CHAPTER I

INTRODUCTION

I. INTRODUCTION

1. General:

Austenitic stainless steels occupy an important place among the sophisticated materials today, owing to their excellent combination of properties such as high corrosion-resistance, formability, weldability and very desirable low temperature properties. In general, the austenitic structure is maintained at room temperature on account of one or more austenite stabilizers like Nickel or Manganese. Thus a common commercial grade (AISI 304) belonging to this series contains about 2% Mn in addition to 18% Cr and 8% Ni.

Phase transformations in these steels, particularly in the AISI 300-series, have been of interest to many researchers because these are quite close to being other than totally austenitic.[1] Consequently, thermo-mechanical treatments lead to the transformation of austenite to other phases, notably to martensite - a fact, known for quite sometime.[2] However, one can again draw specific distinctions between the types of martensites formed,and a considerable effort and discussion have been channelised towards understanding their property, morphology and mode of transformation. The martensitic transformation resulting from metastable austenite is of interest because of at least two important reasons - (a) such a transformation induces strength in the structure which otherwise does not lend itself to conventional heat-treatment techniques (b) this transformation plays an important role in imparting ductility to the TRIP Steels.[3,4]

It is generally noted[5,6] that steels of the 300 series (18% Cr, 8% Ni) transforms martensitically to two products - one magnetic and body-centered cubic (α') and the other, non-magnetic and hexagonal close-packed (ε). While the transformation to α'-martensite by deformation below the M_d temperature is fairly well established[6-21], the mode of transformation to ε (in an analogous manner, below E_d when deformation-induced or E_s when spontaneous) is less distinctly understood. Since ε-martensite is commonly observed in conjunction with α'-martensite in the Fe-Cr-Ni alloys, the sequence of transformation of the martensites has been of considerable discussion. A good deal of controversy exists in this area. However, the broad view-points which emerge in this connexion can be put down as follows:

(i) ε-forms first and α' nucleates from the ε-bands.[7,9-11,22-]

(ii) austenite (γ) transforms directly to α'[26-28] with ε forming as a sequel to the rather large shear-strain component of the invariant plain strain associated with the γ - α' transformation and the low stacking fault energy (SFE) of the untransformed austenite.

It is established that increasing strain and decreasing temperature tend to induce more α'[14-30], although the amount of ε has been shown[29-30] to pass through a maximum with increasing strain. The alloy chemistry has also been shown to play an important role in deciding the choice between α' and ε transformation of γ.

Apart from the austenite and martensite phases, the presence of the body-centered delta ferrite (δ), its appearance and morphology have also been of considerable interest both to researchers and technologists because of its influence in welding[31]. The extent of delta (δ), which is essentially a high temperature phase, in the structure has been shown to be governed by the temperature and composition of the alloys.[32-33]

Corrosion of stainless steel is another subject which has attracted considerable study and research[34]. With regard to the general corrosion of the austenitic steels, there is a near unanimity to the effect that these are highly resistant to industrial atmosphere and acid media. However, as conditions become more severe (stronger acids, higher temperatures etc.) additions of several alloying elements to the Fe-Ni-Cr base become imperative.

In view of a general shortage of Nickel, attempts have been on for several years now to replace this element partially or fully. The elements, which have been generally favoured for performing this function are Nitrogen[35-38] or Manganese.[35,37-38] Although no serious attempts have been made to explore Copper for this purpose, the element has been added to some martensitic variety of precipitation grades (e.g. 17-4 PH) of stainless steels, also termed as stainless maraging steels. In maraging steels proper however, some attempts have been made[39] to replace Nickel partly by Copper in view of the similarity between the Fe-Ni, and Fe-Cu equilibrium diagrams. Although it is known that in the presence of Nickel, the solubility of Copper in the Fe-Cr lattice increases appreciably and in the common 304 grade the figure is around 8%[40] (compared to only 3.5% and 2.1% in austenite and ferrite phases respectively in the binary Fe-Cu system[2,41-47]), it has been recommended to add Nickel upto at least half the amount of copper to counter the deleterious effect of the latter in hot-working properties of austenitic stainless steels.[48]

2. Scope of the Present Investigation:

As the literature reveals, compared to the situation prevailing with regard to the behaviour of conventional 300-series stainless steels the extent of information available on the phase transformation and corrosion behaviour of the copper-bearing grades is rather scanty although copper is added to some varieties of stainless steels and in principle, can replace, at least partly, Nickel in the austenitic variety. The present investigation has therefore been carried out on a series of copper bearing stainless steels. The chemistry of the various alloys has been selected keeping in mind the following broad aims -

(i) Examining the behaviour of the 304-type when various levels of Copper are added to the basic composition

(ii) Gaining an insight into the behaviour of the 304-types where Copper has substituted Nickel to various extents.

(iii) To investigate the behaviour of steels where Mn has been brought down to almost negligible levels so that the characteristics of copper containing non-manganese steels can be established.

(iv) Assessing the role of Cobalt and Molybdenum in these steels in the light of the fact that they have been added in the past to some copper substituted varieties of maraging steels for preventing harmful distribution of precipitates.

The investigations have been undertaken essentially in two directions -

One, in which martensitic phase transformations during room and sub-zero temperature deformation have been studied. The strain hardening characteristics following these treatments have been included in this analysis, as also the changes brought about during ageing following the deformation. Further, the presence of delta-ferrite and its behaviour during the above treatments has been looked into. It may be added in this connexion that the mode of deformation adopted by most of previous researchers in similar field has been uniaxial (either tension,[6-8,10-22] or compression) while only a limited number of published work[22,49,50] relates to a more common mode - i.e. rolling. For this reason the present investigation has chosen to look into the transformation characteristics of rolled sheets. Detailed TEM and optical microscopic studies have been included in order to throw some light on the characteristics of various phases present. magnetic property changes have been undertaken.

The second aspect has been the general corrosion behaviour of the various grades of steels chosen. For this purpose an extensive study using a combined polarisation technique has been undertaken.