Evaluation of Deformation and Densification Behavior in Sintered Fe-0.8%C-1.0%Mo Steel Preforms

A. Narayanan R. Kannan[1,*] K.S. Pandey[2] S. Shanmugam[3]

[1]Mechanical and Manufacturing Engineering, School of Engineering and Physics, Faculty of Science & Technology, Engineering Division, The University of the South Pacific, Laucala Campus, Suva, FIJI. E-mail: ananthanarayanan_r@usp.ac.fj
[2]Maulana Azad National Institute of Technology, Bhopal – 462 007, Madhya Pradesh, India.
[3]Department of Mechanical Engineering, National Institute of Technology, Tiruchirappalli – 620 015, TamilNadu, India.

Present investigation is aimed to evaluate the densification behaviour of sintered iron-carbon-molybdenum powder metallurgy steel system under the influence of two different heights – to – diameter ratio, namely 0.40 and 0.75 respectively. The sintered preforms are produced by proper selection of aforementioned materials and mixed in a proportion to yield Fe-0.8%C-1.0%Mo, which were blended to achieve a homogenous mix using pot mill. These powder mixes are consolidated on a suitable die set assembly to make a cylindrical shape of preform of two different aspect ratios using 100tons capacity hydraulic press. Further, the green compacts are sintered and are subjected to cold deformation operation. Incremental step of loadings were applied on the preform under dry friction condition. The critical evaluation of compressive deformation, which contributing for the densification of material reveals that induced strain are linearly contributing to enhance densification till the specimen fracture; however overall resistance to deformation of material is exhibiting in three different responses with respect to enhancement in densification. That is at initially, high resistance to deformation followed by high kinetics of deformation and finally exhibiting little resistance against overall deformation. Although, the aforementioned criteria is common for both the aspect ratios, the applied deformation is little homogeneous when aspect ratio is less that directly contributes to enhance the rate of attainment of densification as little faster.

Key words- **Deformation & Densification behaviour, Strain, Poisson's ratio, True stress**

I. INTRODUCTION

Powder metallurgy is at times the only manufacturing route that can be used for some materials such as porous materials, composite materials, refractory materials and special high duty alloys [1]. The P/M processes employed to produce components from such materials include loose powder sintering, liquid phase sintering, cold and hot isostatic pressing and other powder preform forming techniques. Less obvious applications of P/M involve common materials since these can also be processed by casting, metal forming and machining, however P/M method competes with other methods on the basis of cost which can be lower for high volume production of complicated parts. In most cases such components are manufactured using a conventional P/M route, which involves compaction of the metal powder, followed by sintering [2]. Meanwhile understanding the densification and deformation behaviour of powder preforms during compaction and secondary forming operation is very important in achieving good quality P/M parts. Uneven density distribution in powder compacts gives rise to distortion of parts after sintering and pores in parts, which are detrimental to their mechanical properties.

The presence of pores in a powder preform can be attributed to the combined effect of inadequate application of pressure, powder size, shape and its distribution, compaction temperature, purity of the powder particles and atmosphere under which the compaction has been performed [3,4]. Depending upon the aforementioned conditions the shape, size and distribution of pres affect the properties of powder preforms, leaving aside the material properties. In general, the pores must be closed to achieve full density and a sound metallurgical structure. Since, pores are sites of weakness where cracks may be initiated during deformation [5].

The chance of pore closure in the compaction stages are quite small because the pore closure kinetics is a function of shear stress existing around it [6,7] and magnitude of the shear stress in any point inside the compact is gradually changing while the pressure is being applied. Once the powder preform is subjected to secondary deforming operation such as cold forging (uniaxial compression), gradual changes in density are expected. This is due to the fact that extensive heterogeneous deformation occurs and the pores are subjected to shear as well as compressive forces; a situation more favourable for pore closure.

In the light of above fact, the present investigation is aimed to evaluate the densification behavior of sintered Fe-0.8%C-1.0%Mo P/M steel preforms during the cold upset forming operation because of the industrial importance of the above steel. In fact, many industrial application of steels such as in structural applications and in tool steel making etc., the steel of eutectoid