CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

Wind power seems to stand out as a global success story with an increasing demand for clean energy. The continuous fluctuation in oil prices because of wars and political instabilities has made the WTG the fastest growing energy source at the global level. The wind would supply 12% of the world’s electrical demand by 2020 (Fairkey 2003). The current technology improves the wind energy in two directions: i) by making the wind power more portable to grid operators; ii) by making it possible for the engineers to exploit the wind resources in remote locations. India is endowed with an abundance of natural wind energy resources which can supply the energy needed even in the remote area.

During recent days considerable efforts have been made in India for the substantial development of wind energy. Wind power generation has grown at an alarming rate in the past decade because of the advancement in power electronic technology. Wind power installations in worldwide have reached 159,213 MW producing more than 340 TWh of electricity annually. The wind power programme in India was initiated towards the end of the 6th plan in 1983-1984. This chapter discusses the research approach used in this study and the manner in which the research is carried out to operate the wind
turbine in an efficient manner without disturbance due to frequent failure of critical components in the WTG.

3.2 PROBLEM STATEMENT

India’s significant and sustained economic growth is placing enormous demand on its energy resources. An increased prosperity, an urbanization, economic growth, rise in per capita consumption and spread of energy access caused huge demand for electricity in India. In view of the shortage of electricity the usage of diesel and furnace oil have been increased explicitly in industries, commercial offices, institutions and residential area. Lack of rural lighting is leading to large scale use of kerosene.

This usage needs to be curtailed, as it is leading to enormous costs in the form of government subsidies and increasing the country’s import dependence and foreign revenue. In view of the above fact that there is a need to do research in the wind energy field to avoid the frequent failure of the wind turbine generator in the present scenario so as to get continuous power supply from the turbines.

The problem for this research study is formulated to analyze the root cause for the frequent failure of the major and costly components such as gearbox, coupling and the generator; suggesting solution and remedial action to overcome the problems in the wind industry.

3.2.1 Wind Energy in India

The development of wind power in India began in 1990’s and has progressed steadily for the past few years. The short gestation periods for
installing the wind turbines and the increasing reliability and performance of
the wind energy machines have made wind power a favoured choice for
capacity addition in India. According to Gyan research and analysis (2012),
existing wind power accounts for 70% of the installed capacity from
renewable sources in India.

Wind power accounts for nearly 8% of India’s total installed power
capacity. Present situation of power shortage in India especially in Tamil
Nadu to meet out the industrial and domestic requirements stimulated to
improve the performance of wind turbine generators. According to the state
run Centre for Wind Energy Technology (CWET), out of 207.8 GW installed
power generation capacity in India, renewable energy accounts for about 25
GW (∼12%) of which wind occupied a major share in the year 2011. Figure
3.1 gives internal details of the drive train components in nacelle unit of
WTG.

The feasibility for continuous operation of WTG is horrible as the
occurrence of components failure seems to be very high. The objective of this
research work is to analyze the root cause for the failure of critical parts in
WTG and suggesting the solution for curtailing the frequent failures in the
operational environment.
3.3 THE RESEARCH AIMS AND OBJECTIVES

The aim of this research study is to identify the root cause for the components failure in the wind turbine generator and to devise suitable mechanism to get an uninterrupted power supply from the wind turbine. The above said goal is achieved by adopting root fillet modification in the spur gear, tooth profile modification in the helical gear, detailed failure analysis on shear pins and the bearing through different approaches which are well established in providing modifications for a better design.
3.4 RESEARCH METHODS

The research methodology employed in the empirical evidence is illustrated in Figure 3.2. The research methodology is derived into two main categories;

i. Design optimization

ii. Failure analysis

In the first category, root fillet modification in spur gear and composite profile (combination of involute and cycloidal profile) instead of standard involute profile in helical gear were discussed. Detailed study on shear pin failure and bearing failure are carried out using various techniques such as SEM and metallurgical microscopic study in the second category. A comparative study of non-linear contact shear stress, deflection and stiffness was made between the circular root fillet gear and the trochoidal root fillet gear. Similarly, comparative study of bending stress was made between an involute and composite profile gear. The obtained tooth bending stress is cross verified with the permissible tooth root stresses. Also, the tooth stiffness and the tooth deflection matchup is done for choosing the optimal design for the wind turbine gearboxes as these gearboxes have experienced over load due to fluctuation in the wind force, non synchronizing of pitching and sudden braking because of frequent grid drops. ANSYS version 11.0 software is used in both the category for evaluating the performance between the proposed and the existing design. The obtained contact shear stress from FEA is also compared with the Lewis maximum bending stress.
As a preliminary step in the failure analysis, the drive train alignment between the gearbox shaft and the generator shaft was made via optical laser measurement technique to verify whether the misalignment is attributed due to the drive train related problems, as most of the failures in rotating machinery are because of misalignment in the system.

Besides, temperature measurements from various bearing locations and produced power of the WTG were compared for any abnormalities. Further, the detailed studies include material examination, compositional analysis, and hardness measurements, bearing clearance measurements, Energy Dispersive X-ray analysis and visual inspection.

3.5 JUSTIFICATION OF METHODOLOGY

The method selected to carry out this research study were case studies, many field surveys conducted in Indian wind turbine site for about 8 years starting from 2004 to find out the most critical failure of mechanical components in the wind turbine gearbox, use of literature survey (Chapter 2) and documentary evidence as appropriate. Because of the numbers of issues raised by the gear manufacturer, gear designers, operation and maintenance personnel’s from the wind turbine site and the need to associate them as the reason of current and their previous employer, I decided not only to do a survey for my research study, but also to do case studies on design optimization (Profile modification in spur and helical gears) and failure analysis in shear pins and the bearing (Chapter 4 to 7).
Figure 3.2 Schematic illustration of research methodology
The Case Study complements and "puts flesh on the bones" by means of physical hands on experience with the gear manufacturer and the gear designer for about 16 years and with the wind turbine site for about 9 years, the field surveys and the articles published by Beghini et al (2004), Spitás et al (2005), Florin Tutulan et al (2004), Robb (2005) and Smith (2007). In addition to the above, most of the techniques listed in Figure 3.2 like SEM, EDS, FEA, bearing clearance measurement, metallographic study and other techniques are not yet been used in the wind industry for maintaining the wind turbines. Further, adequate studies have not been taken up to address the issues related with gearbox functionality in the wind turbine generator. Hence, it is thought of worthwhile to take up research in identifying the root cause for the problem and provide solutions to avoid the mechanism failure.