MECHANICS OF FORMATION AND STRENGTH OF A CLASS OF PLASTIC FLOW JOINT

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Dedicated to

My Father Shri Akella Rama Sastry
&
My Mother Shrimati Akella Savithri

CERTIFICATE

*This is to certify that the thesis entitled **'Mechanics of Formation and Strength of a Class of Plastic Flow Joint'** being submitted by **Sri A. S. Prakash** to the Indian Institute of Technology, Delhi for the award of the Degree of **Doctor of Philosophy** is a record of bonafide research work carried by him under our supervision and guidance. The thesis work, in our opinion, has reached the requisite standard for the Doctor of Philosophy Degree.*

The results contained in this thesis have not been submitted in part or full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Plastic Flow Joint (or PFJ) involves the rigid joining of two components by applying a forming load on a small area of one of the components so that it undergoes a plastic deformation and flows. This flow is directed into pre-fabricated grooves on the second component, thus producing a joint called as the PFJ. This joining process possesses several inherent advantages that include absence of protrusions, little production of heat, reduced weight of assembly and possibility of joining dis-similar materials.

Plastic flow joints may be classified as axisymmetric and non axisymmetric depending upon the shape of the mating surfaces. In the present study, plastic flow joints were produced between a circular shaft and a disc having a central hole to accommodate the shaft. One or more grooves are produced on the shaft. The shaft is slipped through the central hole in the disc and is positioned centrally over the grooves. A portion of the disc is subjected to axial compression with the a help of a special die. It causes some of the disc material to flow into the groove and produces a permanent joint.

The present work is concerned with the study of strength and mechanics of formation of the axisymmetric and plane plastic flow joints. The strength of the PFJ has been analyzed by conducting a series of experiments involving fabrication of the forming dies and other components of the set-up, preparation of shaft and disc specimens, machining of grooves of different shapes, dimensions and configuration on shafts, actual production of joints, fabrication

of set-ups for strength testing the joints and carrying out the actual tests. Experimental results on the strength of the axisymmetric plastic flow joints have been presented and discussed. Groove geometries employed include circular, triangular, rectangular, and square and groove dispositions include axisymmetric, knurling, longitudinal slots and keyways. The strength of the plastic flow joint is found to increase with increase in width of groove and number of grooves. Use of knurling on the shaft enhances its strength.

The mechanics of formation of PFJ has been studied in three different ways namely visualisation of flow pattern using plasticine, obtaining the limit load using the upper bound technique and numerical simulation of the joining processes using the finite element technique. The result of the flow pattern obtained from plasticine modelling were utilised to construct a velocity field for the proposed upper bound solution of the forming processes. The finite element simulation model of the joining process has been analyzed with the help of the Forge2 code. Computational results on the deformation pattern and on the distribution of equivalent stress, equivalent strain and equivalent strain rate at different stages of the forming process are presented and discussed. The influence of the different process parameters namely the groove geometry, groove dimensions and their number has been analyzed. The variations of the forming load and extent of groove fill-out during the course of the joining process have also been studied. The upper bound loads calculated were found to be in reasonable conformity with the experimentally determined loads. The finite element simulation provides detailed results on the pattern of deformation and the distribution of stress and strain in the disc. It is also found that the geometry of the groove greatly influences the groove fill-out. For grooves with smaller front width, groove fill-out rate is fond to be higher..

The main contribution of the present thesis is in the modelling and analysis of the forming process of the plastic flow joint and in generating strength data of the joint for possible use by the designers.

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