / 2,5	2,6 / 2,5	2,7 / 2,6
	10	2,4 / 2,4	2,5 / 2,3	2,5 / 2,1	2,6 / 2,6
	20	2,7 / 1,9	2,4 / 1,7	2,5 / 1,7	2,5 / 1,8
	30	2,9 /	2,4 /	2,6 /	2,4 /
	40	3,2 /	2,8 /	2,9 /	2,6 /
	50	2,6 /	2,9 /	3 /	3,1 /

This feature can be explained by the orientation of fibers during melt flow, unlike the powdery fillers with advanced surface which is chalk and talc does not cause a significant increase in viscosity. A slight increase in productivity with increasing fiber content, apparently caused by a possible interaction between a fiber that causes the growth of effective viscosity. Yet it should be noted that when using the auger to the ratio l/D = 30 composition of 30 % glass fibers could be processed into the air that was used for research, it obviously can be explained by a significant increase in energy consumption due to friction with the increased length of the screw.

Conclusion. Using of extruders, which has the feed zone with vent grooves influence the extrusion process in general and the change characteristics extruder depending on the material processed for thermoplastic compositions, which are filled with small-dyspersed powdered filler, and fiberfill for changes in construction zone power extra grooves makes a noticeable effect.

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