CHAPTER 1:

INTRODUCTION

CHAPTER 1

INTRODUCTION

The important prerequisites of any engineering system are its reliability, efficiency and long life. Relative sliding movement between the two components in an engineering system causes a loss of the material from the surfaces of both the components and this loss, termed as "*wear*", may affect its reliability, efficiency and long life. In most of the situations, the failure of the machines is due to the wear and not due to the breakage of component. Wear is not an intrinsic property of a material but a characteristic of an engineering system. Wear is rarely catastrophic, but it reduces the operating efficiency and increases power losses, oil consumption, and component replacement rates. It, therefore, becomes necessary that the parts having sliding motion relative to each other may be designed to minimize wear. During rubbing some fundamental changes occur in the surface of the contacting materials and these changes determine the nature of the wear process and friction force. The study of the complex phenomena occurring during rubbing and the need to minimize both energy and material losses in mechanical systems has led to an enlarged interest in the field of "Tribology", the science of friction, wear and lubrication [1].

Wear leads to an unwanted and inevitable loss of material, which can only be minimized but cannot altogether be completely mitigated. Wear encountered in the industry has been classified as the following types and their estimated relative occurrences are:

Abrasive 50%; Adhesive 15%; Erosive 8%; Fretting 8% and Chemical 5% [2]. In 1983, it was estimated that a total loss of 38.71 billion DM (£ 13 billion) is incurred through tribological causes in FRG. Unlubricated systems accounted for a loss of 17.78 billion DM (≈ £ 6 billion). In steel and other metallurgical industries in Germany, the loss due to unlubricated wear was estimated as 53% of the total loss. Economic loss in the United States due to wear and friction has been put at about 2.5 % of GNP while in Germany it has been put at 4.5 % of GNP [3]. As a consequence, it is vital to become aware of different aspects of wear and take preventive steps to avoid the huge economic loss due to wear. It is believed that a proper attention given to tribology, especially in education, research and application, could lead to economic savings between 1.3% to 1.6% of the GNP [4]. Hence, in view of the quantum of the loss due to wear it becomes imperative for an engineer to develop better defence against wear by exploring newer wear resistant and cost effective materials for the tribological applications.

Erosive wear of material refers to the process of material degradation and removal from the steel surface due to the impact and movement of solid particles, such as abrasive materials or fluids containing suspended particles. Erosion is a serious issue in automotive industry, thermal and hydro-electric power plants, slurry transportation through pipe lines and farm implements etc. apart from other industries which often suffers the direct and indirect losses due to the shutdown of the machinery/plant or industrial unit and causes severe burden on their economic health [5].

Corrosion is the gradual deterioration and loss of material from the surface of the steel leading to a reduction in structural integrity and strength, compromising the safety and performance of the components. The loss of material due to corrosion results in dimensional changes, affecting the functionality and fit of steel parts which impairs the functionality and performance of the machine elements. For example, in pipes and tubing, corrosion can result in blockages, leaks, and reduced flow capacity whereas in electrical and electronic applications, it can cause poor conductivity and signal degradation [6]. Corrosion requires regular maintenance and preventive measures like surface cleaning, use of protective coatings and corrosion-resistant alloys, proper heat treatment, and periodic inspections to mitigate its adverse effects. The costs associated with corrosion prevention, repair, and replacement are also significant which affect the overall budget and economics of an industry.

The microstructure plays a crucial role in governing the behavior of steels under erosive as well as corrosive conditions. The hardness, composition, amount and distribution of the constituent phases such as ferrite, pearlite, retained austenite and martensite within a steel renders the particular steel with unique mechanical properties which dictate its response to the solid particle erosion and also affect its susceptibility to corrosion as each of the phases responds to corrosive attack in a different manner [7]. While hardness is crucial for wear resistance, toughness is also important to resist the impact of erosive particles. A tough microstructure, characterized by a combination of softer phases like ferrite or austenite, can absorb the energy of particle impact, reducing the likelihood of material fracture or spalling. Hence, an optimal balance between hardness and toughness is necessary to attain good resistance against erosive wear. Also, a well-dispersed harder phase can help in dissipating the impact energy from erosive particles, minimizing localized material removal. The heat treatment processes such as annealing, quenching, and tempering have been reported to alter the phase distribution, grain structure, and residual stresses within the steel, consequently influencing its corrosion behavior [8]. Hence, understanding the relationship between microstructure and erosion & corrosion behavior is quite important for selecting the appropriate steel and optimizing the material processing to obtain better resistance to either erosion or corrosion.

The necessity to minimize wear has given impetus to the development of the new wear resistant materials and has attracted the attention of the materials scientists worldwide. Metals and alloys are widely used in engineering for their wear resistance, overriding the growing interest in ceramics and polymeric composites as tribomaterials. Consequently, a significant portion of wear research focuses on metallic materials. Despite the development of light weight wear resistant composites or alloys containing different reinforcements, steels continue to dominate a wide range of wear-resistant applications. Steels offer a distinct advantage by allowing the tailoring of their properties through simple heat treatment techniques, making them highly versatile.

Dual phase (DP) steel has the potential to be used as a wear resistant material. It has unique structure consisting of hard martensite islands in the ductile matrix of ferrite and possesses some special properties viz., absence of yield point phenomena, large ratio of tensile strength to yield strength, high rates of work hardening, high total and uniform elongation, excellent forming characteristics and high fracture toughness [9]. Also, the mechanical properties of the DP steels can be tailored by changing the amount of martensite in the structure, by carrying out a simple intercritical annealing heat treatment for different holding times followed by water quenching. Due to superior properties and relatively simple processing, the DP steels show a great promise for a wide range of applications. Due to their exceptional energy absorption capability and resistance to fatigue, Dual Phase Steels are especially ideal for producing structural and safety components in the automotive industry, including longitudinal beams, cross members, and reinforcements. These steels have been employed in several automotive components such as bumpers, wheel discs and rims, steering columns, chassis components, doors, pulleys, spring supports, car bodies etc. The use of these steels in automobiles has led to a weight reduction of up to 30% with a notable increase in the life of the components [10]. In the field of mineral processing, mining and pipeline transportation of slurry, DP steel has already been employed as wear resistant material [11] but still there is a need to understand the tribological behaviour of DP steel in order to explore its full potential as tribological material.

The microstructure plays a crucial role in dictating the tribological behaviour of the two phase materials. It is not only the amount and the morphology of the second phase but also the coherency of the dispersed phase with the matrix, which has a significant effect on the wear behaviour. In the steels with spheroidized carbides, the interface between the carbides and the ferrite is, in general, incoherent which causes dislocation pile-up during straining leading to the nucleation of voids and fracture. In DP steels the coherency between the martensite and the ferrite phase allows the penetration of the dislocation from the ferrite phase into the martensite and so, large strain concentrations do not result in the boundary and the fracture occurs at relatively higher strains.

Dual phase steel exhibits a combination of softer ferrite and harder martensite phases, which contribute to its enhanced hardness and toughness, resulting in reduced wear loss. Thus, the DP steel may prove to be an interesting material from the point of view of erosion & corrosion resistance. Hence, the aim of the present study is to understanding of the erosion and corrosion behaviour of the DP steel. The presence of the second phase markedly influences the behaviour of the materials under erosive or corrosive conditions but the effect has not been systematically investigated so far. The present study also intends to propose the mechanisms of material removal erosion as well as corrosion based on the response of the constituent phases against erosion or corrosion.

In summary, the present study has been carried out in order to correlate the microstructure evolved after the intercritical annealing with the observed mechanical properties and erosion & corrosion behaviour of the DP steels. The knowledge base generated through this study is expected to provide a better understanding of this unique class of steels and help utilize its potential as a future material in erosive and corrosive condition