SOME ASPECTS CONCERNING THE MICRO INDENTATION TESTING OF ULTRAMID PLASTIC MATERIALS

Ciprian Ciofu, Gheorghe Crețu

"Gheorghe Asachi" Technical University of Iasi-Romania, Department of Machine Manufacturing Technology
Blvd. Mangeron, No. 59A, 700050 Iasi, Romania

Corresponding author: Ciprian Ciofu, ciprian.ciofu@gmail.com

Abstract: The Microindentation analysis is a very important tool for the materials engineer, but it must be used with care and full understanding of potential problems. From this point of view a Universal UMT-2 (CETR-Center of Tribology, INC. USA) device was used for the microindentation tests. It was used a 2kg sensor and applied a maximum forceof 10N. Also was used diamond tip Rockwell indenter with a radius of 200μm. The capacitive sensor used measured the vertical indenter displacement.
As materials were used two types of ultramid plastic materials such as: A3EG5 and A3EG6.
The research will be focus on the load diagrams dependent on the vertical indenter displacement. The software package we used enabled us to read both the micro hardness values, and the reduced indentation modulus and Young's modulus. Also will be included the displacement and recovery values of the studied materials. The research was conducted on three test samples of each material.The fiber orientation was in three directions, such as: 0^o, 45^o and 90^o. The micro indentation analysis was done for samples with above angle of fiber orientation presented. The software package used enabled to read the micro hardness values, the reduced indentation modulus and Young's modulus. Also the results are focus on displacement and material recovery.
Key words: micro indentation, injection, ultramid material

1. INTRODUCTION

The ultramid plastic materials are a 6.10 polyamide and are used as a technical material in cases where low moisture absorption and the associated high dimensional stability are key requirements. That's why the ultramid plastic materials are especially used for the manufacture of precision parts in precision mechanics and apparatus engineering. The main properties are as follow: low moisture absorption; good dimensional stability; extremely tough and good abrasion resistance, [1].
The ultramid plastic materials are molding compounds based of PA6, PA66 and PA66/6. Could be included also PA610 and partially aromatic polyamides such as PA6T/6. The compounds are available reinforced with glass fibers or minerals, unreinforced and reinforced with long glass fibers up to the industrial applications. The ultramid plastic materials have high mechanical strength, stiffness, thermal stability, good toughness at low temperature and favorable sliding friction behavior. This material is used in many special applications, [2].
As commercial materials ultramid polyamides supplied by BASF can be considered. Take into account them production it can be mentioned that they are molding compounds based on Nylon 66 (Ultramid A) and Nylon 6 (Ultramid B) and on their copolymer (Ultramid C). There are eight variants of Ultramid A and more than 10 variants of Ultramid B. These materials are used in almost all fields of activity and for many industrial applications, [3].

2. EXPERIMENTAL PART

The planning of the experiments was achieved by means of the Taguchi methodology, [4].
The model proposed by Viger and Sisson is also easy to study; this is the matrix model of the system comprising "I" factors: F_1, F_2 ... F_i each factor having n_i levels. Each experiment was conducted three times. The proposed matrix model takes into consideration six technological parameters with two levels. The coefficients of a type (1) model were determined within the experimental research:

$$Z_t = M + T_{top} + t_{inj} + T_{top} + t_r + S_s + P_{inj} + T_{mat} + P_{inj}T_{top} + P_{inj}t_{inj} + P_{inj}t_{tr} + P_{inj}S_s + P_{inj}T_{mat} \quad (1)$$

where: M-general average; T_{top}-melting temperature, [^oC]; t_{inj}-injection time, [s], t_r-cooling time, [s],
S_s-screw speed, [mm], P_{inj}-injection pressure, [MPa], T_{mat}-matrix temperature, [^oC], [5, 6]. The most significant influence on the process is exercised by the injection pressure followed by the melting temperature and the matrix temperature. Screw speed, injection time and cooling time have less influence on

the injection process.
The geometry of tensile specimens is shown in figure 1, according to the recommendation of DIN EN ISO 527-1/1A/5.

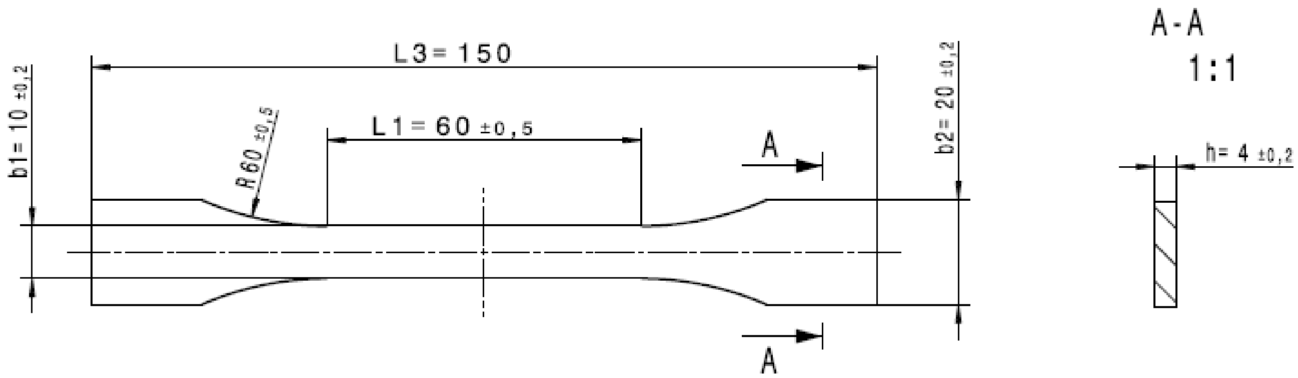

Fig. 1. Specimen dimensions according to ASTM D638-02

Simulation using Plastics module from SolidWorks was held using three different patterns, according to the figure 2. During experimental research were used two ultramid materials A3EG5 and A3EG6.

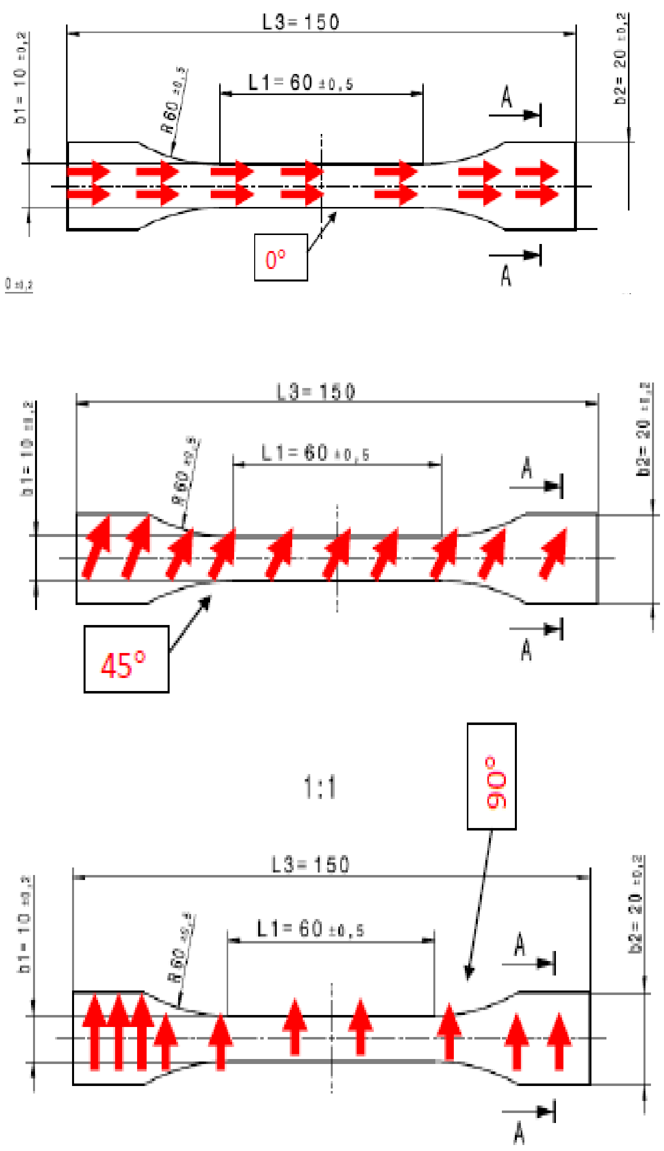

Fig. 2. Three injection pattern used

3. RESULTS AND DISCUSSION

For the microindentation testswas used aUniversal UMT-2 (CETR-Center of Tribology, INC. USA) device. It was used a 2kg sensor and applied a maximum forceof 10N. We also used diamond tip Rockwell indenter with a radius of 200µm. The capacitive sensor used measured the vertical indenter displacement.
The load diagrams dependent on the vertical indenter displacement are presented on figures 3 and 4. The software package we used enabled us to read both the microhardness values, and the reduced indentation modulus and Young's modulus. These values are shown in table 1. The table also includes the displacement and recovery values of both materials used. The research was conducted on three test samples of each material.
According to Table 1, was done a comparison chart for each measured parameter for samples obtained in similar condition (same molding pattern) for Ultramid A3EG5 and Ultramid A3EG6 (figures 5, 6, 7, 8, 9).
As it could see from above diagrams, for A3EG6 material, injection pattern does not have such a great influence over the material displacement, recovery, micro hardness and indentation modulus (reduced and Young's).
For A3EG5 material, it could conclude that injection pattern have influence on measured parameters. On 45^0 injection pattern, micro hardness is almost double than that one obtained on same material and manufacturing conditions but using 0^0 injection pattern.

4. CONCLUSIONS

Both materials used in experimental research were injected smoothly on three directions of injection process. Take into account the main properties such as low moisture absorption, good dimensional stability,

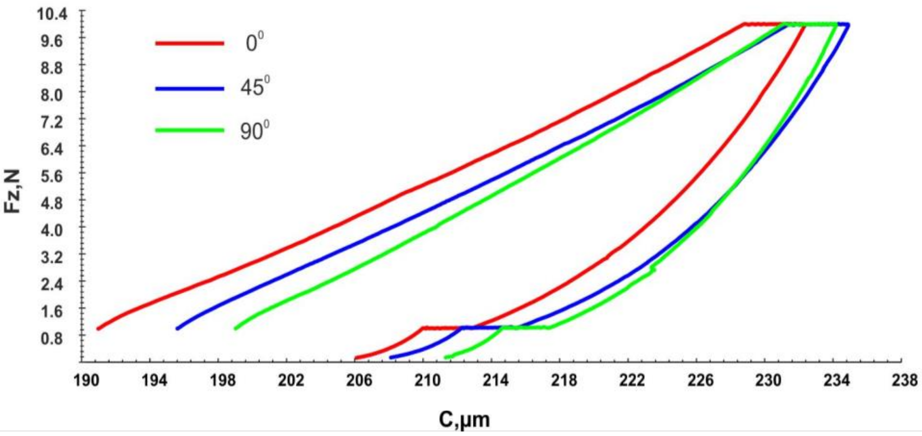

Fig. 3. Microindentation Test on A3EG5

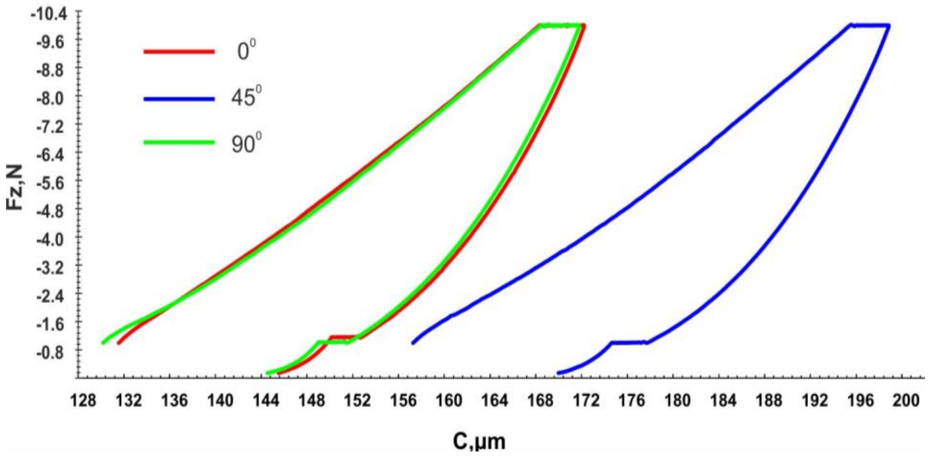

Fig. 4. Microindentation Test on A3EG6

Table 1. Synthetic Presentation of the Research Results

Material	Injection angle	Parameter					
		Material displacement (µm)	Recovery (µm)	Micro hardness (GPa)	Indentation modulus (GPa)		Load (N)
					Reduced	Young's	
Ultramid A3EG5	0^0	41.401	19.047	0.229	3.719	3.582	8.998
	45^0	39.315	16.674	0.242	3.925	3.781	8.968
	90^0	35.184	15.632	0.271	4.637	4.470	8.996
Ultramid A3EG6	0^0	40.680	18.185	0.238	3.481	3.352	8.973
	45^0	41.587	19.751	0.234	3.373	3.248	8.992
	90^0	41.633	18.845	0.232	3.394	3.268	8.977

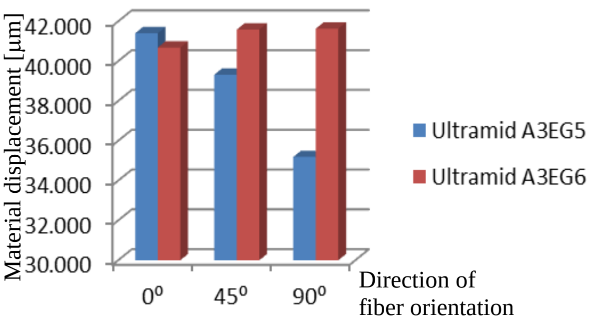

Fig. 5. Material displacement

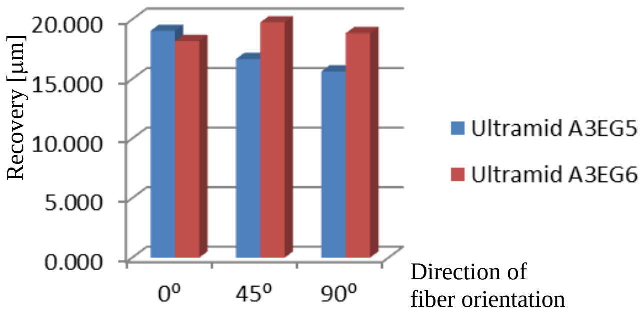

Fig 6. Recovery

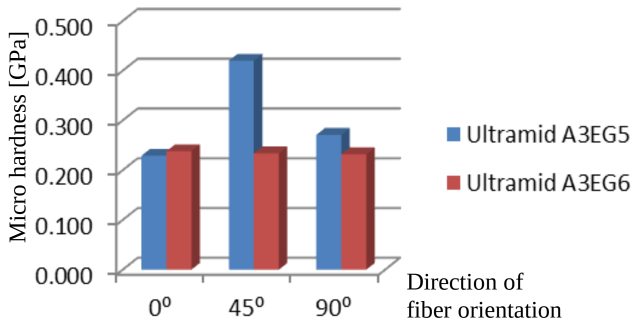

Fig. 7. Micro hardness

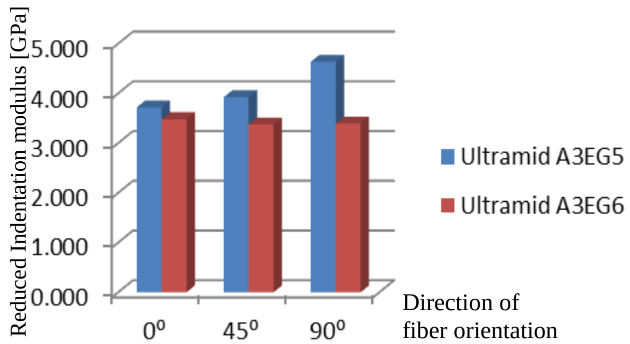

Fig. 8. Reduced Indentation modulus

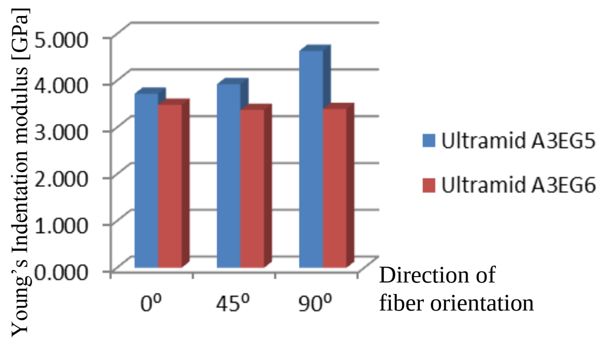

Fig. 9. Young's Indentation modulus

extremely tough and good abrasion resistance these materials are used in many industrial applications and especially used for the manufacture of precision parts in precision mechanics and apparatus engineering.

In terms of material displacement it can be seen when the injection angle is 0° degrees both materials have comparable values and in case of 45° and 90° material displacement is greater for A3EG6 material.

The same conclusion results in the analysis of the material recovery of both materials studied. The situation is reversed in case of micro hardness. In this situation slightly higher values are obtained for material injection A3EG5 at 45° and 90° injection angles while at 0° injection angle the higher value of micro hardness belongs to A3EG6 material.

The values of reduced indentation modulus are higher for A3EG5 compared with A3EG6 material. The same aspect is available also for Young's modulus.

REFERENCES

1.http://www.albis.com/en/products-solutions/products-brands/ultramid-s/, Accessed: 02/07/2014

2.http://www.basf.com/group/corporate/en_GB/literature-document:/Brand+Ultramid-Brochure--Ultramid+PA-English.pdf, Accessed: 28/07/2014

3.http://books.google.ro/books?id=KmuK4w_D7UUC&pg=PA64&lpg=PA64&dq=ultramid+plastic+material&source=bl&ots=CA2P22Xtox&sig=zulXUZkvJe3_bgBZ3JbiErno0Po&hl=ro&sa=X&ei=S9pRVMukJcv7ywOWwgE&ved=0CGUQ6AEwBjgU#v=onepage&q=ultramid%20plastic%20material&f=false, Accessed: 30/07/2014

4. D. Nedelcu, O. Pruteanu, (2000), *Aspecte ale formarii canelurilor e xterioare prin deformare plastic la rece utilizand metoda Taguchi*, Tehnica-Info Publishing House, pp. 243-261, Chisinau.

5. C. Ciofu, Dumitru Nedelcu, (2014), *Finite element in designing of the gate location, shape and moulding injection path*, Advanced Materials Research, Vol. 1036, pp. 417-421.

6. C. Fetecau, D.V. Dobrea, I. Postolache, *Overmolding injection molding simulation of tensile test specimen*, Int J of Modern Manufacturing Technologies, II(2), 2010, pp. 45-50.

Received: June 12, 2014 / Accepted: December 10, 2014 / Paper available online: December 15, 2014 © International Journal of Modern Manufacturing Technologies.