CHAPTER 1

INTRODUCTION

The great challenge posed to process designer in metal forming is to produce shapes economically with required mechanical properties and quality. This necessitates the designer to have an understanding of the behavior of metals and alloys at hot deformation conditions. The finite element methods and deformation processing maps are the two important tools used to characterize the material behavior under different processing conditions in metal forming operations. To use these techniques effectively for better process control and parameter optimization in the hot working operation an accurate constitutive model is needed.

Since the constitutive relation among flow stress, strain, strain rate and temperature is complex and nonlinear, the results obtained from the conventional approaches to constitutive modeling are not accurate. Because of the inherent properties the ANN approach is found to be an alternative to the traditional modeling

1.1 MOTIVATION OF THE RESEARCH WORK

Though a large amount of flow stress data for hot working of aluminum wrought alloys is available in the literature the flow stress data for hot working of as cast aluminum alloys are very much limited. Hence flow stress data of cast 4043 (Al-5Si), 5182(Al-4.5Mg) and RR58 aluminum alloys have been generated by conducting compression tests.
The flow stress data obtained from the experiments were used in conjunction with back propagation (BP) neural network for the purpose of the training network. This could in turn be used to predict the flow stress value for any given processing conditions.

1.2 AIMS OF THE RESEARCH

The aim of the present investigation is also to study the deformation processing of aluminum alloys with a view to establishing an interrelation between the process parameters (temperature and strain rate), the microstructure and the product properties namely yield strength, reduction in area and hardness. Based on the micrographs and mechanical properties optimum process parameters namely the safe processing windows for the cast aluminum alloys have been identified.

1.3 RESEARCH OBJECTIVES

The following aspects are taken as objectives of the present research work:

- To determine the flow stress data of cast Al-5Si, Al-4.5Mg and RR58 aluminum alloys by conducting compression tests in the range of temperatures from 500K to 800 K and strain rates from 0.02 s\(^{-1}\) to 8 s\(^{-1}\).
- To develop artificial neural network model using the above experimental data.
- To determine the safe working and instability regimes from the processing map developed by the application of the predicted flow stress data.
- To compare the processing maps of as cast alloys with that of wrought alloys available in the literature.
1.4 RESEARCH METHODOLOGY

1.4.1 Experimental Determination of Flow Stress

Flow stress of the metals can be determined by using various kinds of tests like tension test, torsion test, ring test and compression test etc. Among these tests, compression tests give unambiguous results. Hence they are preferred to determine the flow stress.

- During the test, a state of uniform stress must be maintained in the sample along with isothermal test conditions.
- Other methods used for determining flow stress are tensile test, ring test and torsion test
- The data obtained from tensile test are of limited use in bulk metal forming (forging, rolling) processes, because the results are valid only for relatively small amounts of plastic strains. On the other hand flow stress data found by compression test is valid for large amounts of strains, as experienced in most bulk metal forming processes.
- The torsion test is typically used for finding flow stress data at higher true strains up to 2 to 4.

The temperature range 500-800 K and strain rates 0.02, 0.2 and 8 s\(^{-1}\) are selected to conduct the compression tests. These selections are based on the flow stress data of the wrought alloys 4043, 5182 and RR 58 aluminum alloys available in the literature, Prasad and Sasidhara (1997).
1.4.2 Establishment of ANN Model Using Experimental Data

The most preferred ANN by various authors is feed forward back propagation training neural network to predict flow stress values. Three layer network architecture along with one hidden layer is selected.

1.4.3 Construction of Deformation Processing Map Using ANN Data

The power dissipation map is first prepared. The strain rate sensitivity factor is used to determine the power dissipation efficiency which is contour plotted as a function of temperature and strain rate. The instability map is constructed by plotting instability as a function of temperature and strain rate. These two maps are super imposed to identify the safe regimes and instability regimes.

1.5 ORGANIZATION OF THE THESIS

The thesis has been organized in the following chapters. The second chapter deals with the literature survey which gives the review of the use of ANN for prediction of flow stress values and use of ANN in the development of processing map. The third chapter describes the research methodology and scheme of the work to be carried out. The fourth chapter deals with the experimental determination of flow stress using compression tests. It also describes the ANN modeling using experimental data and the development of processing map using the ANN predicted data.

The fifth chapter gives the results and discussions. The sixth chapter provides the important conclusions derived from the research.