THE INFLUENCE OF COOLING BLOW MOULDING PROCESS ON MECHANICAL BEHAVIOR

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Abstract: Plastic materials are in general bad heat conductor therefore is apply for their production the temperature/ cooling systems. The system is able expressively reduce time of working cycle which increase profit of company. It is important to know that this effect brings influence behavior of plastic. The article descriptions in next pages are examined influence of cooling effect on mechanical behavior of plastic products which was production in blow moulding technology. Mechanical behavior is evaluated with help of tensile strength and deformation characteristics.

Keywords: Blow Moulding Process, Cooling System, Mechanical Behavior

1 Introduction

The aim of all producer company is produce products with maximum profitability. The ways how to get this stage is a lot. One very often application possibility is reduction time of production. Plastic material have in general bad heat conductor and so take the longest time of production cycle time of cooling. Therefore is very important looking for the optimally way of cooling. There are a lot of studies which are aim on these issues.

This article deals with cooling of blow moulding process. The cooling process is possible separate into two different temperature cooling systems. The first one is temperature cooling system of mould and second part is cooling inside blowing product (from blowing medium-usually Air). When we comparing efficiency of both systems we can unambiguously say that the cooling efficiency of mould is expressively bigger. It is because the common blowing medium - Air has low heat transfer coefficient in standard condition /2/. The right proposal of temperature cooling system of mould is therefore necessary condition for minim production time. It is important to know that the reduce time of production have influence on change of structure behavior of polymer materials. Change structure behavior impresses of change next behavior for example mechanical, physical, optical behavior etc. This article examine just by the influence cooling effect on mechanical behavior. Mechanical behavior is evaluated in relation to their tensile strength and deformation characteristic.

2 Blowing Process

This capitol presented the reader parts which entered to blowing process. It is used blowing machine, material of product, product, set up parameters. Next it is here showed and clears up using cooling system of blowing mould.

2.1 Blowing Machine

In this experiment it was used blowing machine GM 251 from company GDK s.r.o Karlovy Vary. The cooling effect blowing process on mechanical behaviour was examined on product void content 200 ml. It is bottle which has easy and periodical shape (figure 1). Bottle was blowing from material PE – HD Liten BB 29.

2.2 Set up Parameters

For finding influence of cooling effect on research behaviour it was made three solved set up parameter of blowing process which are demonstrated on table number 1. How it was said from look the producer company is the main attributed in this process time of cooling. From look of technology is the main parameter speed of screw. Because the rate speed of screw influence the whole time dependent of process (faster speed of screw brings shorter time of process, more slowly speed brings longer time of process-cooling). This parameter is limited with shape stability of product by which is drawing (it is dependents on cooling efficiency) and with working possibility of machine. The too much fast running speed of screw leads to heating of transmission box and excessively abrasion parts of machine. The maximum recommended running speed of screw is for this machine 120 round/min but our product had not by this parameter enough shape stability. The maximum speed whereat it was made good products was by parameter 100 round/min and the ideal cooling effect it was by value 40 round/min. For discover influence of cooling system on mechanical behaviour it was made the third measured without connected cooling system.

Tab.1 Process parameters of blowing machine

Parameters	1.Maximum	2.Optimal	3.Without cooling
Speed of screw	100 [round/min]	40 [round/min]	40 [round/min]
Time of cycle	17 [s]	39 [s]	39 [s]
Time of cooling	14 [s]	36 [s]	36 [s]
Time of blowing	14 [s]	36 [s]	36 [s]
Machine time	3 [s]	3 [s]	3 [s]
Temperature of parison	195 [°C]	195 [°C]	195 [°C]
Blowing pressure	0,3 [MPa]	0,3 [MPa]	0,3 [MPa]

2.3 Blowing Mould

The temperature cooling system of mould for blow moulding process working on the same principle as temperature system for the injection moulding process. It is system of drilled channel connect together when circulated liquid medium (most often water) keeps temperature field on set up degree (figure 1). The channel system lead away transmits heat from melt of plastic and so shortening time of cooling. The temperature cooling system is complicated process where enter to mutual interaction a lot of factors: place and shape of channel, type and rate circulated medium, material of mould and fixative desk, etc. In produce factory is the temperature of cooling medium for blowing process usually using in range 5-20 °C. Of course that the lower value brings more efficiency of cooling system but we have to be careful with using this parameter because low value can made condensations water on parts of mould and next surface defects of products. For this experiment it was used temperature of cooling medium 15 °C.

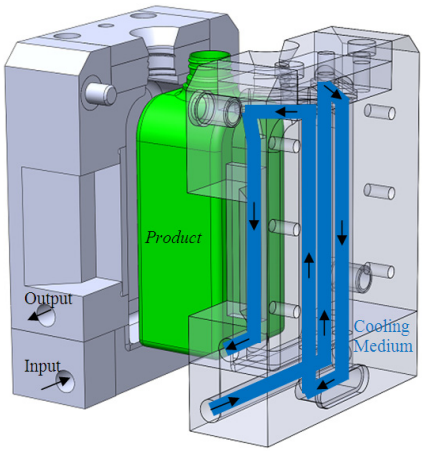

Fig. 1 Blowing mould with cooling system of drilled channel

3 Experiment

In this chapter are presented the results of measured experiments. The mechanical behavior is here confronted in relation to their tensile strength and deformation behavior. Tensile strength is analyzed with help of yield strength which is

for this type material the same as ultimate strength. The deformation behavior is able evaluated with help of modulus of elasticity in tension and relative deformation. From detection evenness of cooling efficiency it was took the tests specimens in different place which are showed on the picture 2. The test specimens have a normalized shape (ČSN EN ISO 527-2) type 1BA. The specimens were loaded uni-axial tensile stress at a constant speed 10 mm/min on blasting machine Housnfield H 10 KT.

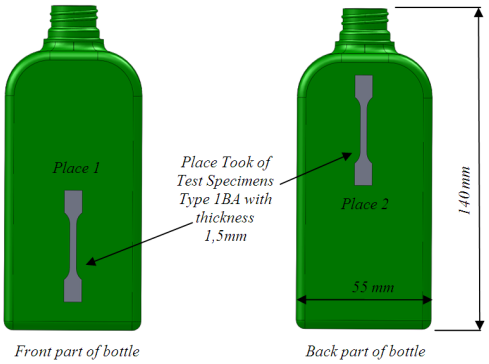

Fig. 2 The place took of test specimens

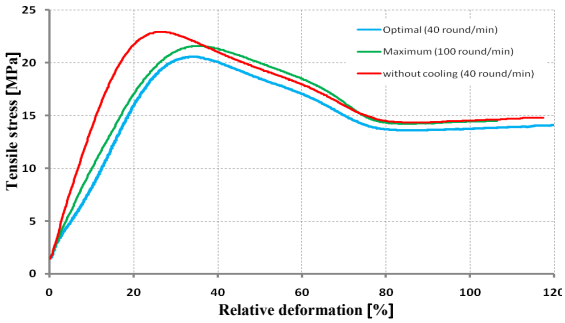

Fig. 3 The tensile diagram of test specimens took of place 1

Tab.2 The test specimens took of place 1

Examining Process	σ_v [MPa]	ε_y [%]	σ_B [MPa]	ε_B [%]	E [MPa]
Without cooling (40 round/min)	23,89 ± 1,02	25,77 ± 1,52	15,03 ± 2,21	410 ± 55	420 ± 32
Optimal (40 round/min)	22,05 ± 1,59	34,96 ± 1,33	14,98 ± 1,04	469 ± 31	345 ± 43
Maximum (100round/min)	21,12 ± 2,01	32,85 ± 0,98	13,75 ± 1,43	502 ± 29	363 ± 60

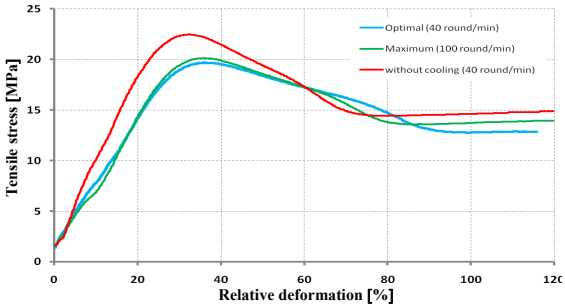

Fig. 4 The tensile diagram of test specimens took of place 2

Tab.3 The test specimens took of place 2

Examining Process	σ_y [MPa]	ε_y [%]	σ_B [MPa]	ε_B [%]	E [MPa]
Without cooling (40 round/min)	22,54 ± 1,26	32,04 ± 1,17	15,10 ± 1,34	427 ± 52	400 ± 43
Optimal (40 round/min)	20,09 ± 2,10	35,97 ± 1,21	13,75 ± 2,03	376 ± 71	380 ± 35
Maximum (100 round/min)	19,87 ± 1,18	36,08 ± 1,42	14,81 ± 2,60	483 ± 38	371 ± 31

4 Conclusion

How it was said the aim of all producers is to reduce production time of products. The plastic material have in general bad heat conductor and therefore is to production apply cooling system which can expressively reduce time of working. We have to let know that the reduction time have influence in dependence on change structure behavior on other behavior of plastic. It is for example mechanical, physical, optical behavior etc. This article examines cooling effect of blowing process on mechanical behavior of small blowing product. For detection of cooling effect it was applied three different set up parameters of blowing process. The first one it was by running speed of the screw 100 round/min. which ensured the minimum necessary cooling time. The second set up it was by running speed of screw 40 round/min which ensured the best cooling effect (even distribution of temperature) because the cooling system of mould working longer time. The last set up it was created running speed of screw 40 round/min by not connection cooling system.

The mechanical behavior are predetermined their structural behavior. The theoretically and experiment research say that semicrystal polymers reach bigger rate of crystallinity by highest temperature of cooling then by lower temperature. It is because grow of crystallic structure (spherolits) is not suppress fast cooling and spherolits have longer time to grow /1/. For our experiment it means that with lower efficiency of cooling should increase area of spherolits and so rate of crysltallinity. The experiment set up parameters of blowing moulding machine without connect cooling medium reach the lowest cooling efficiency than should get the highest rate of crystallinity. On the other side the set up parameters with optimal cooling should get the lowest rate of crystallinity. For easy opinion on change structure it was made the analysis of density - immersion method (ČSN EN ISO 1183 -1). We can say that with increasing destiny of polymers increase rate of crystallinity because crystallic phase have more density than amorphous phase. From the results which are interprets in table 4 it is possible confirm this theory but with reminder that the difference are very low.

The influence of semicrystal structure on mechanical behavior is that the material which have higher area of spherolits and rate of crystallinity reach higher tensile strength behavior but degrease of deformation behavior because the big spherolits evoked brittleness of materials. With regard to above mentioned results it possible says that examined test specimens from production process without connection cooling system should reach the most value of tensile strength (ultimate strength) with highest tensile modulus and the lower deformation behavior (relative deformation). The opposite dependence should get by test specimens with optimal cooling time. The results of measured experiment confirm this opinion but with relation to this value it necessary says that the difference with regard to their deviation is very low. For production company it mean that the cooling effect had not significant influence on mechanical behavior but it is question how cooling effect of blowing process had influence on another behavior of polymers.

Tab.4 The immersion exam of density

Parameters	Without cooling	Optimal	Maximum
Took of Place 1	943 [kg/m^3]	937 [kg/m^3]	940 [kg/m^3]
Took of Place 2	939 [kg/m^3]	936 [kg/m^3]	935 [kg/m^3]

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