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IMPACT ASSESSMENT OF THE UNIFORMITY MIXING RECYCLED AND VIRGIN POLYMERS ON THE TECHNICAL EXTRUSION BLOW MOLDING EFFICIENCY

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Abstract

Extrusion blow molding of technical products (EBM-TP) is a significant technological polymer manufacturing process ex. for the automotive branch. Implementation of the extrusion blow molding process in an operating arrangement of polymer technology is a component of many technological factors, but also of factors related to feedstock material. The products can be manufacturing with the participation of plastics recyclate. The homogeneity of the recyclate-virgin polymer mixture strongly influences the distribution of spreading the wall thickness of the final products. For this type product wall thickness distribution should be uniform and very close to each other or determined in a specific range of values. Work presents the mixture influence (HDPE recyclate-virgin polymer,) with different characteristics of mixing degree defined as homogeneous and heterogeneous, on the part features (the intake manifold airflow in a motor vehicle) with respect to the weight of the weight and wall thickness in reference required by the customer of the product. Mixtures of HDPE were prepared via a specialized gravimetric mixer, which is directly connected to the feed circuit extruder blow molding. They began to manufacture defined types of test specimen (actual Products of) and their evaluation according to criteria adopted burden of weight and wall thickness.

Key words: *technical extrusion blow molding, plastics mixing recyclate and virgin plastics, mixing uniformity, part weight, wall thickness*

1. Introduction

Extrusion blow molding of technical products (EBM-TP) is a significant technological polymer manufacturing process ex. for the automotive branch [4]. Next to him importance is injection blow molding (IBM) and injection stretch blow molding (ISBM). IBM and ISBM not apply in the case for the automotive industry but rather for packing. Extrusion blow molding is the highest share among the three of these technologies. It is estimated that the total processing industry blow molding of polymers is increasing every year in the number of 3 to 5% and this trend is maintained [3]. Increasingly, as in the case of polymer processing in different technology talking about efficiency including energy efficiency [7] due to rising energy costs as well as being clearly competitive in the market.

2. Description of extrusion blow molding process for parison over 2 kg and its effectiveness

In extrusion blow molding technical products the preparation of virgin melt or recyclate-virgin plastics mixtures take place in extruder. A plasticized plastic is addressed to the angular head with a accumulator system. Extrudate parison is placed in blowing mold, welded in a pinch off area and shut off. Welding and prepare to cut the parison is due to specially shaped elements on the surface of pinch-off section. Extruder head occurs with a molten polymer accumulator for weight extrudate parison over 2 kg.

In this case, the parison cycle extrusion is performed discontinuously, and when the mold is ready to receive the parison. Blow mold is placed just below the extrusion head. Quick discontinuous extrusion reduces the tendency of the parison to stretch under its own weight. Welding and preparation for cutting off of the parison as a result of specially-shaped mold elements on the parting line (pinch – off) or partially welding strip. Blowing, usually compressed air, followed until contact of the parison with the cavity molds and mapping the structure of its surface [5].

Finally blown product, after cooling in the mold cavity, leaves the mold, followed by removal of technological waste on the finishing station (or partially by hand in case of EBM-TP complex structure), where the product goes to the quality control station. After fulfilling the requirements, products go into the warehouse and target customer [3, 4]. In the case of technical products with complex geometries often result significant technological waste values, which for the rational management of polymeric materials must be submitted as soon as possible recycled directly in the line.

Technological wastes usually after separation of part of the target audience have still a certain amount of heat energy, which still remains in prepared recycled materials (recyclate temperature is approx. 40°C), which is consumed to reduce energy consumption in the plasticizing process. In the case of preparing the mixture of recycled materials (80%) of virgin material (20%), it is important to obtain the most homogeneous mixing ratio [2]. Insufficient mixing results in a heterogeneous mixture, which may cause fluctuation of extrusion blow molding process

The effectiveness of extrusion blow-molding can be determined by different types of agents, eg. screw construction, modifying polymer material, technical condition of the machine (extruder), mold design, technical condition et cetera. By analyzing the efficiency of the extrusion process takes into account specified criteria and assessment methods the effectiveness and impact of design features individual machines and tools involved in the manufacturing process. Among the criteria for assessing the effectiveness of the extrusion process stands criteria: qualitative, quantitative and operational [5].

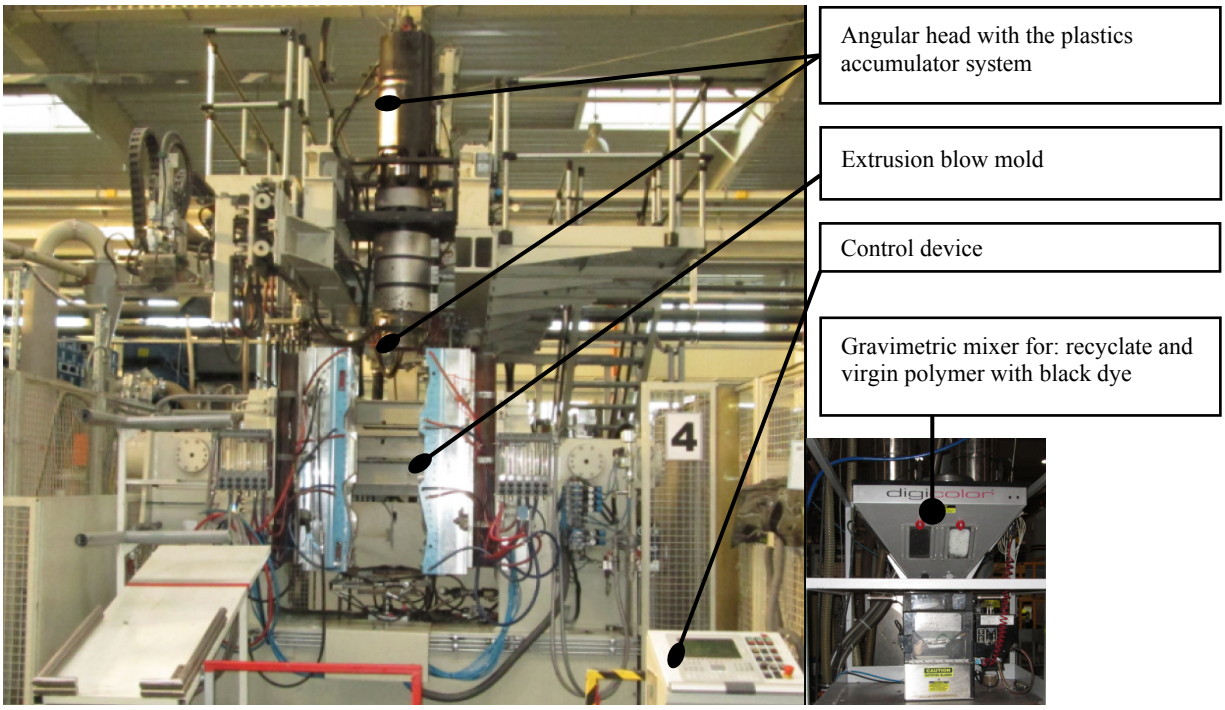
3. Explanation of experiment

To accomplish the research task impact assess the uniformity of mixing degree (mixing correct, incorrect) to the quality blowing parts in relation to its weight and thickness values in designated two critical areas required by the customer of the product, used blow molding machine type Batttenfeld VK3-200 with accumulator head, extrusion blow mold and partially automated waste disposal stations. Also during process realization using: mechanical recycling station with gravimetric mixing and dosing system. Concerned produced part (similar to that presented in [6]) is the intake manifold airflow Fig. 2 and 3. Investigations were realized in an industrial company Graform Bydgoszcz [2].

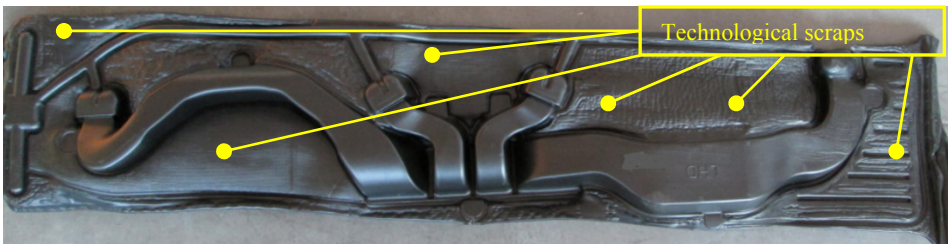
Material used for manufacturing a technical product was recycled polymers (79%) and virgin polymers (20%), high density polyethylene (Marlex HHM 5502 BN) and black colorant (1%). Recommended processing temperature for this type of material is 171÷204°C. The investigation was realized for both homogeneous mixture (Series J) and non-uniform (Series N) in accordance

with the technological parameters set on the production line. In the case of a mixture J material supplied to the extruder was mixed properly, and in the case of mixture N material was inconsistently, where the mixing proportions have been disrupted. The basic parameters of output in two series of series J and N were the same: temperature extruded plastic – 210°C, mold temperature – 18°C, parison extrudate length – 42 units, extrusion speed – 60%, the blowing pressure – 8 bar.

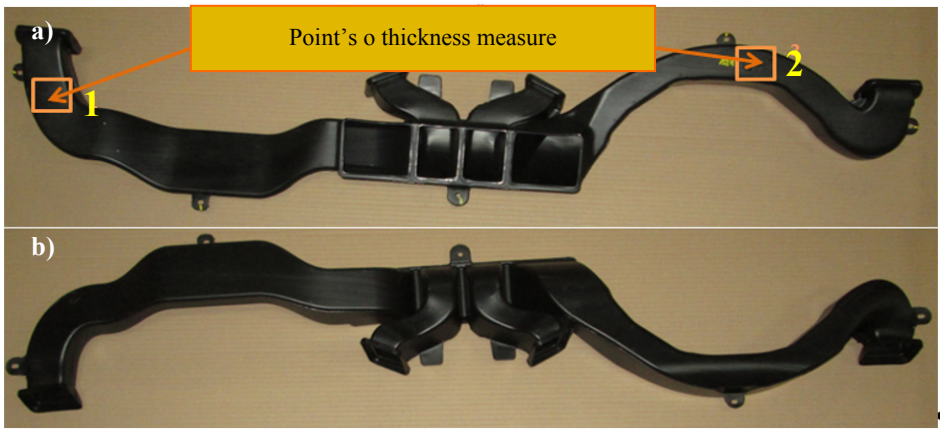
As a result of extrusion blow molding process obtained blowing products witch technological overmeasure - technological plastics scraps (Fig. 2). After using finishing station, technological scrap plastics were directed to the recycling station. In the first and the second production run (each 50 units) were randomized 18 products. Next, using a wall thickness device – Magna Mike 8500 GE Panametric, at designated critical locations wall thickness and the weight of a product were measured.



„Fig. 1. Extrusion blow moldin station witch different seeing components [2]"



„Fig. 2. Blowin prodact with technological scrap plastics"



"Fig. 3. Finish blowing products: a)critical measure points – side view, b) product top view"

4. Results

The weight and thickness measurement result of blowing product, are presented in Table 1 and Fig. 4 and 5. Visualized that the quality of the mixture (polymer material, recyclate, dye) has a significant impact on maintaining the quality regime (dimensional and weight). In the case of the J Series the parts are within tolerances established by the customer (weight 580 $^{+}/_{-}$ 20 [g] – 100% creations), wall thickness (in Section 1) 1.3 $^{+}/_{-}$ 0.5 [mm] – 100% products, wall thickness (in Section 2) 1.3 $^{+}/_{-}$ 0.5 [mm] – 100% products). In the J Series, measurements of weight and thickness show 30% incompatibility. Spread weight of the homogeneous mixture J does not exceed the value of 13.47 [g], and in the case of dispersion heterogeneous mixture N reaches to 46.61 [g] (Fig.4). In the case of the wall thickness for the heterogeneous mixture of dispersion shifted significantly beyond the upper limit imposed by the tolerance (Fig. 5).

Tab. 1. The range of part weight and wall thickness in technical blowing products (bold value – out of tolerance)

J Series				N Series		
No.	Part weight [g]	Wall thickness [mm] - 1	Wall thickness [mm] - 2	Part weight [g]	Wall thickness [mm] - 1	Wall thickness [mm] - 2
1.	586,40	1,46	1,48	586,00	1,43	1,55
2.	589,62	1,48	1,52	**622,21**	**1,71**	**1,84**
3.	599,87	1,51	1,55	590,30	1,49	1,52
4.	587,10	1,48	1,57	589,50	1,48	1,50
5.	599,00	1,55	1,69	591,00	1,60	1,63
6.	587,57	1,40	1,49	575,60	1,42	1,37
7.	596,37	1,28	1,17	**606,35**	**1,64**	**1,84**
8.	599,51	1,32	1,38	**607,78**	**1,51**	**1,55**
9.	597,23	1,28	1,41	599,21	1,50	1,55
10.	597,50	1,36	1,39	597,32	1,23	1,41
11.	598,10	1,42	1,47	**610,32**	**1,72**	**1,84**
12.	599,53	1,47	1,52	**608,88**	**1,65**	**1,73**
13.	598,87	1,51	1,55	**614,00**	**2,12**	**1,85**
14.	589,70	1,62	1,70	575,66	1,48	1,40
15.	595,60	1,35	1,22	581,20	1,56	1,48
16.	592,36	1,48	1,63	577,95	1,32	1,25
17.	588,60	1,39	1,42	592,30	1,23	1,14
18.	588,30	1,40	1,39	588,60	1,48	1,52

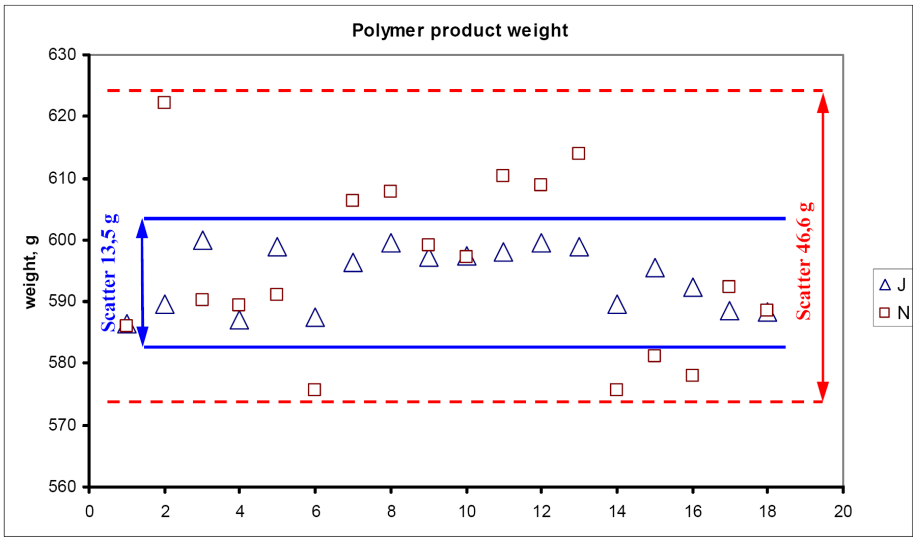


Fig. 4. Changing the weight of blowing produc, depending on the initial charge a mixture of polymer: J - homogeneous, N – heterogeneous

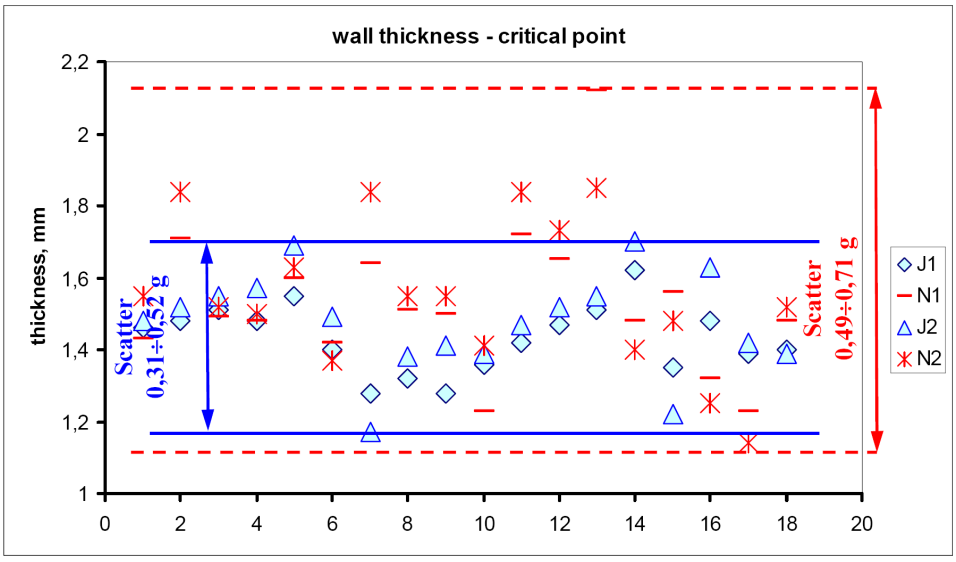


Fig. 5. The wall thickness values at the critical points in blowing product, measurement for the two types of mixtures: J1, J2 - homogeneous mixture, N1, N2 – heterogeneous mixture

Taking into account the two criteria behavior adopted by weight and the wall thickness, it is judged that, only the case in which the mixture is homogeneous can be considered as appropriate.

5. Final consideration and summary

Extrusion blow molding process allows manufacturing the hollow technical products of varying complexity of geometric as a result of extrusion parison and their blow in mold cavity. The efficiency of the extrusion blow molding is not only dependent on the machine (the extruder, head extruder, drive) and processing parameters but also on the devices working together with extruder (in this case, the gravimetric mixer).

In order to fulfill specific assumptions related to performance criterion: product weight and wall thickness distribution, it is important to properly prepare the feed material (polymer recyclate, virgin polymer, dye), which in this case means keeping a certain mixing procedures.

By incorrectly programmed working procedure gravimetric blender, followed a significant deterioration in the efficiency of the blow molding process (amount of compatible quality parts in this case is reduced by about 30%). This is also a decisive effect on the economic aspect and manufacturing products of significant reduction implemented eco energy efficiency of the process.

To improve the efficiency of the mixer, enter the daily visual inspection and cleaning mechanisms responsible for dosing and mixing of primary and recycled materials, which are pollinated by crude recyclate (too much dust after grinding technological waste). Another option is to install a dust collection system recyclate. This option is a procedure not economically justified.

To prevent overall disruption in the manufacturing process (the plasticizing process, recycle technological scraps, mixing materials, material transport etc.) must be entered proven production management system for example TPM [9]. The system will feature detects "weak points" production cells. It is also possible to replace or modernization of machinery, equipment and tools that directly affect to increase of the process efficiency, include energy efficiency.

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