Experimental Study of Friction in Cold-Rolled Advanced High-Strength Steel

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Abstract—*Two different techniques were used to assess friction, namely unidirectional crossed cylinders sliding with linear increase of the load and an equipment which allows measuring the friction coefficient under stretch-forming conditions in a sheet metal forming process. The tested materials are a cold-rolled advanced high-strength steel, DP600, and an aluminium 1100 alloy against heat-treated AISI D3 steel. The test protocols were established to allow the study of several effects: sliding speed, the surface roughness, the lubricant effect, the load and the running-in effect. The differences between the two techniques are widely discussed and laser profilometry and scanning electron microscopy are used to help understand the prevalent friction mechanisms.*

Key Words :- Tribology , Sheet metal forming

I. INTRODUCTION

Concerning classic tests, Podgornik et al. performed a study to evaluate galling properties of tool materials for metal forming operations comparing several tribological test methods. Among several possibilities, it was proved that load scanning is a very simple and suitable method to evaluate galling properties of tool materials. This method was successfully applied to study the effect of the surface treatment and the roughness of tool material as well the behaviour of different lubricants . The assessment of friction during sheet metal forming operations is a very complex task, and the laboratory test selected presents a fundamental importance on the friction results. Stretch forming was used by several authors to study the influence of several parameters on friction during sheet metal forming.

New die materials and surface treatments have been investigated as well as the effect of blank material, surface roughness and lubricant viscosity. Instrumented deep-drawing tests were used especially to evaluate the effect of lubricants .

II. EXPERIMENTAL SETUP & PROCESS-

Fig. 1: vertical press

Fig. 2: roller with metallic strip

Fig.3:roller with non contact RPM measurement device

Fig.4: Experimantal setup

A. Load-scanning tests

The load-scanning test was done with two opposite cylindrical surfaces, with cross relative position, i.e. with the axes in perpendicular directions. Relative sliding motion during testing forms 45◦ in relation to each specimen axis, therefore the contact spot moves along a contact path on each specimen. This test procedure derives from the research work of Hogmark .

This type of test, with point-contact geometry, can be done with a constant normal load or varying the load, using different loading waves, during the test. The sliding velocity is another test parameter that can be adjusted. The equipment also allows changing the diameter of specimens, their roughness and the lubrication. Moreover tests can be done applying single or multi-pass conditions. The equipment developed at the University of Coimbra has a high precision of motion and positioning and is numerically controlled . The sliding motion corresponds to the movement of the horizontal base, where the specimen is fixed on a three-axis piezoelectric load cell. Normal load is applied by a spring, with well-defined constant rigidity, controlling the vertical motion of the upper specimen. Therefore, both the specimen path and the loading wave are numerically controlled. Both normal and tangential forces, measured by the load cell, were acquired in real-time during the test.

The draw-bead test allows the simulation of the bending and unbending in a sheet metal forming process and to measure the friction coefficient during the sliding of the sheet against a die during the forming process . To do this type of test, test equipment was especially designed in order to be used in conjunction with a classical electromechanical tensile test machine.

III. RESULTS AND DISCUSSION-

Comparison between draw-bead and load-scanning friction Tests In order to compare the results obtained by load-scanning anddraw-bead testing systems, a set of tests was performed for bothpairs of materials under study. Inthis case, the effect of abrasion by steel asperities is determinant inthe result. Therefore, an increase of the roughness induced a rise inthe friction coefficient. Comparing friction coefficients obtained forthe two tested pairs, in the same roughness conditions, the highestvalue corresponds to the steel sheet material, which should be dueto the higher yield stress value.

Table .1. Load applied with 10 RPM roller and stainless steel Thickness 2 mm

Sr. No.	Applied load in N	Friction force in N
1	10	2
2	20	5
3	30	7
4	40	9
5	50	10
6	60	12

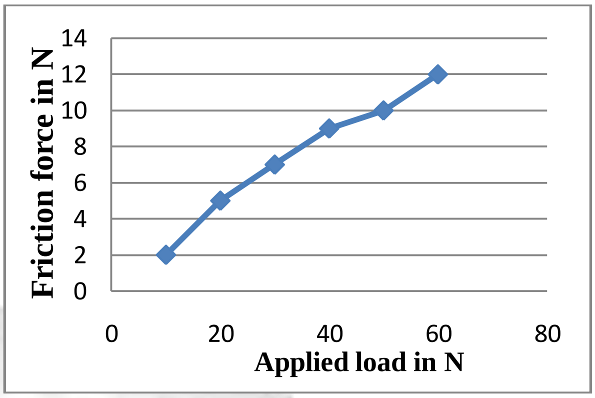

Fig.5: Load applied with 10 RPM roller and stainless steel Thickness 2 mm

Table 2. Load applied with 15 RPM roller and stainless steel Thickness 2 mm

Sr. No.	Applied load in N	Friction force in N
1	10	3
2	20	6
3	30	9
4	40	13
5	50	12
6	60	10

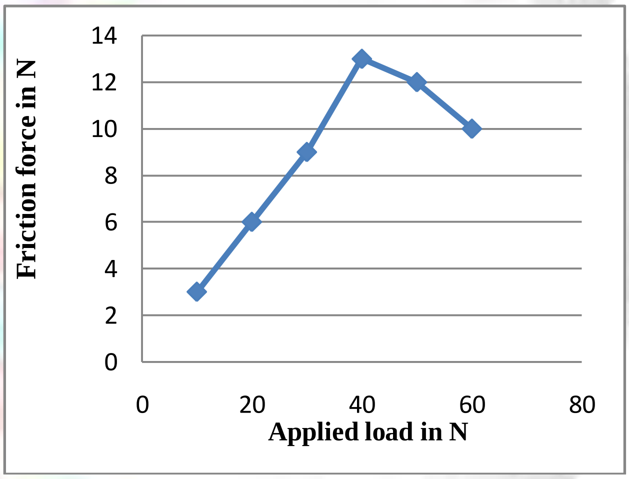

Fig.6. Load applied with 15 RPM roller and stainless steel Thickness 2 mm

Table .3. Load applied with 20 RPM roller and stainless steel Thickness 2 mm

Sr. No.	Applied load in N	Friction force in N
1	10	4
2	20	6
3	30	10
4	40	12
5	50	10
6	60	9

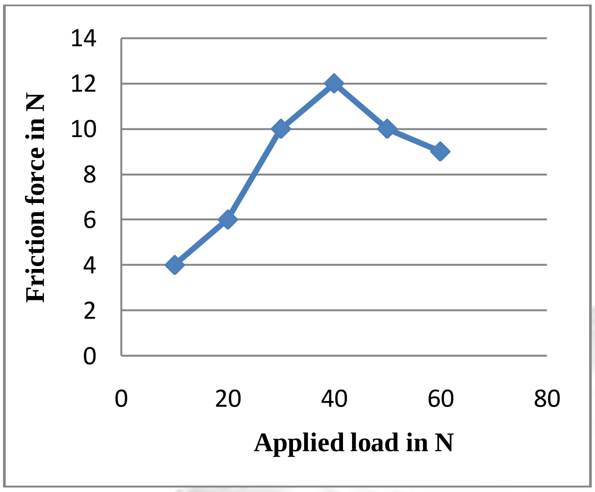

Fig.7: Load applied with 20 RPM roller and stainless steel Thickness 2 mm

IV. Conclusions

Tribological characteristics involved in sheet metal forming have been investigated using two experimental approaches: a load scanning type tester and a recently developed draw-bead type device. The following conclusions can be drawn from this study:

1. Comparing the results obtained by both experimental techniques load scanning always produced lower friction values. This difference could be due to the highest contact pressure on the load-scanning test.
2. A significant effect of reduction of friction by the running-in effect has been achieved by multi-pass load-scanning tests. The reduction of the friction occurs especially by the attenuation of the roughness components with high wavelength.

Reference

[1] S. Hogmark, S. Jacobson, O. Wanstrand, A new universal test for tribological evaluation, in: D.J. Schipper (Ed.), Proceedings 21st Meeting of International Research Group on Wear of Engineering Materials, IRG-OECD, Amsterdam, March, 1999, pp. 25–26.

[2] A. Ramalho, A reliability model for friction and wear experimental data, Wear 269 (2010) 213–223.

[3] W.C. Emmens, J. Bottema, Friction of aluminium in deep drawing, in: Proceedings IDDRG Congress, 1998.

[4] A. Azushima, J. Miyamoto, H. Kudo, Effect of surface topography of workpiece on pressure dependence of coefficient of friction in sheet metal forming, Ann. CIRP 47 (1) (1998) 479–482.

[5] Shigley, Joseph Edward, et al., Mechanical Engineering Design, 7th ed., McGraw- Hill, 2004.

[6] B.E. Soumya Subramonian, Evaluation of lubricants for stamping deep draw quality sheet metal in industrial environment; M.Sc. Thesis, Ohio State University, 2009.

[7] ZhuWei, Z.L. Zhang, X.H. Dong, Deep drawing of rectangle parts using variable blank holder force, Int. J. Adv. Manuf. Technol. 29 (2006) 885–889.

[8] E. Rabinowicz, Friction and Wear of Materials, 2nd ed., John Wiley & Sons, 1995.

[9] Peter J. Blau, Running-in: art or engineering? J. Mater. Eng. 13 (1991) 47–53

[10] K. Roll, Simulation of sheet metal forming – necessary developments in the future, in: P. Hora (Ed.), Proceedings NUMISHEET'08, 7th International Conference and Workshop on Numerical Simulation of 3D Sheet Metal Forming Processes – Part A, 2008, pp. 859–863, ISBN: 978-3-909386-80-2.

[11] Miklos Tisza, Numerical modeling and simulation in sheet metal forming academic and industrial perspectives, Mater. Sci. Forum 473–474 (2005) 135–140.

[12] Miklos Tisza, TiborFulop, A general overview of tribology of sheet metal forming, J. Technol. Plast. 2 (2001) 11–25.

[13] B. Podgornik, S. Hogmark, J. Pezdirnik, Comparison between different test methods for evaluation of galling properties of surface engineered tool surfaces, Wear 257 (2004) 843–851.

[14] B. Podgornik, S. Hogmark, O. Sandberg, V. Leskovsek, Wear resistance and anti-sticking properties of duplex treated forming tool steel, Wear 254 (2003) 1113–1121.

[15] B. Podgornik, S. Hogmark, Surface modification to improve friction and galling properties of forming tools, J. Mater. Process. Technol. 174 (2006) 334–341.

[16] B. Podgornik, S. Hogmark, O. Sandberg, Influence of surface roughness and coating type on the galling properties of coated forming tool steel, Surf. Coat. Technol. 184 (2004) 338–348.

[17] A. Ramalho, Study of the relationships friction – contact stresses using load scanner tests, in: Proceedings 11th Nordic Symposium on Tribology – NORDTRIB2004, 2004, pp. 699–707.

[18] B.H. Lee, Y.T. Keum, R.H. Wagoner, Modeling of the friction caused by lubrication and surface roughness in sheet metal forming, J. Mater. Process. Technol. 130–131 (2002) 60–63.

[19] J.H.C. de Souza, M. Liewald, Analysis of the tribological behaviour of polymer composite tool materials for sheet metal forming, Wear 268 (2010) 241–248.

[20] V. Severo, L. Vilhena, P.N. Silva, J.P. Dias, D. Becker, S. Wagner, A. Cavaleiro, Tribological behaviour of W–Ti–N coatings in semi-industrial strip-drawing tests, J. Mater. Process. Technol. 209–10 (2009) 4662–4667.

[21] D.D. Olsson, N. Bay, J.L. Andreasen, Int. J. Surf. Sci. Eng. 4 (1) (2010) 2–12.

[22] Hyunok Kim, Ji Hyun Sung, Rajesh Sivakumar, TaylanAltan, Evaluation of stamping lubricants using the deep drawing test, Int. J. Mach. Tool Manuf. 47 (2007) 2120–2132.

[23] Hongying Gong, Zhonling Lou, Zhiling Zhang, Studies on the friction and lubrication characteristics in the sheet steel drawing process, J. Mater. Process. Technol. 151 (2004) 328–333.

[24] S. Hao, B.E. Klamecki, S. Ramalingam, Friction measurement apparatus for sheet metal forming, Wear 224 (1999) 1–7.