Scientific Bulletin of the „Petru Maior" University of Tîrgu Mureş
Vol. 13 (XXX) no. 2, 2016
ISSN-L 1841-9267 (Print), ISSN 2285-438X (Online), ISSN 2286-3184 (CD-ROM)

EXPERIMENTAL DETERMINATION OF PRESSURE IN INVERSE EXTRUSION USING ACTIVE FRICTION

Teodor SOCACIU
Petru Maior University of Tirgu-Mures
Nicolae Iorga st., no. 1, Tirgu-Mures, 540088, Romania
teodor.socaciu@ing.upm.ro

Abstract

Inverse extrusion of cave parts is increasingly applied in present. In production conditions the results of this process are conditioned by tools durability, which depends on pressure, requested by deformation. Friction conditions between workpiece and tools, especially those with active plate, have a great influence about pressure. To lessen the effect of the friction force it found that they could be active and contribute to the deformation of the material if their sense and direction coincide with the sense and direction of flow of material deformed. This paper presents experimental researches concerning the way in which using the active effect of friction makes possible the decreasing of pressure requested by inverse extrusion.

Keywords: inverse extrusion, experimental research, friction, force, pressure

1. Introduction

At the classic inverse extrusion high friction forces occur between tools and material [3, 5, 10, 18, 23, 24]. These forces cause increased pressures that influence in negative way the extrusion process [2, 4, 11, 26, 27]. The uniformity of material flow decreases and the tool wear increases.

Searching for new methods of diminishing the extrusion force it has been found out [1, 8, 9, 14, 16, 19, 21, 25] that friction forces can become active and can contribute to the material's deformation process if the extrusion is done with a mobile active plate, fig. 1.

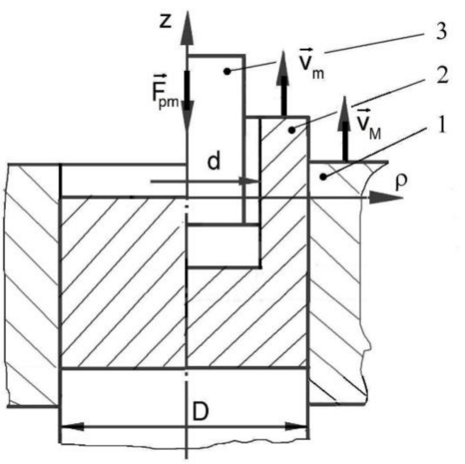

Fig. 1: Inverse extrusion with moving active plate

By moving the active plate 1 together with the extruded wall 2 with the rate v_M, the sense and direction of the friction forces coincide with those of the displacement of the material that is being deformed. This way, the friction forces between the workpiece and the extrusion plate become active they don't oppose to the flow of material anymore, on the contrary, they favor its deformation, thus improving the parameters of the extrusion process.

Active forces are [14, 17, 20] function by value of ratio:

$$a = \frac{V_M}{V_m} \qquad (1)$$

where:

v_M – active plate speed;
v_m– flow speed of extruded wall.

2. Materials and Methods

The difference between total force F (fig. 2) and external force F_e (that moves active plate) is the force that action through the punch, F_{pm}, and which supply q pressure requested by the extrusion process.
In this case:

$$F_{pm} = F - F_e \qquad (2)$$

and the pressure requested by extrusion is:

$$q = \frac{F_{pm}}{S_p} \qquad (3)$$

where S_p is the punch section.

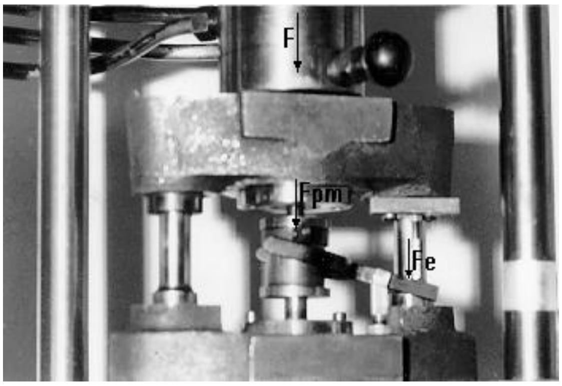

Fig. 2: Die for invers extrusion using active friction forces

From relations (2) and (3) results that for determination of pressure requested by inverse extrusion with active friction forces due to movement of active plate by an external force F_e, it is important to know the value of this force (F_e).

At the device shown in figure 3, the rods through which external force is transmitted was replaced by a force transducer for experimental determination of external force requested by active plate movement.

Extrusion takes place under the action of testing machine's die 1, which transmitted requested force to punch 15 through upper plate 1. Other active elements are contrapunch 13 and active moving plate 3.

Fig. 3: Assembly for experimental determination of external force requested by the movement of active plate

Active plate 3 is controlled by lever 7 (through collar 14), which is supported by support 8, with adjustable position by screw nut 9. In order to move active plate 3 with the right speed, the ratio between the arms of lever 7 can be modified by changing the position of support 4, which is fixed in upper plate by screws that permits this adjustment.

A force transducer measures external force requested for moving active plate. This transducer consists in an elastic jack 5, on which are stocked two tensometric transducers 6, and a compensating plate 12, made by the same steel like elastic jack. On the plate are also stocked two tensometric transducers. Electric wires in a Wheatstone bridge link these four transducers.

This force transducer was mounted on the extrusion device, like is shown in figure 3.

The stand shown in figure 4 was utilized for experimental determination of pressure applied by punch on extruded material. Device 1 – described above – is placed between testing machine's dies [13, 15, 22]. During the extrusion process, dial 2 indicates total requested force F, and indication needle of tensometer 3 – by graduation diagram – indicates external force F_e requested for moving active plate.

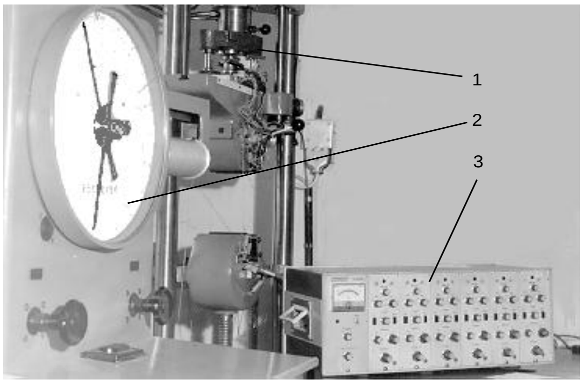

Fig. 4: Stand for experimental determination of forces requested by inverse extrusion using active friction forces

The tests were performed by extrusion of workpieces made by Pb99,96, with diameter D=16 mm, height H=12 mm, and deforming degree ε = 0,47. Material characteristics are presented in table 1.

Table 1: Material characteristics

Material	Chemical composition [%]		Tensile strength [daN/mm^2]
Pb 99,96	Pb	99,96	2,5 - 4
	Bi	0,010	
	Cu	0,003	
	Fe	0,003	
	Sb	0,004	
	Sn	0,002	
	Zn	0,002	
	Other	0,030	

3. Results

It was considered the case of classical extrusion (a=0), and the case of extrusion with active moving plate having a ratio of speeds a=0,5 and a favorable one [16, 17, 19] a=0,9. The forces were determined at different work displacements. The pressure requested by the process with active moving plate were obtained using relations (2) and (3), and for the case of extrusion with fixed active plate with relation:

$$q = \frac{F}{S_p} \qquad (4)$$

The values obtained for pressure are represented in table 2 and diagram shown in figure 5.

Table 2: The extrusion pressure according to the different work displacements

h_c [mm]	q [daN/mm^2]		
	a=0	a=0,5	a=0,9
0	9,2	8,5	7,6
2	9,3	8,65	7,9
4	9,4	8,8	8,1
6	9,5	9,05	8,5
8	9,7	9,15	8,9

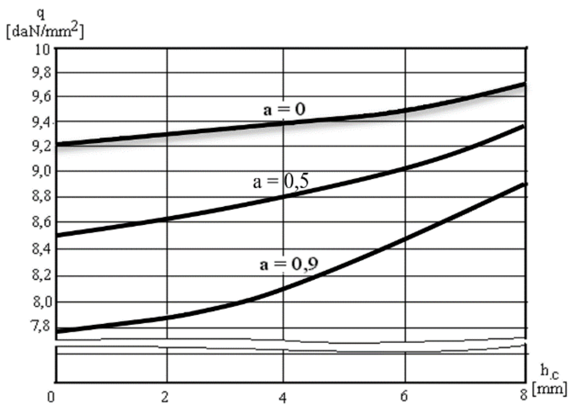

Fig. 5: Experimental variation of pressure requested by inverse extrusion

4. Discussion and Conclusions

Analyzing experimental results concerning pressure requested by extrusion process that is to conclude:

- at inverse extrusion with moving active plate, the pressure requested by the process is considerably decreased, that is because apart of punch's loading are taken by active plate, friction forces between plate and workpiece having a great contribution in deforming process;
- in the case on which were performed experimental determinations, pressure requested by inverse extrusion with active friction forces, comparatively with classical extrusion was reduced with (5…10)% for a=0,5 and with (15…20)% for a=0,9, important decreasing being observed on the last portion of the work stroke;
- in this case the durability of tools is increasing and, due to lower pressure, the danger of dry friction between tool and material (friction which causes deficiency in the parts obtained by classical extrusion) no longer exists;
- due to lower pressure and uniform flow the parts obtained is better quality [6, 7, 12].

Acknowledgement

The authors thank Research Centre TAPFA of the Faculty of Engineering, "Petru Maior" University of Tîrgu Mures, Department of Industrial Engineering and Management, for providing opportunities to use machines and equipments.

References

[1] Berejnoi, V.L., ş.a. (1984), *Razrabotka sposobov vâdavlivania s activnâm deistviem trenia*, Kuzniecino Ştampovocinoe Proizvodstro nr. 2.

[2] Brezeanu, L. C. (2014), *Contact Stresses: Analysisby Finite Element Method (FEM)*. The 7th International Conference Interdisciplinarity in Engineering, INTER-ENG 2013, 10-11 October 2013, PetruMaior University of TirguMures, Romania,Elsevier, Procedia Technology, Volume 12,ISSN 2212-0173.

[3] Brezeanu L., Bucur B.(2014), *Comparative Study by FEM of the Stress and Strain in the Worm Gear Reverse Tapered Pinion for Different Materials*, Scientific Bulletin of the „Petru Maior" University of Tîrgu Mureş Vol. 11 (XXVIII) no. 1, pp. 5-12, ISSN-L 1841-9267 (Print), ISSN 2285-438X (Online), ISSN 2286-3184 (CD-ROM).

[4] Capan, L., Baran, O. (2007), *Calculation method of the press force in a round shaped closed-die forging based on similarities to indirect extrusion*, Journal of Materials Processing Technology-Elsevier, Volume 102, Issues 1–3, 15 May 2000, pp. 230–233.

[5] Lee, J.S., Son, H.T., Oh, I.H., Kang, C.S., Yun, C.H., Lim, S.C. Kwon, H.C. *Fabrication and characterization of Ti–Cu clad materials by indirect extrusion*, Journal of Materials Processing Technology-Elsevier, Volumes 187–188, 12 June, pp. 653–656.

[6] Moica, S., Harpa, E. (2014),*Identify the Most Significant Variables That Influence the Economic Efficiency in a Productive Company*. Scientific Bulletin of the „Petru Maior" University of Tîrgu Mureş Vol. 11 (XXVIII) no. 2, pp. 65-70, ISSN-L 1841-9267 (Print), ISSN 2285-438X (Online), ISSN 2286-3184 (CD-ROM).

[7] Moldovan, L. (2015), *European Quality Assurance in VET Towards New Eco Skills and Environmentally Sustainable Economy*. Scientific Bulletin of the "Petru Maior" University of Tîrgu Mureş Vol. 12 (XXIX) no. 1, pp. 63-67, ISSN-L 1841-9267 (Print), ISSN 2285-438X (Online), ISSN 2286-3184 (CD-ROM).

[8] Müller, K (2001), *Encyclopedia of Materials: Science and Technology*, Chapter 4.8.4.d Extrusion, Elsevier Science Ltd.. Oxford, ISBN 0-08-0431526.

[9] Ovcinikov, A.G., Dimitriev, A.M. (1981), *Holodnoe vâdavlivanie polâh cilindriceski hizdenii s aktivnâm salami trenia*, Kuzniecino Stampovocinoe Proizvodstvonr 6, pp. 24.

[10] Park, S.S., Tang, W.N., You, B.S.(2010), *Microstructure and mechanical properties of an indirect-extruded Mg–8Sn–1Al–1Zn alloy*, Materials Letters-Elsevier, Volume 64, Issue 1, 15 January, pp. 31–33.

[11] Park, S.S., You, B.S., Yoon, D.J.(2009).*Effect of the extrusion conditions on the texture and mechanical properties of indirect-extruded Mg–3Al–1Zn alloy*, Journal of Materials Processing Technology-Elsevier, Volume 209, Issues 18–19, 19 September, pp. 5940–5943.

[12] Pop, L., Socaciu, T. (2013),*Study on the evolution of the current ISO certifications in Romania*, Scientific Bulletin of the „Petru Maior" University of Tîrgu Mures, Vol.10 (XXVII), no. 1, ISSN-L 1841-9267 (Print), ISSN 2285-438X (Online), ISSN 2286-3184 (CD-ROM), pp. 58-61.

[13] Socaciu, T., Bucur, M., Simon, M. (2011),*Researches on improvements in metallic structures using aluminum foam*. The International Conference on Materials Science and Engineering, BRAMAT 2011,Metalurgia International, vol. XVI, no. 4, pp 89-92, ISSN 1582-2214.

[14] Socaciu, T.(2015), *Experimental study regarding variation of force in inverse extrusion using active friction*. Elsevier, Procedia Technology, Volume 19, pp. 85–89, ISSN 2212-0173.

[15] Socaciu, T., Pop, L. (2011),*Experimental determination of rigidity for mechanical press PAI 40*. The International Scientific Conference Inter-Eng 2011 "Petru Maior" University Faculty of Engineering, Tg. Mureş, 3 – 5 November. Scientific Bulletin of the „Petru Maior" University of Tîrgu Mureş, ISSN 1841-9267.

[16] Socaciu,T, Tureac, I.(2001), *Matriţă pentru extrudare inversa la rece (Cold inverse extrusion die)*, Brevet nr. 116877/28.06.2001.

[17] Socaciu, T., (2004), *Tehnologii şi echipamente noi de extrudare (Technologies and equipment for extrusion)*, Editura Universităţii "Petru Maior" Tg.-Mureş, ISBN 973-8084-91-I.

[18] Socaciu, T., Pop, L.(2012),*Optimizing the shape for stamping of short parallelepiped parts with small radiuses*. The 6th edition of the Interdisciplinarity in Engineering International Conference "Petru Maior" University of Tîrgu Mures, Romania, Octomber 4 - 5, Conference Proceedings, pp. 99-102, ISSN 2285 – 0945, ISSN-L2285 – 0945**.**

[19] Socaciu, T. (2014),*An analysis regarding the variation of necessary force by the indirect extrusion processes*. The 7th International Conference Interdisciplinarity in Engineering, INTER-ENG 2013, 10-11 October 2013, Petru Maior University of Tirgu Mures, Romania,Elsevier, Procedia Technology, Volume 12,ISSN 2212-0173.

[20] Socaciu, T., Pop, L.(2009),*New experimental research concerning the improvement of energetics parameters in the extrusion using the friction forces as active forces*. Proceedings The 4th International Scientific Conference Inter-Eng2009 "Petru Maior" University Conference Proceedings, ISSN 1843 - 780X.

[21] Socaciu, T., Pop, L.(2014),*Tehnologia presării la rece (Cold pressing technology)*. "Petru Maior" University Press Tg.-Mureş, ISBN 978-606-581-086-0.

[22] Şimon, M.(2014), *Method for Testing the Rigidity of Large Mechanical Parts.* The 7th International Conference Interdisciplinarity in Engineering, INTER-ENG 2013, 10-11 October 2013, Petru Maior University of Tirgu Mures, Romania,Elsevier, Procedia Technology, Volume 12,ISSN 2212-0173.

[23] Tãpãlagã, I., Berce, P., Achimaş, G. (1986), *Extrudarea metalelor la rece (Cold extrusion of metals).* Editura Dacia, Cluj-Napoca.

[24] Teodorescu, M.,ş.a. (1987), *Prelucrări prin deformare plastică la rece (Working through plastic deformation)*. Bucureşti, EdituraTehnică.

[25] Tureac, I., Socaciu, T. (1997), *Research on the possibility of increasing extrusion efficiency by active use of the fiction force.* Journal of Plastic Deformation nr.7-8, Sibiu, pp.34-37.

[26] William H. Van Geertruyden, Heather M. Browne, Wojciech Z. Misiolek, Paul T. Wang, (2005),*Evolution of surface recrystallization during indirect extrusion of 6xxx aluminum alloys*, Metallurgical and Materials Transactions, April 2005, Volume 36,Issue 4,pp. 1049-1056.

[27] Xu, S.W., Ohishi, K., Kamado, S., Homma, T.(2011),*Twins, recrystallization and texture evolution of a Mg–5.99Zn–1.76Ca–0.35Mn (wt.%) alloy during indirect extrusion process*, Scripta Materialia-Elsevier, Volume 65, Issue 10, November 2011, pp. 875–878.