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Fatigue life distribution and size effect in ductile cast iron for wind turbine components

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ABSTRACT

The present paper deals with the experimental determination and statistical analysis of high cycle fatigue properties of EN-GJS-400-18-LT ductile cast iron. Constant amplitude axial fatigue tests were performed at room temperature at $R = 0$ and $R = -1$. In order to evaluate the size effect, fatigue tests were carried out on two sets of specimens with different dimensions. The specimen diameters were 21 mm and 50 mm. Statistical analysis of fatigue data was done by means of the Weibull distribution, and *P–S–N* diagrams were established. The established *P–S–N* diagrams showed that the Weibull distribution is well fit to the scatter of the experimentally obtained fatigue life data. Weibull's weakest-link method was used to evaluate the size effect. It made a satisfactory prediction of the fatigue strength for specimens with different dimensions.

1. Introduction

Wind power is presently the world's fastest growing source of energy. For the next twenty years it is expected to expand at double-digit rates. Metal components make up nearly 90% of the weight of a modern wind turbine. Due to a favorable combination of high tensile strength, good wear resistance and ductility, the load bearing structural components in wind turbines are mostly made of large, complexly shaped ductile iron castings. Cast iron is typically used for the rotor hub, forward housing or frame, gearbox housing and bearing housings. Depending on the size of the turbine, a single wind turbine contains 10–25 tons of ductile iron.

The high ductility and toughness are of paramount importance for these castings because of the harsh weather conditions to which they may be exposed. The majority of wind turbine parts are made out of the challenging ductile iron grade EN-GJS-400-18-LT. This grade of ductile iron features the properties necessary to withstand the force of the wind and long-term exposure to the environment without failure. Moreover, the castings must exhibit high-impact strength at low temperatures [1].

For wind power to become competitive compared to other sources of energy, larger, more efficient and less expensive wind turbines have to be developed. Cast components make up much of the weight of the wind turbine. To develop larger and more powerful wind turbines, lighter cast components are required. The cast components should be optimized with respect to fatigue life.

The current design of large wind turbine castings against fatigue is usually based on the safe life design approach. In the safe life design, fatigue testing is carried out on baseline material to produce *S–N* curves. In order to apply these *S–N* curves to a real wind turbine cast component, reduction factors must be used to account for different parameters such as stress concentration, stress gradient, fatigue scatter and also taking into account nondestructive test results such as ultrasonic

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