Large scale axial fatigue testing of ductile cast iron for heavy section wind turbine components

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Abstract

The present paper deals with axial fatigue testing of heavy section EN-GJS-400-18-LT ductile cast iron specimens with 120 mm × 140 mm cross section and also smaller cylindrical specimens with 21 mm diameter at room temperature and load ratio \( R = -1 \). The load levels for heavy section specimens were adjusted to cover endurances from 10,000 to 14 million cycles. Each heavy section specimen weights 380 kg. The specimens were cut from castings with 150 mm thickness. The heavy section specimens thickness is close to the common thicknesses of heavy section wind turbine ductile cast iron components. Fatigue strength of large 120 mm × 140 mm specimens were compared with fatigue strength of smaller 21 mm diameter specimens and geometrical size effect was evaluated. To evaluate the wall thickness effect on fatigue strength (technological size effect), the obtained fatigue test results for 21 mm specimens from billets with 150 mm thickness were compared with the published fatigue test results of the same specimens but from billets with 95 mm thickness. Metallography analysis of 21 mm specimens from billets with 95 mm and 150 mm thicknesses were performed and important microstructural parameters were measured and compared. Finally the effect of casting thickness and microstructure on fatigue strength of this material was evaluated.

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1. Introduction

Wind turbine manufacturers have to compete with other sources of energy such as natural gas and coal. In order to produce cheaper wind electricity, larger and lighter wind turbines have to be developed. Cast components make up much of the weight of the wind turbine. The majority of wind turbine parts are made out of the challenging ductile iron grade EN-GJS-400-18-LT [1].

The current design of heavy section wind turbine cast components is based on safe life design philosophy [2]. In the safe life design, \( S-N \) curves are derived from fatigue testing on baseline material. To implement these \( S-N \) curves in design of a real component, large reduction factors must be used to account for different parameters. Thus, to develop larger, lighter and more powerful wind turbines, good knowledge of fatigue behavior of EN-GJS-400-18-LT is required.

It is a well known phenomenon that the fatigue strength of a material decreases with increasing specimen size (size effect) [3–5]. Specimens with different sizes but from castings with the same cooling rate, show different fatigue strength (geometrical size effect) [6]. Also, specimens with the same geometry, but from the castings with different cooling rates show different fatigue strength (technological size effect).