

*Factors Affecting The Flow of Metals  
In Extrusion Process*

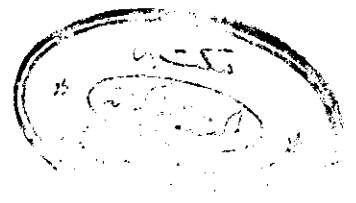
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*Thesis  
Submitted to  
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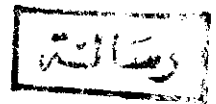
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*in  
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( Metal Forming )*

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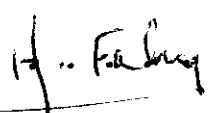




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"FACTORS AFFECTING THE FLOW OF METALS  
IN EXTRUSION PROCESS"

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Arabic Summary .

## S U M M A R Y

### Factors affecting the flow of metals in extrusion process

The aim of this investigation was to study the effect of the extruded shape geometry on the extrusion process. This was done by comparing the extrusion loads required to extrude various shapes with the loads required for the circular section of the same area.

The effect of both extrusion ratio and extrusion temperature on the extrusion process were also studied.

The extrusion process was discussed in terms of the following parameters:

- 1- Maximum experimentally obtained extrusion pressure ( $P_e$ ).
- 2- Ideal extrusion pressure  $P_h$  (pressure to overcome homogeneous deformation without friction).
- 3- The extrusion pressure at the transition (coring) point ( $P_o$ ).
- 4- The extra pressure due to the inhomogeneous or redundant deformation of metal ( $P_r$ ).
- 5- The pressure required to overcome frictional work ( $P_f$ ).
- 6- The extrusion efficiency  $\eta = P_h / P_e$ .
- 7- Redundant work factor  $\alpha = P_o / P_h$ .
- 8- Redundant work ratio  $P_r / P_e$ .
- 9- Frictional work ratio  $P_f / P_e$ .

The flow of the metal was studied using the grid lines on the specimens meridional planes.

The material tested in the present work was commercial purity aluminium; and the extrusion was carried out in an experimental sub-press 25mm. inside diameter which can be heated to the required test temperature.

The experimental results and discussions led to the main four following conclusions:

- In general the circular sections required the least pressure. The increase of the extrusion pressure of the rectangular sections over that of the circular sections varied from 2% to 28%. The difference increased as the breadth to width ratio ( $a/b$ ) of the shape increased. This was attributed to the increase in redundant deformation.

- The value of the ideal extrusion pressure ( $P_h$ ) was found to increase linearly with increasing reduction ratio according to the relation  $P_h = \sigma \ln (A_0 / A_1)$ .

where

$\sigma$  = The flow stress of the metal  $\text{kg/mm}^2$ .

$A_0$  = Initial cross section area "before extrusion"  $\text{mm}^2$ .

$A_1$  = Final cross section area "after extrusion"  $\text{mm}^2$ .

- There was no effect of neither reduction nor temperature on the frictional work ratio ( $P_f/P_e$ ) since the coefficient of friction ( $\mu$ ) was almost constant.

The value of the frictional work ratio was about 16.6 %.

- The extrusion efficiency ( $\eta$ ) of the extrusion process was found to be a maximum at an extrusion reduction of 18.5 for all shapes, and increased with increasing temperature. This was attributed to the improved homogeneity of the flow.

The value of the extrusion efficiency ( $\eta$ ) ranged between 50 % and 65 %.



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## Chapter I

### 1-1 Introduction

Progress has been made in understanding the technology of extrusion since the process was first introduced by Bramah in 1797. Increased insight into the process has been gained, through both experimental and theoretical analysis, in areas such as the pressure of extrusion, temperature rise and distribution during extrusion, and patterns of metal flow under different boundary conditions. Extrusion technology today permits the routine extrusion of tubes, intricate shapes and extrusions of varying cross section (stepped extrusions) .

The theory of extrusion, as in many of the manufacturing fields has lagged considerably behind the know-how of practice. In 1931 Siebel and Fanger first presented an analytical method for calculating the extrusion energy. The analysis of extrusion process was based on the so called "metal strain theory" until the appearance of Hill's work in 1948 using the slip line theory. Considerable application of the slip line theory to the extrusion problem and some experimental verification are due to Johnson and his co-workers, later Johnson and Kudo-applied the upper bound method to various extrusion problems.

One of the reasons that caused the slow progress of understanding the extrusion problem was the lack of data on the behaviour of metals under complex working conditions.

However, suitable correlations can now be obtained between the practical behaviour and laboratory tests. But even then, fundamental informations is readily available only for pure metal and solid solution.