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VERIFICATION OF POLYPROPYLENE RHEOLOGICAL PROPERTIES USED FOR PLASTIC PARTS PRODUCTION IN AUTOMOBILE INDUSTRY

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ABSTRACT:
Paper deals with verification of polypropylene rheological properties. It was measured and compared rheological properties of polypropylene plastic material produced by producer which are used for plastic parts production in automobile industry. These rheological properties are very important for plastic parts production by injection molding. Samples were removed in two different times from materials used for production and after that values of melt flow volume rate were verified.

KEYWORDS:
Polypropylene, rheological, plastic, injection molding

1. INTRODUCTION

Rheology describes the deformation of a body under the influence of stresses. "Bodies" in this context can be solids, liquids, or gases. Ideal solids deform elastically. The energy required for the deformation is fully recovered when the stresses are removed. Ideal fluids such as liquids and gases deform irreversibly -- they flow. The energy required for the deformation is dissipated within the fluid in the form of heat and cannot be recovered simply by removing the stresses. The real bodies we encounter are neither ideal solids non ideal fluid. Real solids can also deform irreversibly under the influence of forces of sufficient magnitude -- they creep, they flow. [1]

Only a few liquids of technical or practical importance come close to ideal liquids in their behavior. The vast majority of liquids show a rheological behavior that classifies them to a region somewhere between the liquids and the solids: they are in varying extents both elastic and viscous and may therefore be named "visco-elastic". Solids can be subjected to both tensile and shear stresses while such as water can only be sheared.

Ideal solids subjected to shear stresses react with strain:

$$\tau = G.\frac{dL}{dy} = G.tan\gamma \approx G.\gamma \quad (1)$$

τ = shear stress = force / area (N/m^2 = Pa)
G = Young`s modulus that relates to the stiffness of the solid (N/m^2)
γ = dL/y = strain (dimensionless)
y = height of the solid body (m)
ΔL = deformation of the body as a result of shear stress (m)

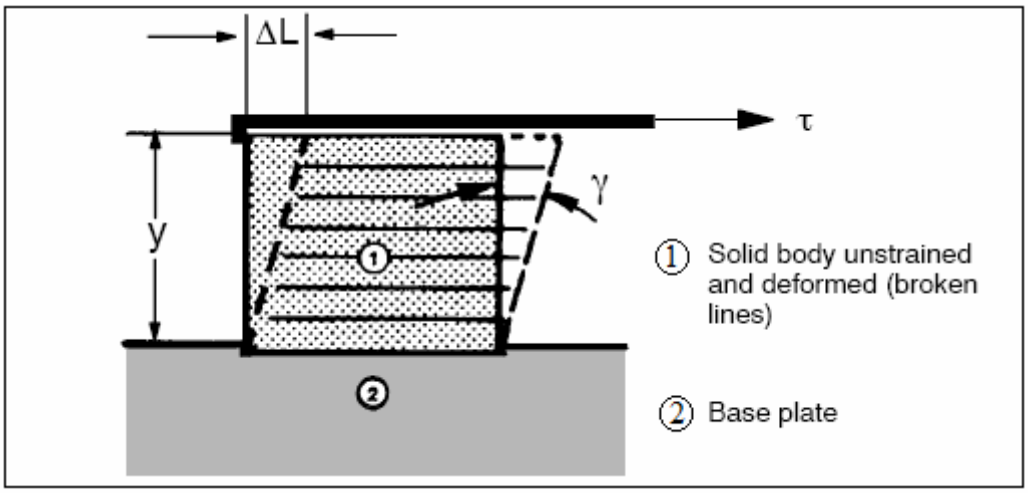
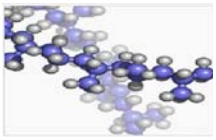


FIGURE 1. DEFORMATION OF A SOLID BODY [2]

2. POLYPROPYLENE

$$(\text{-CH-CH}_2\text{-})_n$$
$$\text{I}$$
$$\text{CH}_3$$



Polypropylene (PP) is a thermoplastic polymer from polyolefin's group used in much kind of industries incl. automotive industry, food industry, textile industry and laboratory equipments. Its commercial names are Tipplen, Tatren, Hostalén, Mostalén. Polypropylene is excelling at very good chemical and mechanical resistance. It has assigned international identification number for plastics materials 5. In 2001 world year production of polypropylene achieved value 30 million tones.
[3 z diplomovky]

Polypropylene has good resistance towards alcohols, organic solvent and oils. It is using for temperature up to 100 °C, at temperature 160 °C begins melting of crystals. Polypropylene is characterized medium gram-molecular weight, density is moving from 0,895 to 0,92 g/cm^3. Also have good heat properties, brittle point is situated at intervals 0 till +5 °C. By the normal temperature is polypropylene insoluble. Its disadvantage is lower resistance with respect to atmospheric pressure. Therefore is necessary stabilization from the UV radiation. Polypropylene is characterized by very good mechanical properties. For all that the polypropylene is the most using polymer.

Thanks to its excellent properties is using in various industries. It is processing as silks and foils. Silks are next processed as carpets, clothing materials and various industry dry-goods. Foils are using mainly in packaging, look like bottles, capsules, pack and containers. Foils for packaging are blowing till the 5 μm. In this time polypropylene find general usage in automotive industry. Polypropylene is using for production of bumpers, bumpers beam and dash-boards. [3]

3. MEASUREMENTS

The measurements were made in specialized laboratory at our department which consists of Thermo Scientific HAAKE Meltflow MT rheometer, evaluating software, analytical balance and other equipment. Thermo Scientific HAAKE MeltFlow indexers are ideal for injection molding companies to be used for incoming or outgoing quality control of polymers. Thermo Scientific HAAKE MeltFlow indexers comply with the ISO 1133, ASTM D 1238, ASTM D 3364, JIS K 7210 and referring standards. Based on a compact design the HAAKE MeltFlow MT

is the ideal table top instrument for small labs and infrequent use in a quality control environment.

Equipped with a digital displacement sensor the apparatus measures the melt volume rate (MVR) semi automatically. The apparatus can also measure the melt flow rate (MFR) semi-automatically with software controlled balance. Using the Thermo Scientific HAAKE MeltFlow software the apparatus can automatically measure apparent viscosity data (shear rate, viscosity, shear stress).

Also was used balance Mettler Toledo EL 4001 with accuracy 0,1g for weighing of sample mass.

TABLE 1. MEASUREMENT CONDITIONS

Measurement conditions		
	Sample 1	Sample 2
Material:	polypropylene - PP	polypropylene - PP
Date of sample remove:	08.08.2008	08.09.2008
Date of measurement:	09.08.2008	09.09.2008
Sample mass:	5,00 g	5,00 g
Temperature:	230 °C	230 °C
Die length:	8,000 mm ±0,025 mm	
Die diameter:	2,095 mm ±0,005 mm	
Weight:	5,00 kg	5,00 kg

FIGURE 2. GRAPH AND TABLE OF MEASUREMENT VALUES – SAMPLE 1

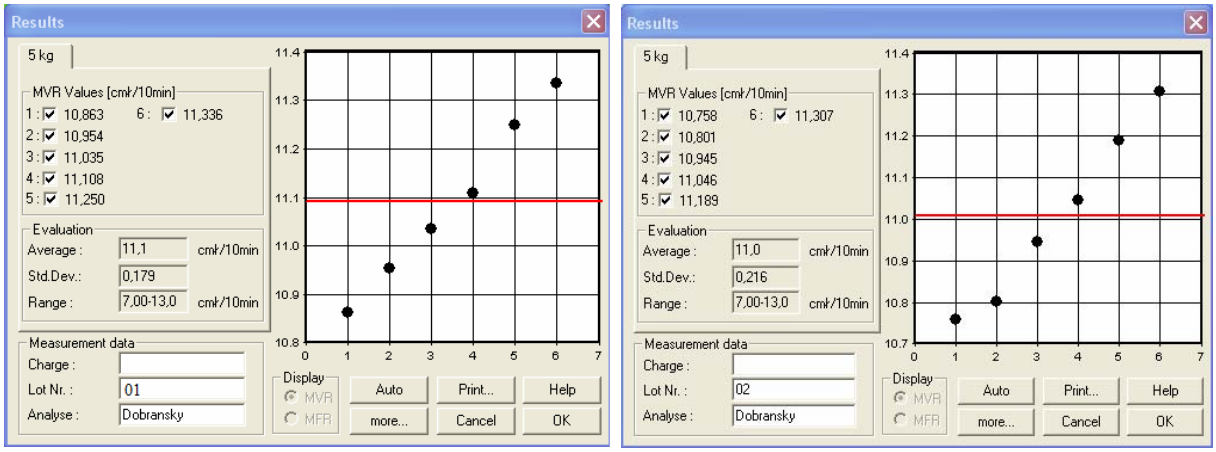


TABLE 2. MEASUREMENTS RESULTS

Measurements results			
Property	Sample 1	Sample 2	Unit
Melt volume rate (MVR)	11,1	11,0	cm^3/10min.
Std. deviation	0,179	0,216	
Time of measurement	1,56	1,56	min.
Shear rate	2,0494E1	2,0309E1	1/s
Shear stress	4,4831E4	4,4831E4	Pa
Viscosity	2,1875E3	2,2074E3	Pa.s

4. CONCLUSION

Paper deals with verification of polypropylene rheological properties. It was measured and compared rheological properties of polypropylene plastic materials produced by producer which are used for plastic parts production in automobile industry. During

experiment were tested two materials (polypropylene) which was removed in the different time from production process of injection molding. Samples were tested in specialized laboratory by means of Thermo Scientific HAAKE Meltflow MT rheometer. Samples was evaluated by special software Thermo Haake, which determined melt volume rate value, shear rate, shear stress and viscosity what are the basic rheological properties of plastic materials.

The target was determined and verified melt volume rate value which is presented in material list and which is important to verify it. Values of melt volume rate by both materials were in allowing tolerance. Required value is from 7 till 13 cm^3/10min. Value by sample 1 was 11,1 and by sample 2 was 11,0 cm^3/10min. It means that the material has good flow properties and it is qualified for production process of injection molding.

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