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[1.] LUBOŠ BĚHÁLEK, [2.] JIŘÍ BOBEK

CONTACT-LESS ANALYSIS OF POLYPROPYLENE TENSILE STRAIN AND INFLUENCE OF LOADING RATE

Abstract:
Paper deals with analysis real deformation of polymers injection parts measured by contact-less optical measurement system ARAMIS. Observed is influence of loading rate (with regard to viscoelastic behavior of polymers) on surface specific deformation of injection part and deformation properties of chosen part on its surface – under uniaxial tensile loading. In chosen areas of injection part surface are its deformation properties describes by means of dependences of displacement and loading rates (chosen areas) on elongation of sample in the loading direction.

Keywords:
viscoelastic properties, tensile strain, ARAMIS, polypropylene

INTRODUCTION

Mechanical properties of plastic parts are given namely by used material [1], i.e. its chemical composition, structure and added additives. To a great extent are however (especially in injection technology) influenced by process conditions of processing and design of mould [2], [3]. With respect to viscoelastic properties of polymers is clear that their mechanical properties also depends on time or more precisely on loading rate. With increasing loading rate, plastic part will exhibit e.g. higher ultimate tensile strength. That is reality, which is absolutely apparent for technical public [4]. The aim of this paper is however describe for four different loading rate distribution of surface deformation of plastic part under tensile loading with the help of contact-less measuring system ARAMIS both in the loading direction (direction x) and also in the direction perpendicular to this direction (direction y). Conventional tensile test which is using strain gauge does not enable to monitor surface deformation of part.

CONTACT-LESS ANALYSIS OF TENSILE STRAIN

Material, preparation and experiment

For experimental measuring was by injection technology prepared normalized testing samples from homopolymer PP Mosten type 1A according ISO 527-2 in agreement with ISO 294-1 and ISO 1873-2 on injection machine Engel Victory 80/25. Before tensile loading were testing samples conditioning in standard conditions 23/50 according ISO 291.
For contact-less analysis of surface deformation distribution was used 3D measuring system ARAMIS 2M [5] based on principle of scanning deformed part by two cameras (see fig. 1). On measured sample was dabbed stochastic pattern (see fig. 2), after setting cameras was system calibrated on the measuring accuracy 0,01% and

from scanned frames during loading of sample were by means of image processing computed 3D coordinates of points placed on its surface.

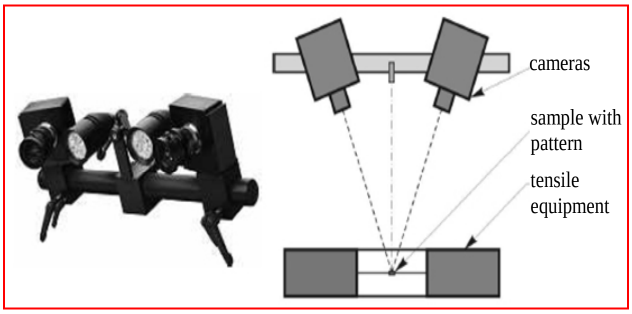

Fig. 1 Sensing system of ARAMIS

Testing samples (always five samples for each loading rate) were loaded by static tensile mode in the direction of its major longitudinal axis on device Hounsfield H10KT and with four different constant loading rates: 5 mm/min up to 200 mm/min. With regard to reality that under different loading rates is also changing value of specific elongation for the moment of fracture, is for evaluation of specific elongation distribution in different directions used comparison limit which for this case is elongation of virtual strain gauge of ARAMIS system to the value 9,3 mm.

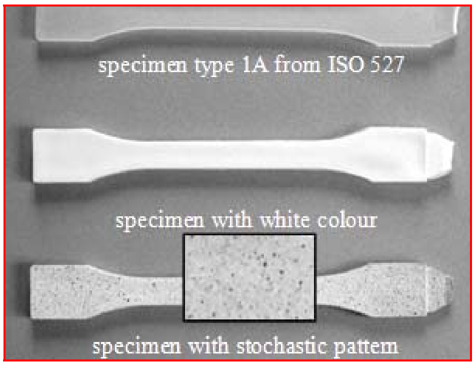

Fig. 2 Preparation of pattern

Technical strain distribution of part in dependence on loading rate

Figures representing technical strain distribution in the individual directions „x" and „y" in dependence on loading rate are given in fig. 3. Further is in fig. 4, respectively in fig. 5, shown graphic dependence of technical strain in the direction „x", respectively „y", along the length of testing sample between jaws (110 mm) onto which was created mesh of points (for already written elongation 9,3 mm).

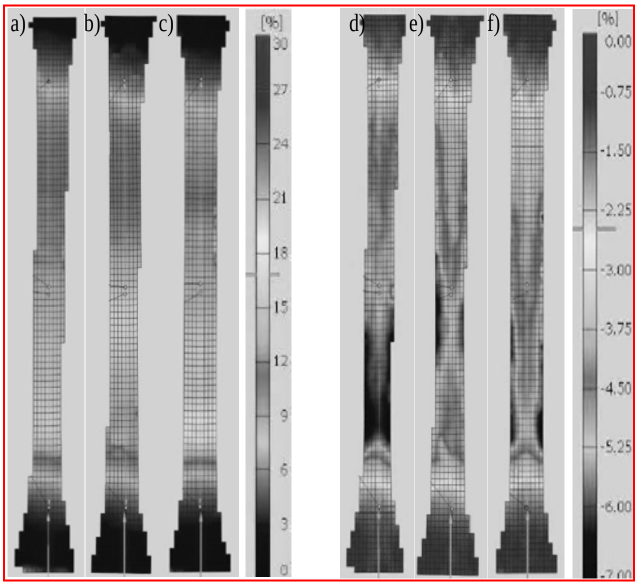

Fig. 3 Comparison of loading rate for technical strain distribution of Mosten GB 005
a,b,c) direction "x"; d,e,f) direction "y";
loading rate: 5 mm.min^{-1} (a,d); 100 mm.min^{-1} (b,e); 200 mm.min^{-1} (c,f)

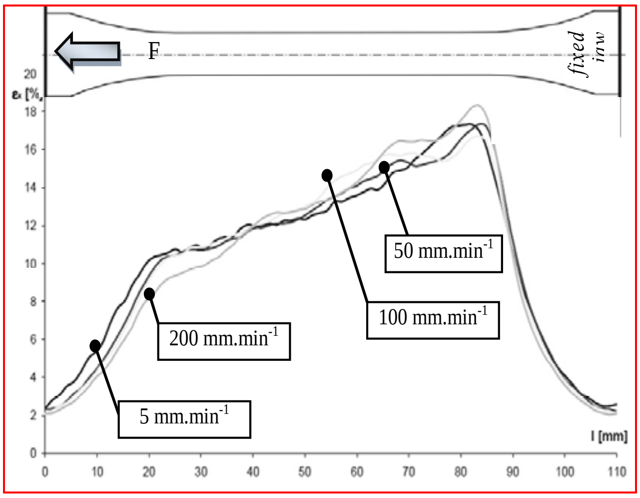

Fig. 4 Technical strain in „x" direction - specimen length chart

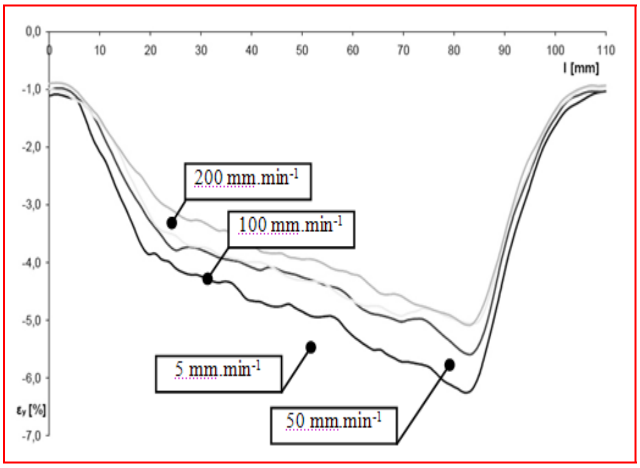

Fig. 5 Technical strain „y" direction – specimen length chart

Behavior of three chosen points on the testing sample surface xy is given in time dependence of displacement of these points in the direction „x" in fig. 6 and in fig. 7 are given dependences of these points displacement rate in the same direction „v_x" on elongation „ΔL_x".

CONCLUSION

Based on the results of contact-less deformation analysis of polypropylene Mosten GB 005 under tensile loading is possible to state following:

- *Strain distribution in the direction „x" is for all used loading rates very similar (see fig. 3a, fig. 3b and fig. 3c), on the contrary strain distribution in the direction „y" is dependence on loading rate (see fig. 3d, fig. 3e and fig. 3f). The highest strain in the direction „y" is achieved under the lowest loading rate 5 mm/min (see fig. 5), which can be explain by means of viscoelastic behavior of plastics.*
- *Also Poisson ratio is changing not only in dependence on temperature, but also on loading rate (see table 1). With higher loading rate is Poisson ration decreasing. Difference of Poisson ratio between the lowest and the highest loading rate is 24%. So with increasing value of Poisson ration there is increasing of necking and decreasing of elongation.*

Table 1 Poisson ratio for Mosten GB 005 and different tensile loading rates

Loading rate	Poisson ratio
5 mm.min^{-1}	0,37 ± 0,01
50 mm.min^{-1}	0,34 ± 0,02
100 mm.min^{-1}	0,30 ± 0,01
200 mm.min^{-1}	0,28 ± 0,01

- *From time displacement dependence of chosen points on sample's surface in longitudinal direction (see fig. 6) is clear that points 1 and 3 under the lowest loading rate displace onto given value at higher time segment than for higher loading rates. Point 1, placed in the moveable jaw, achieves higher values of elongation than point 3 placed in the fixed jaw (evidently as a result of nozzle intake location, which was always on the side of moveable jaw) after future neck which was observed to appear close to fixed jaw.*

From chosen points displacement dependence on change of strain gauge (see fig. 7) is for point 3 evident that with higher elongation of virtual strain gauge of ARAMIS system is displacement velocity of points decreasing and on the contrary for point 1 is displacement velocity of points increasing (for the case of higher loading rate). It follows certain in homogeneity of material, when all loading rates should be constant up to yield strength (just as is evident from loading rate 5 mm/min), when is created neck and strain is concentrated only into this area and other points are not more in motion.

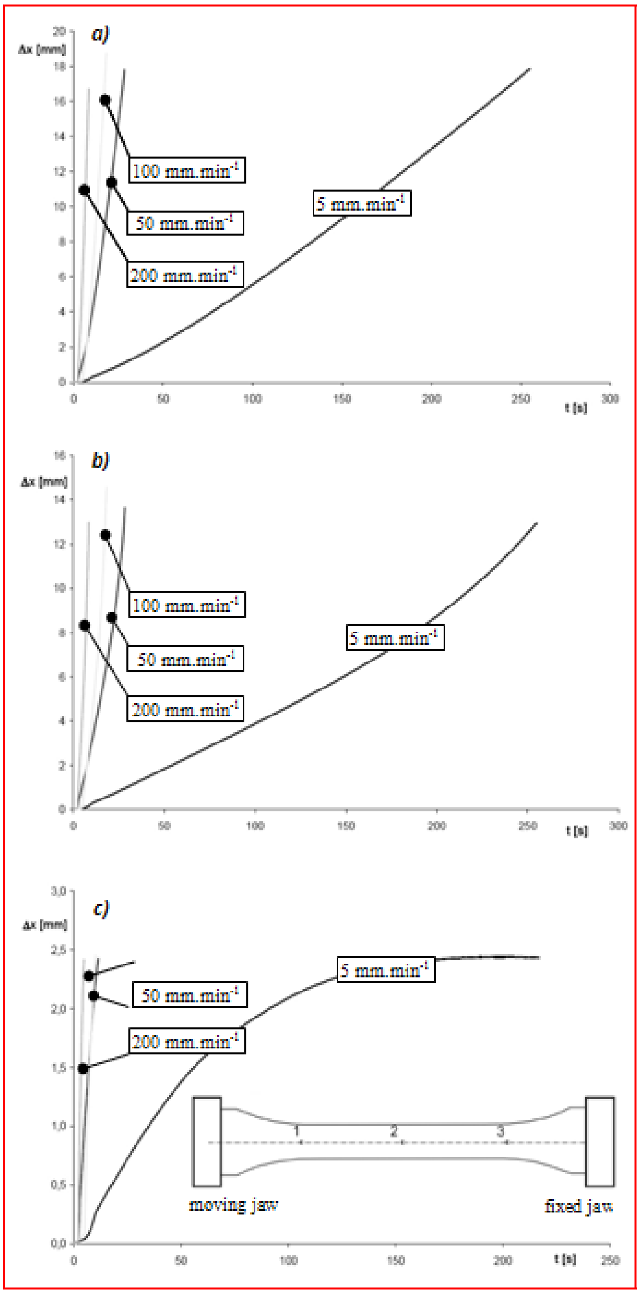

Fig. 6 Time dependence of point displacement 1 (a), 2(b) and 3 (c) in the loading direction (axis - x) in dependence on loading rate

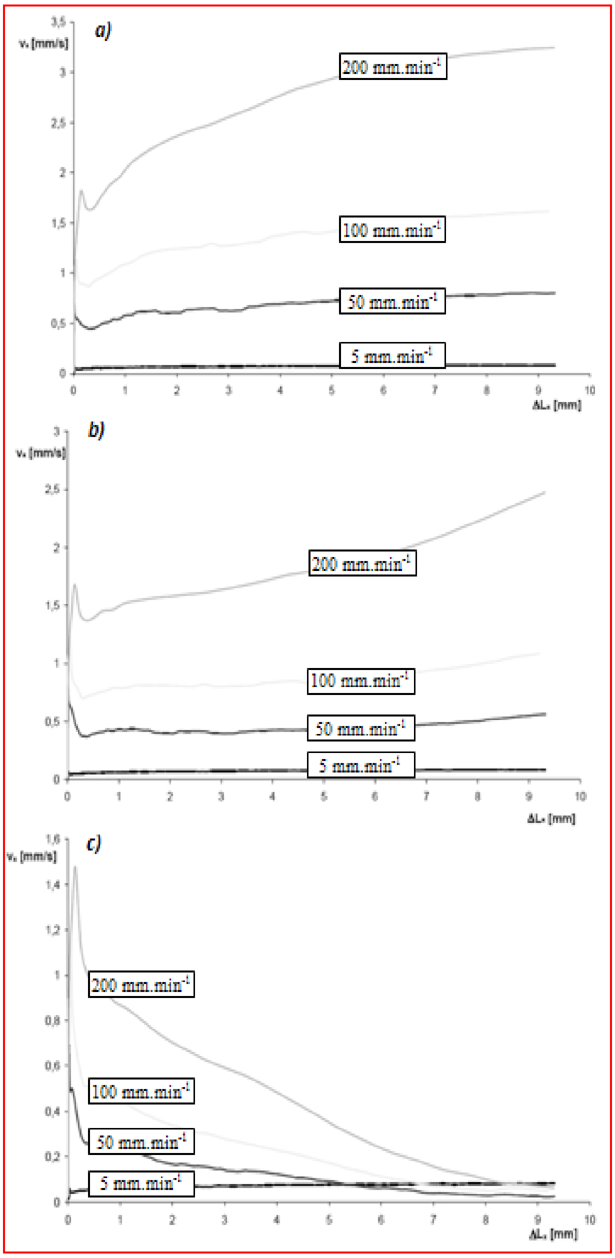

Fig. 7 Dependence of displacement rate of points 1(a), 2(b) and 3 (c) in the loading direction (axis - x) on elongation for different loading rate

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[5.] Materials of GOM mbH

AUTHORS & AFFILIATION

1. LUBOŠ BĚHÁLEK,
2. JIŘÍ BOBEK

1. 2. DEPARTMENT OF MECHANICAL TECHNOLOGY, TECHNICAL UNIVERSITY OF LIBEREC. CZECH REPUBLIC