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SUMMARY OF Ph.D. DISSERTATION

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Title

Development of High-Performance Gears by Super Rapid Induction Heating and Quenching

Abstract

Induction heating (IH) and quenching is a common surface modification process. This process hardens only the surface layer of a material and gives the surface a high compressive residual stress. This type of quenching is widely used as a convenient surface modification process for various kinds of machine parts. However, the ordinary IH quenching cannot be used to harden the surface of small machine parts, such as low module gears, because the treatment heats the entire teeth of the gears.

In recent years, the development of a new device that controls heating time precisely and of high output induction heating equipment, makes it possible to heat a steel surface over austenitizing temperature in less than 1.0 seconds. In order to apply this super-rapid induction heating and quenching (SRIQ) process, it is very important to understand the basic mechanical properties of steel modified by the process.

Chapter 1 introduces motivation specific to this thesis with discussing the previous studies related to the surface modification process by the IH system.

In Chapter 2, high cycle fatigue properties of surface hardened steel specimens, having different thickness of hardened layers, are examined. The experimental results showed that the SRIQ process greatly improves fatigue strength of machine parts which have sharp notches. This is due to the existence of an extremely high compressive residual stress field in treated surface layer.

Chapter 3 deals with the influence of prior microstructure of the steel on the SRIQ properties, with special attention focused on the cementite dissolution process. Fatigue strength of SRIQ treated Ferritic Ductile Iron is also discussed, in relation to the diffusion of carbon element from the graphite to surrounding structures.

When surface of quenched steel is tempered through the ordinary IH process, the hardened layer possesses a hardness distribution where hardness decreases as approaching the surface. Chapter 4 describes that the above disadvantages can be overcome by using the SRIQ system. This is because the hardened layer is uniformly tempered and the remarkable decrease of the compressive residual stress at the surface is prevented.

In Chapter 5, in order to develop a high performance low module gear, new types of surface hardened gears are prepared by the SRIQ system, and then bending fatigue strength of various types of gears hardened by different methods are compared.

Chapter 6 summarizes the results of this study.