# ABSTRACT

Nitrogen Alloyed Martensitic Stainless Steel (NAMSS) is a new class of material for aero, automobile, nuclear, corrosive and wear resistant applications. Specialty of NAMSS is high hardness without compromising toughness due to nitrogen.

Nitrogen is an interstitial element. The main difficulty in production of NAMSS is the solubility of nitrogen. Therefore, NAMSS were produced using different advanced technology such as AOD, VOD, VIM, VAR, PESR, HIP etc. A common limitation of various techniques is that they have to be processed in controlled atmospheric conditions with specialized equipment which is highly expensive.

Conventional high frequency induction melting can be opted as a better choice to overcome the above stated limitation because of its ease of operation when supported by proper alloy design and process control. The work involved in this research is production and characterization of NAMSS in cast, heat treated, forged and heat treated condition.

Detailed literature review has confirmed the following observations.

- Nitrogen solubility increases by adding elements like Cr, Mn, Mo, Nb, V and Ti.
- Optimum heat treatment temperatures for NAMSS are greater than 900°C and less than 1100°C.

- Optimum (thermo mechanical treatment) hot forging temperature for NAMSS is greater than 1000℃ and lesser than 1100℃.
- Increase in wear resistance on dry sliding contacts depends on the hardness and precipitates on the material.
- Increase in corrosion resistance on Sulfuric acid depends on Chromium, Nitrogen and Carbon contents.

Even though extensive work on production and characterization of nitrogen alloys stainless steel has been done, the production of NAMSS using regular induction furnace and further processing by hot forging have not been reported. The present work involves production of NAMSS with different nitrogen and chromium contents using quality tools like QFD, FMEA and to study the effect of heat treatment between 900℃ to 1100℃ and then hot forging to study the effect of various sizes of reduction.

Interest was particularly focused on understanding the role of nitrogen in improving the mechanical properties like hardness, impact strength, and tensile strength, yield strength of NAMSS specimen before and after hot forging.

The scope of the present investigation is limited to NAMSS.

The experimental procedure adopted in this research is carried out as three phases.

The data on results and detailed discussions on the findings of this research work are given as phase I, phase II and phase III.

In phase I the results and discussion of alloy design using QFD and production process control using FMEA are presented for eleven melts. The actual nitrogen solubility obtained (0.05 to 0.125 wt%N) is compared with theoretical nitrogen solubility (0.0974 to 0.1279wt%N). Among the 11 melts of different compositions produced only six melts were taken up for this research. Five melts were rejected due to gas defects because of higher nitrogen and melt was rejected due to higher chromium.

Discussions are made on hardness measurements, and micro examination in cast conditions for six melts.

In phase II, the results, discussion and detailed analysis are made on hardness (HV) (hardening and tempering treatments). Hardening was carried out between 900°C to 1100°C and tempering was carried out between 100°C to 700°C. Impact testing and wear testing was carried out on the tempered samples.

In phase III thermo mechanical treatments were carried out at 1100°C for 10%, 30% and 52% of reduction using 2000T pneumatic hammer.

Characterizations (Hardness measurement, Micro examination) were carried out on hot forged, hardened, tempered conditions. Followed tempering, impact and tensile studies were carried out and the fracture surface analysis carried out by using SEM. Wear, corrosions studies were carried out and discussions made.

The research clearly reveals the fact that NAMSS can be produced successfully in the conventional induction furnace and the resultant

mechanical properties is superior in the nitrogen alloyed martensitic stainless steels.