Experimental and Theoretical Calculation of Energy Required in Extrusion Process

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Abstract

The main objective of this study is to find the best angle for tilting extrusion die by linking the die with springs having different stiffnesses and the die having different coefficients of friction. The energy required for each extrusion process was calculated and found for lubricant is less than for unlubricant. The results show good agreement between the theoretical and experimental results. The results show that the energy increase in a ratio of 7.64% for the lubricated cases and 20% for the unlubricated case, while when the spring stiffness is changed from 1000N/mm to 10000 N/mm the energy decrease in a ratio of 18.1% for the lubricated case and 34.15% for the unlubricated case. From these the best angle of the die can be deduced which was 8.7° when the stiffness of the spring is K=10000N/mm with μ =0.005.

الخلاصة

الهدف الرئيسي لهذه الدراسة هو لايجاد افضل زاوية لقالب بثق مائل وذلك بربط نوابض ذات معاملات جساءة مختلفة وقالب ذو معامل احتكاك مختلف . حيث انه تم حساب الطاقة المطلوبه لعملية البثق ووجد انها في حالة وجود تزييت تكون اقل من عدم وجود تزييت. وقد بينت الدراسة تقارب بين النتائج العملية والنظرية . حيث اوضحت النتائج بان الطاقة تزداد بنسبة 7.64% لحالات التزييت و 20% لحالة عدم التزييت ، بينما عند تغيير جساءة النابض من 1000 نيوتن/ملم الى 10000 نيوتن/ملم وجدنا ان الطاقة تنخفض بنسبة 18.1% في حالة التزيت و 34.15% في حالة عدم التزييت ومن هذه النتائج تم ايجاد افضل زاوية لعملية البثق حيث وجدت قيمتها 8.7° عندما يكون معامل الجساءة للنابض 10000 نيوتن/ملم ومعامل الاحتكاك 0.005 .

Introduction

This study includes a complete apparatus and a theoretical analysis using ANSYS package (V5.4) for extrusion process. A comparison is made between the two approach for the energy required in extrusion process.

Farouq M. ,1990 studied the effect of extrusion die profile on the mechanism of forward extrusion at different temperatures and he used the theoretical concepts (CMSR, CRHS) with different deformation rods and different die lengths. Abdul K., 2004 studied the die design and manufacturing preparation for extrusion by CAD/CAM of elliptical sections from round billets. Also he studied the stress distribution in the die by using ANSYS package. Bhavin et al, 2005 they applied CAD/CAM/CAE to design and manufacture streamlined dies, for extrusion of metals, polymers and composites, using a modified software package STREAM to design conical part streamlined dies, and packages like ALPID , ABAQUS, POLY3-D and FIDAP were applied to finite element analysis of materials flow inside the die, it is concluded that using a CAD/CAM/CAE system for designing and manufacturing of dies helps in obtaining better product quality and it is more economical.

According to the previous works, it is suggested for using the springs linked to the die to find the energy required for each extrusion process and then found the best die angle by manufacturing a complete system.

Theoretical Analysis

In the theoretical part (Tieupathir *et al*, 1997) the extrusion process is investigated by using ANSYS software, this program depends on the finite element method in the analysis (Saeed,1999) . The model of this study consider the visco-plastic case for the material and the coefficient of friction between the die and the metal flow where the coefficient of friction values are (0.005, 0.008, 0.015). A numerical solution considered the element (visco106) for the metal, the element (beam3) for the die and the element (combin14) for the spring stiffness. The spring stiffness vary (100 N/mm, 1000 N/mm and 10000N/mm).

The model considered in this work is the axi-symmtric model where this model considered the non-linear method of three elements to solve this problem and the effect of the friction in the solution which explain it by friction surface to surface by using the element (contac171 and targ169) and Newton–Raphson method was adopted to solve this model by ANSYS (ANSYS , structural manual, 1999) .

Experimental Analysis

The apparatus of the extrusion process is made to study the energy required of the process and to find the best angle for the extrusion die.

The dimensions of the experimental part is done in a similar way to the theoretical part and prepared the samples according to the standard methods with choosing slow and fixed velocity of extrusion, the assembly of extrusion is designed by using Acrylic material. It is also used in order to that the process can be photo and bearing the high pressure of extrusion process (Blazynski., 1976).

In this study, manufacture the extrusion instrument containing upper and lower plate and the metal spring fixing at the beginning of the die and it have the stiffnesses (100 N/mm, 1000 N/mm, 10000 N/mm).

Results

Figure (1) shows the experimental and theoretical results of load-displacement relations when the coefficient of friction is taken as 0.015 (without lubricant) and the stiffness of spring is equal 100 N/mm. Good agreement is presented between the theoretical and experimental results.

Figure (2) shows the experimental and theoretical results of load-displacement relations when the coefficient of friction is taken as 0.005 and 0.008 (with lubricant) and the stiffness of spring is equal 100 N/mm. Good agreement is seen between the theoretical and experimental results .

Figure (3) shows the experimental and theoretical results of load-displacement relations when the coefficient of friction is taken as 0.015 (without lubricant) and the stiffness of spring equal 1000 N/mm. Good agreement is presented between the theoretical and experimental results.

Figure (4) shows the experimental and theoretical results of load-displacement relations when the coefficient of friction is taken as 0.005 and 0.008 (with lubricant) and the stiffness of spring is equal 1000 N/mm. Good agreement is seen between the theoretical and experimental results.

Figure (5) shows the experimental and theoretical results of load-displacement relations when the coefficient of friction is taken as 0.015 (Without lubricant) and the stiffness of spring equal 10000 N/mm. Good agreement is seen between the theoretical and experimental results.

Figure (6) shows the experimental and theoretical results of load-displacement relations when the coefficient of friction is taken as 0.005 and 0.008

(with lubricant) and the stiffness of spring is equal 10000 N/mm. Good agreement is seen between the theoretical and experimental results.

The relation between the force and displacement in the theoretical part represents the perfect case for the extrusion process using the spring to link the die; this relation is direct relation, because the forming process occurs, till the force reaches to maximum value. After the forming process is finished and due to constant area at the outlet of the die the force is decreased.

The relation between the force and displacement in the experimental part represents the actual case of the extrusion process with die linked to spring, in which the force increases with the extrusion displacement inside the die, till the forming process is finished, then the force has still the same value with displaced sample until it exits from the outlet of the die.

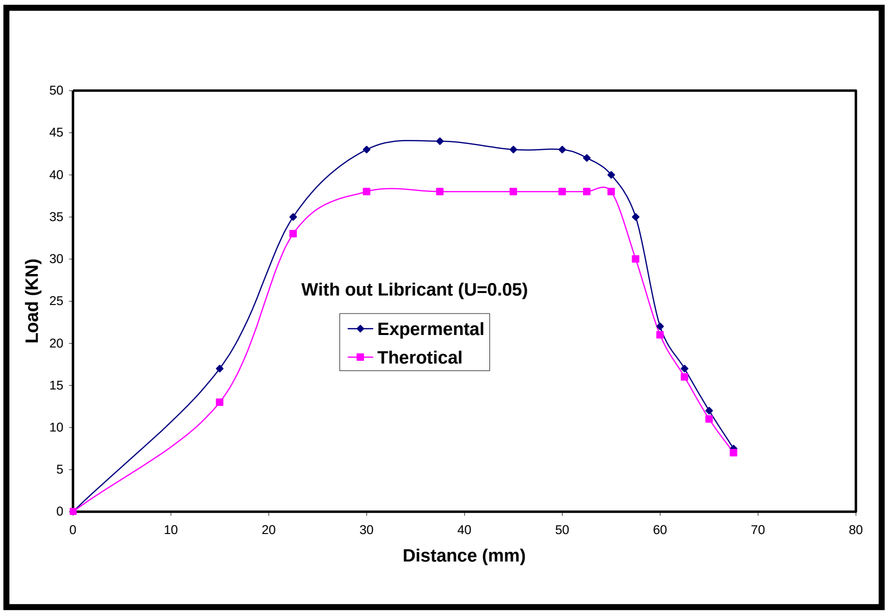

Fig. (1) The load- displacement, when K=100N/mm and μ=0.015

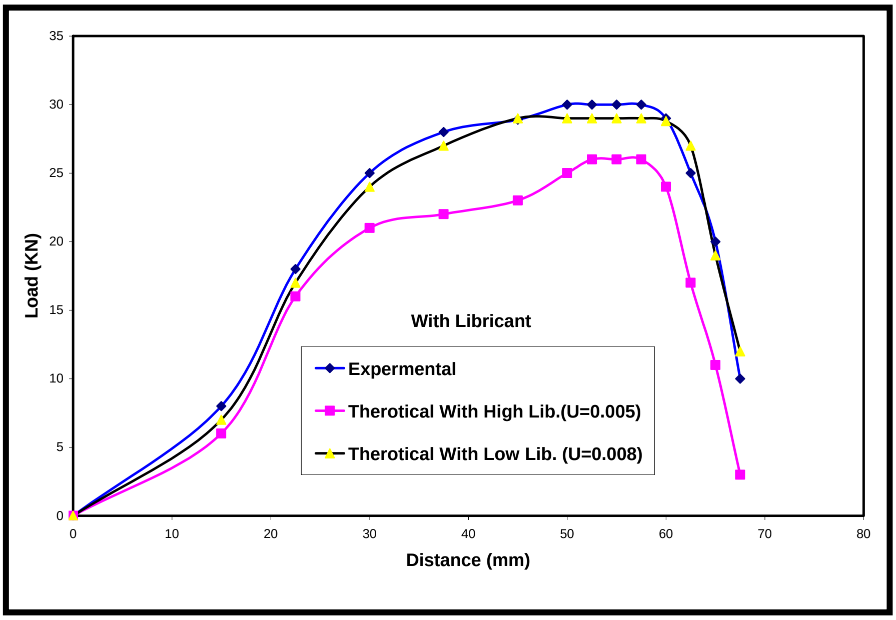

Fig. (2) The load- displacement, when K=100 N/mm

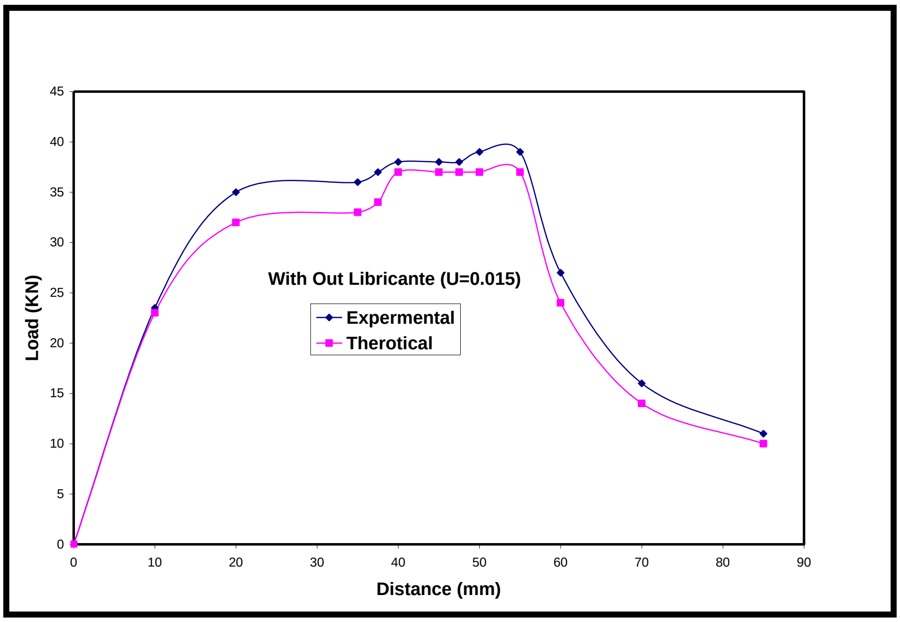

Fig. (3) The load- displacement, when K=1000 N/mm and μ=0.015

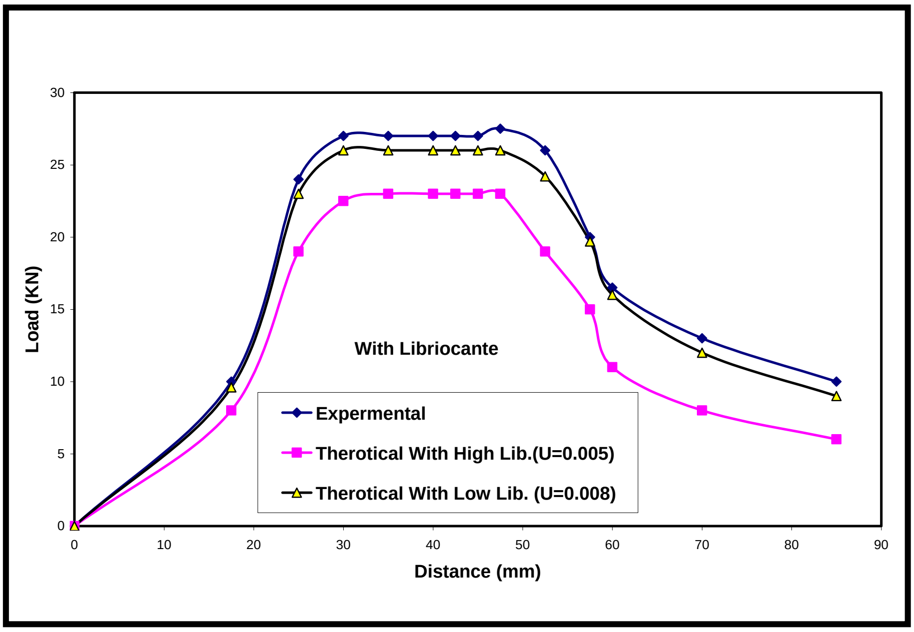

Fig. (4) The load- displacement, when K=1000 N/mm

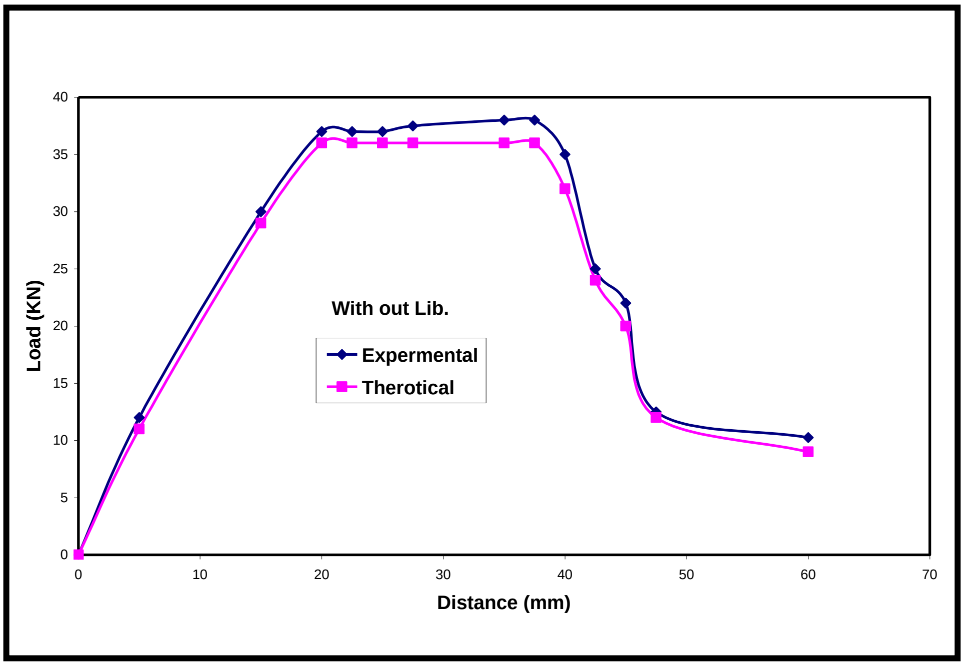

Fig.(5)The load- displacement , when K=10000 N/mm and μ=0.015

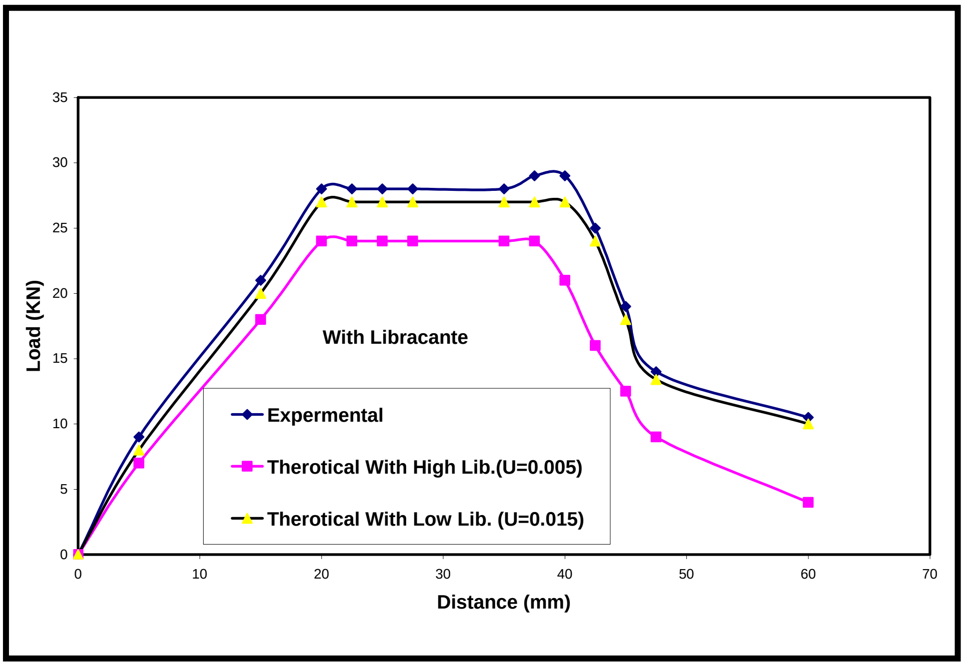

Fig. (6) The load- displacement, when K=10000 N/mm

Discussions

In order to give a more practical meaning to tilting dies extrusion and the effect of spring stiffness, the energy required for each extrusion process was calculated and tabulated as shown in table (1). This extrusion energy represents the product of punch load and punch distance traveled . It can be seen that the energy required for the lubricated process is less than that for the unlubricated, this is true since lubrication reduces the losses during the process. Another remark can be withdrawn from these results regarding the spring supporting each half of the die , namely , as the spring stiffness increases from 100 N/mm to 1000 N/mm , the energy increases in a ratio of 7.64 % for the lubricated case and 20.61% for the unlubricated case. While , when the spring stiffness is changed from 1000 N/mm to 10000 N/mm, the energy decreases in a ratio of 18.1% for the lubricated case and 34.15% for the unlubricated case .

Table (1) Energy required for each extrusion case

Case of Lubrication	Spring Stiffness N/mm	Energy (N/mm) Theoretical	Energy (N/mm) Experimental
With lubricant	100	1256.5	1349.25
Without lubricant	100	1759	1983.5
With lubricant	1000	1352.5	1444
Without lubricant	1000	2121.5	2303.5
With lubricant	10000	1107.75	1177.25
Without lubricant	10000	1397.125	1486

Conclusions

From the theoretical and experimental works, it can be concluded that the force needed to make the extrusion process is increased with decreasing the stiffness of spring i.e. when the stiffness of spring increases we get the less force.

The best semi- angle of the die that is concluded in this study is (16^o) without using lubricant (μ=0.015) and (8.7^o) when lubricant (μ=0.005) is used and the worst semi-angle is (16^o) without lubricant and (28^o) with lubricant.

References

Abdul Kareem Jaleel, 2004, “Assessment of die design and manufacturing preparation for the extrusion of elliptical section from round billets" Ph.D. thesis, Uni. of Tech. Iraq.

ANSYS, 1999 , " Structural Manual" , Ansys , Inc.

Bhavin, V.M., Gunasekera J.S., Kapadia A. And Z. Yu, 2005, “CAE of extrusion dies for metal and polymers flows" (http://books.google.com/books?hl=en&lr=&id=DMYXKb9C9boC&oi=fnd&pg=PR19&dq=CAE+of+extrusion+dies+for+metal+and+polymers+flows&ots=nxNht-RoOh&sig=-tA6I5FmubatNSUbPVTikS3bM0M).

Blazynski, T.Z., 1976, " Metal forming , Tool Profiles and flow " ,London.

Farouq M. Al-Salmani, 1990, "Effect of extrusion die profile on the mechanism of forward extrusion on aluminum alloy" Ph.D. thesis, Uni. of Tech. Iraq.

Saeed Moaveni , 1999, " Finite Element Analysis , Theory and Application with ANSYS".

Tieupathir Ch. & Ashak D. Belegunda, 1997, " Introduction to Finite Element in Engineering" , Prentice Hall of India.