ABSTRACT

The demand of miniature components in the field of manufacturing, aviation, electronics, medical science, space technology, and nano technology is increasing day-by-day. To meet up those demands a dedicated process with novel design and development is essential in manufacturing of miniature components. Industrial sectors are now focusing on key issues in micro manufacturing and their ability to meet the manufacturing and quality requirements. Apart from feasibility; micro manufacturing also focuses on practicality of manufacturing process to be employed in mass production. One such emerging micro manufacturing process is micro-forming.

Although the conventional knowledge, methods and tools for analysis of material behaviour in macro-forming process have been well established, the development of micro-forming processes cannot depend upon those established knowledge due to size effects. Better understanding of size effects and related mechanism is essential because, it leads to inaccuracy in product due to the increase in the scattered process parameters. Along with size effect, friction is an important parameter, which affects the dimensions of extruded product.

The aim of the present work is to investigate the viability of one of the important micro-forming process for producing high quality and defect free micro parts using copper. The material formability is predominantly dependent on size effects and interfacial friction at micro-scale. Further, the mechanical properties of micro parts are governed by grain size, shape and orientation. Proper understanding of material deformation pattern at varying grain sizes and effect of friction is critical is predicting the quality of micro-parts.

Current work investigates the influence of grain sizes on material behavior. Experiments are carried using indigenously developed micro-forming tooling system. Three different grain sizes were accounted in copper for

investigation. Effect of each grain on punch force was investigated and found that smaller grains exhibited higher forming load and better formability compared with larger grains. To investigate the effect of friction at micro scale deformation three different lubrication conditions are examined.

Force displacement curve for each grain size under different friction conditions are noted and the effects of different process parameters are investigated. A significant reduction of forming force is noticed due to the difference in adhesion behavior between tool and coated die. To overcome the problems caused by size effect, hot micro-extrusion process is adopted. To raise forming temperature a suitable heating assistance setup is developed and interfaced with die assembly. The effect of temperature on extrusion force, friction, microhardness and surface finish are discussed in detail.

Better material formability and good replication of die dimensions along with homogeneous material behavior was observed when forming temperature is raised. The results obtained from this work will definitely facilitate in producing defect less micro components with high dimensional accuracy and dedicated micro manufacturing process for mass production. The outcomes of this research work have a high potential in bulk manufacturing of micro components for micro-electromechanical system, bio-medical industry and electronics industry