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Influence of adding painted recyclated on polypropylene properties

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Abstrakt These days just because of still increasing price of oil and its products there is tendency about using recycled plastics at full blast. That´s mainly in automotive industry where is produced great amount of plastic scrap added by painted layers. This article deals with examination influence of such painted layer on mechanical and rheological polymer properties which are necessary to know because of further possible using such painted recycled.

Key words: recycled, paint layer, mechanical properties

1. INTRODUCTION [1], [2], [3]

These days, in spite of still increasing price of oil and its products, there is rapid global growth about polymeric materials. Global plastics consumption by using volume units has already get over steel production. Plastics fruitfulness is proved also during last years when there is because of economical growth recession decrease in plastics consumption about 10% however other competitive materials revealed much faster decline. Plastics consumption higher increase is influenced mainly due to material replacement instead traditional materials as e.g. metals, glass, wood and so on. This plastics consumption growth is also influenced by continually increasing portion of recycling and trend about lowering material consumption in many application areas (thinner foils with the same properties or lighter wraps and so on). According Plastics Europe values there was maximal global plastics consumption in 2008 when was produced totally 260 mil. tons of polymers. Current inter-year global plastics consumption decline was noted for the first time during last 34 years. In 2009 was plastics consumption equaled to value from 2007 thus global consumptions was 245 mil. of tons. There are markedly differences between individual regions about consumption growth rate and it´s possible to view region advance according plastic consumption per capita. While in the most advance regions is plastics consumption per capita over 100 kg/year, in development regions nowadays there are these values from 25 up to 35 kg per capita. Czech Republic can be ranked among advanced western European countries from this point of view. E.g. there is annual only polypropylene production per capita in the Czech Republic over 30 kg per capita.

At every plastic part production there is indispensable plastic scrap. These scraps are further possible to divide on technological and utility scrap. Technological scrap origins during production process and covers inflow systems, defective products, cut-offs and so on. Thus this scrap type means that every producer has to take into account that these scrap is returned back into production process as input raw material e.g. only due to high energetic costingness when to produce 1 ton of plastic there is necessary to use about 2,5 tons of oil. Moreover there is so-called utility scrap which represents parts after expiration of their durability life. While first scrap group provides quite quality material comparable with initial still unprocessed material, this second scrap group is often polluted and polymer is more or less depreciated by ageing. Pulverized or re-granulated plastics scrap and parts are possible to process during production chain separately or to use them as addition into parent material. First way is less suitable because by regeneration aren´t ensured original material properties. The better way is to use regenerate as addition whereas is necessary to blend only such ratio where volume percentage of subsequently regenerated material is decreased rapidly. Majority of well-known plastics producers, processors, scientific and research centers advice to blend maximal 20% of recycled into parent material. By such approach is ensured that material will not pass through regeneration more than 10-times which is suitable for major portion of plastics. Reprocessing of scrap (milled or re-granulated) and part final quality depends strongly on polymer type, its additives and original material processing conditions. Generally is valid that polymer degradation depends on volume and type of stabilizers, humidity, injection temperature and material delay time in melting chamber. Processing scrap quality evaluation is possible to carry out only by means of experiments.

During last decades there is still immoderate pressure about increasing plastic parts quality namely in automotive industry. This is mainly true about outer components as e.g. fenders, spoilers, dash-boards, central consoles and so on. This pressure results in creation of high amount of scrap at production and not only as increase number of raw parts waste but also for final parts. In the case of fender is final part moreover already added by painted layer which is possible to remove only by using truly very expensive process using chemical and mechanical-chemical processes. Thus there is tendency to find out using for material which would contains also certain amount of painted recycled thus painted gravel added into original parent material. That is why is truly necessary to carry out a lot of experiments about influence of paint particles on mechanical and rheological properties of polymer.

2. EXPERIMENTAL PART

To carry out research of Sabic 108 natur + 20MBTF material propertiers in dependence on the recycled amount was prepared the blend containing required amount with 10% of talc thus 80% Sabic

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108 + 20% 20MBTF. By such way prepared parent material was subsequently added recycled in the form of painted parts gravel (the same material of blend) in ratio 20% up to 100% of recycled in parent material.

Testing specimens corresponding to standards ČSN EN ISO 527 or more precisely ČSN EN ISO 3167, ČSN EN ISO 178 and ČSN EN ISO 179-1 were prepared by injection into multiple mould containing two shaped cavities which are filled in parallel with melt flow direction and with inflow throat placed in the end of every testing sample according par. 4.1.1.4 of standard ČSN EN ISO 294-1 and those under technological conditions according ČSN EN ISO 1873-2.

Material preparation for measurement melt volume rate (MVR) evaluation was with regard to amount necessary for determination MVR (c. 8g) carried out in plastic chamber of injection machine (to ensure material homogeneity).

1.1 Routine and conditions of testing for determination tensile properties

Testing specimens were loaded in the main axis direction by constant loading rate up to their fracture. During measurement was monitored evolution of loading and elongation.

Used method: ISO 527/1B/50 (ČSN EN ISO 527-1,2:1998), Used device: TiraTest 2300, Strain-gauge head: 10 kN, Number of tested specimens: 10, Conditions of testing: 23/50 dle ČSN EN ISO 291:2009, Loading rate: 50 mm/min, Pre-loading: 3 N, Method for elongation determination: according initial distance between jaws, Initial length between jaws: 104,5mm

Individual results of tests are digestedly given in tab. 1.

Tab. 1

RECYCLED	σ_y [MPa]	ε_{tB} [%]
0%	17,5±0,5	41,7±16,5
20%	17,4 ±0,4	23,7 ± 6,5
40%	17,1±0,1	22,1± 5,1
60%	17,0±0,1	15,0 ± 3,8
100%	16,9 ±0,2	13,6 ±2,0

1.2 Routine and conditions of testing for determination bending properties

Testing specimens were placed as a beam between two supporters and loaded in bending by constant loading rate due to the punch acting already in the middle of these supporters up to pre-determined strain values (with regard to testing material morphology).

Standard: ČSN EN ISO 178: 2003, Used device: Hounsfield H10KT, Strain-gauge head: 500 N – in the area 2% up to 100% accuracy 0,5% of loading force, Number of tested specimens: 5, Conditions of testing: 23/50 dle ČSN EN ISO 291:2009, Loading rate: 2 mm/min, Pre-loading: 1 N, Supports range: 64 mm, Restrictive movement: 12 mm

Individual results of tests are digestedly given in tab. 2, modulus of elasticity was determinate from linear regression of stress-strain curve in bending – in the area between two points which correspond to strain ε_{f1} = 0,0005 a ε_{f2} = 0,0025.

Individual results of tests are digestedly given in tab. 2.

Tab. 2

RECYCLED	σ_{fM} [MPa]	E_f [MPa]
0%	22,3 ± 0,4	1172 ± 35
20%	21,7 ± 0,2	1108 ± 24
40%	21,6 ± 0,5	1094 ± 37
60%	21,9 ± 0,3	1137 ± 35
100%	22,2 ± 0,1	1131 ± 8

1.3 Routine and conditions of measurement for determination Charpy impact strength

Testing specimens were placed horizontally on supporters and were loaded (offset) by impact pendulum whereas impact velocity was located in the middle distance of supporters at narrower side of testing specimen.
Testing specimens were bended by nominally high constant velocity. During measurement was monitored corrected energy necessary for testing specimen fracture. From such value was finally calculated Charpy impact strength.

Used method: ISO 179-1/1eU (ČSN EN ISO 179-1:2001), Used device: Resil Ceast 5.5, Impact velocity: 2,9 m/s ± 10%, Nominal pendulum energy: 5J, Number of tested specimens: 10, Conditions of testing: 23/50 according ČSN EN ISO 291:2009, Impact direction: at narrower side – marked as „e“, Supports range: 62 mm

Individual results of tests are digestedly given in tab. 3.

Tab. 3

RECYCLED	E_c [J]	a_{cU} [kJ/m^2]
0%	without fracture „N”	
20%	without fracture „N”	
40%	without fracture „N”	
60%	partial fracture „P”	
100%	acU = 75,4 ± 9,5 kJ/m^2 , P	

1.4 Routine and conditions of measurement for determination Charpy impact strength

Testing specimens were mechanically added by „A” type notch and placed horizontally on supporters were loaded (offset) by impact pendulum whereas impact direction was located in the middle distance of supporters and at narrower and opposite side from notch location.

Testing specimens were bended by nominally high constant velocity. During measurement was monitored corrected energy necessary for testing specimen fracture. From such value was finally calculated Charpy impact strength.

Used method: ISO 179-1/1eA (ČSN EN ISO 179-1:2001), Used device: Resil Ceast 5.5, Impact velocity: 2,9 m/s ± 10%, Nominal pendulum energy: 5J, Number of tested specimens: 10, Conditions of testing: 23/50 according ČSN EN ISO 291:2009, Impact direction: at narrower side – marked as „e“, Notch type: A (notch root diameter 0,25 ± 0,05 mm), Supports range: 62 mmIndividual results of tests are digestedly given in tab. 4.

Tab. 4

RECYCLED	E_c [J]	a_{cA} [kJ/m^2]
0%	acA = 53,9 ± 3 kJ/m^2 , P	
20%	acA = 47,0 ± 4,4 kJ/m^2 , P	
40%	acA = 45,8 ± 1,9 kJ/m^2 , P	
60%	acA = 41,5 ± 4 kJ/m^2 , P*	
100%	acA = 33,4 ± 2,4 kJ/m^2 , H	

1.5 Routine and conditions of measurement for determination melt volume rate MVR

Melt volume rate was determinate according method B of standard ČSN EN ISO 1133 by measurement of time during which the piston acting on plastic melt proceeded up to given distance 25 mm (or more precisely 2.5m). Basic principle rests in amount of melt determination which flows through extrusion plastometer nozzle at 10 min under specified testing conditions.

Standard: ČSN EN ISO 1133:2006, Used device: Melt flow tester Ceast, Temperature: 230 ºC, Loading: 2,16 kg, Nozzle diameter: 2,094 mm, Nozzle length: 8 mm, Fixed distance: 25 mm, Pre-heating: 240 s

Individual results of tests are digestedly given in tab. 5.

Tab. 5

RECYCLED	MVR [cm^3/10min]
0%	14,7 ± 0,3
20%	14,3 ± 0,3
40%	15,0 ± 0,2
60%	14,8 ± 0,9
100%	15,1 ± 0,3

3. CONCLUSION

From the tensile properties evaluation is evident that by adding recycled into parent material there is not undesirable influence of stress at tensile yield strength or more precisely at ultimate strength. On the other hand there is clear influence arising from recycled onto nominal strain at fracture (ductility) where with increasing amount of recycled there is decrease in ductility approx. about 43% (20% of recycled), 47% (40% of recycled), 64% (60% of recycled) and 67% with 100% of recycled in given blend.

There wasn´t observed any change in strength and modulus of elasticity in bending for parts loaded under bending with addition of recycled into parent material.

With increasing amount of recycled was observed decrease of impact strength and toughness value of part from material Sabic 108 natur + 20 MBTF. Injected parts produced from parent material containing 20% and 40% of recycled reveal marked toughness and these wasn´t fracture for every tested specimens in contrast to parts with 60% and 100% of recycled where was observed partial offset (arising from their impact toughness decrease). Impact toughness of parts with addition of recycled into parent material is decreasing according following values – about 13% (20% of recycled), 15% (for the 40% of recycled amount in parent material), 23% (60% of recycled) and 38% in the case of 100% of recycled.

Rheological properties of melts (their flow) which influence their workability were evaluated by means of melt flow rate value and it´s possible to state that by adding recycled into parent material there aren´t any undesirable changes in properties or more precisely in MVR.

Literature

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