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SHRINKAGE OF COMPOSITE PLATE WITH GLASS FIBRES IN RELATION TO DEGREE OF REGRANULATION

Recycling of the composite materials with relatively breakable fibres, as the glass fibres shorter than part length, leads to change of length already in and after the processes of injection moulding. This effect is amplified by following regranulation procedures containing milling, melting, filtration of no inadmissible polymers etc. With significant shortening of glass fibres there is a change of shrinkage and other properties.

Keywords: glass fibre, shrinkage, regranulation

Introduction

Shrinkage – a geometric shape change – is known effect of polymeric materials. It is reflected by a change of dimensions of polymeric sections in positive as well as in negative sense. This means that we are capable to observe a dimension growth in relation to form cavity, or more probably its decline. This is a significant physical quantity, which may be affected by setting of injection parameters [1÷3]. In technical practice there are actually changes of physical characteristics of the material entering the process also during relatively short time intervals and all parameter changes in the relation to a relative result empiricity require time and material losses. From the economic point of view it is not possible to perform these operations regularly. In case of large plastic sections in fact it is even not possible to compensate the big part if the shrinkage because of big internal tensions, which rigorously appear in the influx scheme orifice area, but in this case it of course depends on the conception and proportioning of the form influx system.

A value of the shrinkage depends on used polymer. Crystalline polymers or more precisely polymers with partial level of crystallinity have generally larger shrinkage than polymers with amorphous structure. Also it is important to make a difference between lengthwise and crosswise direction, because the value of shrinkage changes in dependency on a melting flow direction. It is known that for unfilled plastics the shrinkage in the melting flow direction is bigger than in the perpendicular direction. This is caused by oriented macro-molecules, which have a trend to get energetically preferable states. In case of filled plastics (concretely filled by fibrillar fillings) shrinkage behavior is different – the shrinkage in the melting flow direction is smaller than shrinkage in the direction perpendicular to the melting flow. It is likely that from global point of view the shrinkage for polymers filled by fibrillar fillings is lower than for their unfilled equivalents.

The shape of a distributive curve of used fibres length has a significant influence on shrinkage changes during the progress cycle of the series plastical manufacture. When the fibres are relatively frangible (glass-fibres, where length is higher in radices than radius), then the fibres are getting shorter during granulate plastification and following injection into form cavity. Invalid sections are currently largely regenerated. The regranulation includes section milling with gain of plastic granulated gravel, which may be consequently processed if its dimensions are valid or it is possible to prepare on pushing machine a granulate, which can eventually decrease dustiness appearing from relatively frangible polymers and improve granulate rheology during taking on by a torsel.

Experimental procedure

There for the given experiment a composite material SMA Dylark was used, it has a matrix made of amorphous thermoplastics and it is underlayed by glass-fibres. The used thermoplastics is a styrene maleic anhydride modified by butadiene rubber, which in fact does not mix with this co-polymer, there actually its crystallization into poly-butadien comes and free distribution in whole material content raises. The filling (as already mentioned above) is glass-fibres with length 2 millimeters and a radius approximately 20 micrometers.

The regenerated composite was prepared from injecting sections by milling and granulation, where the regranulate gradation was reached by repetitious passing through filtering sieves taking off contaminants degraduating composite mechanical characteristics, these contaminants were in this case mainly polyurethan and polyvinylchloride. The setting of mould shrinkage and post-moulding shrinkage was done according to international norm ČSN EN ISO 294-4 with agreed variation in dimensions of testing solids 50 x 50 x 2 millimeters of a desk shape filled by film-layer influx. The injection conditions were equal for all injected solids; there wasn't chosen high injecting pressure and post-pressure on purpose to make solids fill the form cavity exactly, because that was not the purpose of the experiment. The linear solid dimensions (lengthwise and crosswise) were measured by a drift-meter Mitutoyo ID-F150 with reachable measuring precision of 0.001 millimeter put into specially created widget. The prepared scheme by this way was calibrated by a precise end dip-stick for a size of 50 millimeters. All testing specimen were stored and the experiment was in the standard conditions 23/50 by ČSN ISO 291.

The mould shrinkage measuring was done approximately twelve hours after manufacturing. It was followed by post-moulding shrinkage measuring, which is according to appropriate norm measurable after additional adjustment or eventually after longer agreed time (24 hours after manufacturing), which was applied in this case. Total shrinkage was set according to the exact formula (5) and (6), because it is not a simple sum of mould shrinkage and post-moulding shrinkage, because these are not percents of the same base. The mould shrinkage, post-moulding shrinkage and total shrinkage were set according to following formulas (1)÷(6):

$$s_{Mp} = \frac{l_C - l_1}{l_C} \tag{1}$$

$$s_{Mn} = \frac{b_C - b_1}{b_C} \tag{2}$$

where: s_{Mp}, s_{Mn} – shrinkage in flow direction and perpendicular to flow direction respectively,
l_C, b_C – length and width in the middle of the shape form cavity,
l_1, b_1 – length and width of the testing solid,

$$s_{Pp} = \frac{l_1 - l_2}{l_1} \tag{3}$$

$$s_{Pn} = \frac{b_1 - b_2}{b_1} \tag{4}$$

where: s_{Pp}, s_{Pn} – post-moulding shrinkage in flow direction and perpendicular to flow direction respectively,
l_2, b_2 – length an width in the middle of the shape form cavity after additional adjustment,

$$s_{Tp} = \frac{l_C - l_2}{l_C} \tag{5}$$

$$s_{Tn} = \frac{b_C - b_1}{b_C} \tag{6}$$

where: s_{Tp}, s_{Tn} – total shrinkage in flow direction and perpendicular to flow direction respectively.

Results and discussion

From the presented results (Tab. 1÷3) the generally known patterns about size of particular shrinkages comparing are confirmed. Total shrinkage in the direction of flow is approximately 47% of shrinkage in the perpendicular to direction of flow. Total shrinkage in the direction of flow gets maximal values during sixth regranulation level. It is approximately 48% growth in relation to the original composite. Relatively low mould shrinkage in the direction of flow of the particular regranulation levels, which have an average difference approximately 18%, is actually compensated by a relatively big post-shrinkage. In case of fourth regranulation its value is nearly 25% of total shrinkage. Such a big shrinkage actually causes big shape instability, because it happens completely out of the shape cavity of the injecting form. For proving illustration of the fibres

Table 1. Mould injection shrinkage

Tabela 1. Skurcz podczas wtrysku

Material of specimen	s_{Mp} [%]	s_{Mn} [%]
Original composite SMA	0,26±0,01	0,58±0,03
1. Regranulation	0,29±0,01	0,70±0,01
2. Regranulation	0,28±0,02	0,68±0,01
3. Regranulation	0,28±0,02	0,67±0,02
4. Regranulation	0,29±0,01	0,68±0,01
5. Regranulation	0,34±0,01	0,68±0,02
6. Regranulation	0,31±0,01	0,65±0,02
7. Regranulation	0,36±0,01	0,71±0,02

Table 2. Post-moulding shrinkage

Tabela 2. Skurcz po procesie wtrysku

Material of specimen	s_{Pp} [%]	s_{Pn} [%]
Original composite SMA	0,01±0,01	0,03±0,01
1. Regranulation	0,03±0,01	0,07±0,02
2. Regranulation	0,06±0,02	0,07±0,02
3. Regranulation	0,06±0,02	0,07±0,02
4. Regranulation	0,09±0,02	0,09±0,02
5. Regranulation	0,06±0,02	0,08±0,02
6. Regranulation	0,05±0,01	0,06±0,02
7. Regranulation	0,03±0,02	0,06±0,03

Table 3. Total shrinkage
Tabela 3. Skurcz sumaryczny

Material of specimen	s_{Tp} [%]	s_{Tn} [%]
Original composite SMA	0,27±0,01	0,61±0,03
1. Regranulation	0,32±0,01	0,76±0,01
2. Regranulation	0,34±0,01	0,74±0,01
3. Regranulation	0,35±0,01	0,74±0,02
4. Regranulation	0,38±0,01	0,77±0,01
5. Regranulation	0,40±0,01	0,76±0,02
6. Regranulation	0,36±0,01	0,71±0,02
7. Regranulation	0,39±0,02	0,76±0,03

shrinkage the testing solids were made of the original composite and seventh regranulation was burned (Fig. 1).

a) b)

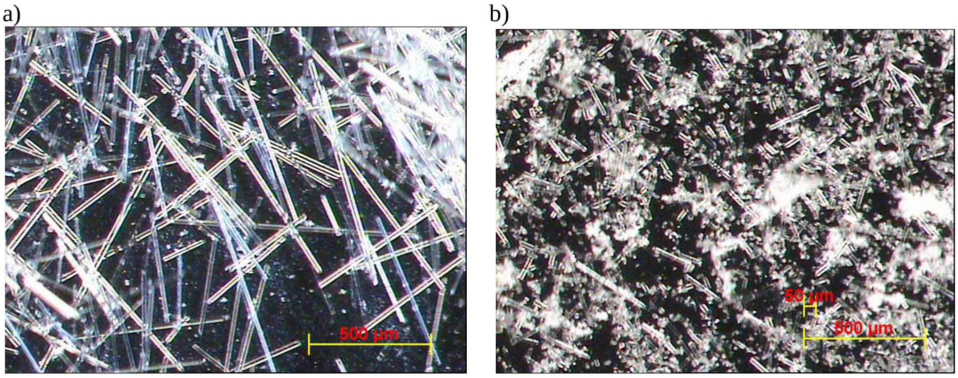

Fig. 1. Glass-fibres of the original composite (a) and assay of the seventh level of regranulation (b)
Rys. 1. Włókna szklane w kompozycie wyjściowym (a) oraz po siedmiokrotnej regranulacji (b)

Conclusions

The growing values of the shrinkage in the lengthwise direction are caused mainly by shrinking of the glass-fibres. There is no doubt about proving of geometric changes of products made of regenerated composite materials filled by glass-fibres. These procedures may decrease also other characteristics of the injecting sections, concretely mainly mechanical characteristics. It is necessary to respect long time well known material characteristics for stoutness calculations of parts made of such materials.

References

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SKURCZ PŁYT KOMPOZYTU POLIMEROWEGO Z WŁÓKNEM SZKLANYM W ZALEŻNOŚCI OD STOPNIA REGENERACJI

Recykling materiału kompozytowego z relatywnie kruchymi włóknami, np. takimi jak włókna szklane krótsze niż długość części, skutkuje powstawaniem skurczu podczas oraz po procesie wtrysku. Efekt ten ulega wzmocnieniu w wyniku procedury regranulacji obejmującej mielenie, topienie, separację niepożądanych polimerów itd. Wyraźna zmiana długości włókien szklanych powoduje zmianę wielkości skurczu oraz innych właściwości.

Słowa kluczowe: włókna szklane, skurcz, regeneracja

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