

# LOADING AND DEFORMATION PROGRESSION DURING OPEN FORGING OF HOLLOW CYLINDRICAL BLANKS

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## Abstract

A solution for a hollow cylindrical blank with a velocity field derived from the equations of equilibrium and compatibility conditions is obtained. The solution, accounts for both platen interfacial friction and the blank geometry. The platens were assumed as flat bodies moving normal to the blank surface. The problem is solved by the upper-bound approach, with the assumption of constant shear factor (average coefficient of friction) between platens and blank. The radius of the blank which does not experience deformation during the forging process is referred to as the neutral radius, and was determined by power minimization. The neutral radius as well as the friction coefficient at the blank interface were found to play an important role in determining the average forging pressure and the blank deformation from initial to final configurations.

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**Key Words:** Forging, Deformation, Interfacial Pressure, Upper Bound Approach

## Nomenclature

$J^*$	– Total consumed energy
$m$	– Friction coefficient
$p_{av}$	– Average forging pressure at interfacial surface
$P$	– Forging load
$R_i, R_o, R_n, R$	– Inner, outer, neutral and general radii, respectively
$T$	– Blank thickness
$\dot{U}$	– Upper platen velocity
$\dot{U}_y, \dot{U}_\theta, \dot{U}_R$	– Deformation rate in $y$ , $\theta$ , and $R$ directions, respectively
$\dot{W}_f$	– Frictional energy
$\dot{W}_i$	– Internal power of deformation
$y, \theta, R$	– Cylindrical coordinates
$\dot{\epsilon}_{yy}, \dot{\epsilon}_{\theta\theta}, \dot{\epsilon}_{RR}$	– Strain rates in $y$ , $\theta$ , and $R$ coordinate system, respectively
$\sigma_o$	– Blank material flow stress
$\tau$	– Shear stress

## 1. INTRODUCTION

During the last few years, forged metal components have assumed an important position in industry, as they are being used successfully in a wide range of applications. Both the mechanical and metallurgical properties of forged metal components compare favourably, and are even superior, to those of cast and machined ones [1-4]. Quite frequently, bulk processing of components by forging is used as a convenient method of reducing or eliminating the

- The continued deformed shape of the blank is mainly governed by its initial dimensions and material as well as the friction coefficient at the blank-platen interface.
- The location of the neutral radius during the forging process influences both the deformed outside ( $R_o$ ) and inside ( $R_i$ ) radii of the blank. If the neutral radius becomes less than the inner radius at any stage of deformation, both the inside and outside radii of the sample continue to increase. However, if the neutral radius exceeds the inner radius, then, the outer radius increases while the inner radius decreases. The blank thickness always decreases during deformation, regardless of the magnitude of neutral radius.
- The relative forging pressure on the blank increases with deformation and high friction coefficient at the blank-platen interface.
- The effect of upper platen velocity on blank deformation and relative average forging pressure is negligible for commonly used velocity range.

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