Chapter 30
A Novel Prediction Perspective to the Bending Over Sheave Fatigue Lifetime of Steel Wire Ropes by Means of Artificial Neural Networks

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ABSTRACT

Steel wire ropes are frequently subjected to dynamic reciprocal bending movement over sheaves or drums in cranes, elevators, mine hoists, and aerial ropeways. This kind of movement initiates fatigue damage on the ropes. It is a quite significant case to know bending cycles to failure of rope in service, which is also known as bending over sheave fatigue lifetime. It helps to take precautions in the plant in advance and eliminate catastrophic accidents due to the usage of rope when allowable bending cycles are exceeded. To determine the bending fatigue lifetime of ropes, experimental studies are conducted. However, bending over sheave fatigue testing in laboratory environments require high initial preparation cost and a long time to finalize the experiments. Due to those reasons, this chapter focuses on a novel prediction perspective to the bending over sheave fatigue lifetime of steel wire ropes by means of artificial neural networks.

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INTRODUCTION

Wire ropes are frequently used in elevators, cranes, bridges, aerial ropeways, mine hoisting, and so on. Personnel, materials, cargo, etc. are lifted by steel wire ropes in a vast variety of material handling systems. Carbon steel rods are drawn to make steel wires with different shapes and sizes. The very high strength of the rope wires allows wire ropes to endure large tensile loads and to run over sheaves with relative small diameters. One or several layers of steel wires laid helically around a center wire form a strand. Traditional stranded steel wire ropes have six or eight strands wound around a core. Rotation resistant ropes have higher number of strands in order to resist rotation (Feyrer, 2015). Cars and counterweights are suspended by steel wire ropes in traction elevators. That is, steel wire ropes are used to lift personnel and freight in the car of the elevator (Janovsky, 1999). In cranes, ropes are used to lift, convey, and discharge heavy goods from one location to another location within a specific area. Crane ropes are selected to maintain a certain lifetime period in service (Suner, 1988). A Koepe (friction) system is often used in mine hoisting to lift heavy loads from deep shafts by means of steel wire ropes with large diameters (Onur, 2012). Wire ropes deteriorate gradually as a result of normal running or misuse while operating. Those deteriorations exhibit themselves in different ways after a certain period of time. Mostly, degradations that occur on steel wire ropes are due to fatigue. Furthermore, under almost all operational conditions, wire ropes are subjected to fatigue due to alternate bending and longitudinal movements. The fatigue in ropes can be divided into two main categories in general. One of the dominant fatigue types in rope applications is tension-tension fatigue in which ropes are subjected to alternate tensile load with time, such as with suspension bridges. Another type is known as bending over sheave (BoS) fatigue in which ropes are subjected to dynamic repetitive bending and straightening travel due to the winding of wire rope on a drum or sheaves, such as with cranes.

Fatigue causes degradation on the rope and reduces the lifetime of steel wire ropes. Knowing the lifetime of the rope is an important issue in terms of occupational safety. Rope manufacturers are also eager to extend their rope's lifetime. Therefore, it is an important research topic to investigate the fatigue lifetime of steel wire ropes.

This study addresses the BoS fatigue of steel wire ropes. Numerous studies have been conducted to shed light on the effect of BoS fatigue on the lifetime of the steel wire ropes.

Gibson et al. (Gibson et al., 1974) performed bending fatigue tests by using 6x36 Warrington Seale rope with a steel core, 6x24 Warrington Seale rope with a fiber core, and 6x26 Warrington Seale rope with a steel core. Each rope has right regular lay. The 6x24 Warrington Seale rope is made of galvanized high carbon steel, and the other two ropes are made of bright high carbon steel. Samples with diameters of 12.7 millimeters (1/2 inch) and 19.05 millimeters (3/4 inch) were used for bending fatigue tests. According to the results, the 6x36 Warrington Seale rope and 6x26 Warrington Seale rope had almost the same fatigue performance, while the 6x24 Warrington Seale rope had lower values. The authors explained that this rope may be used in applications where a low modulus of elasticity is desired. Therefore, it should not be used in applications where better fatigue performance is expected. The authors also measured temperature fluctuations at 45.72 m/min (150 feet/min) and declared that a low diameter ratio and high tensile load would lead to a rapid increase in temperatures occuring on the rope (Onur, 2010).

Bartels et al. (Bartels, McKewan, &Miscoe, 1992) examined the factors that affect the life of wire rope. Two 50.8 mm (2 inch) diameter 6x25 Filler ropes with fiber cores were degraded on a bending fatigue machine. The authors determined the number of wire breaks, residual breaking loads, and percent elongations at break due to the number of bending cycles. The test results indicated that once a

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