



Failure analysis of silicon nitride rings for hot rolling of highly alloyed steel and superalloy wires

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ABSTRACT

Rolls for rolling of metal wires are traditionally made from cemented carbides, but they suffer from roughening of the working surfaces and severe wear which restrict the roll lifetimes. Silicon nitride ceramics are feasible alternative materials for rolls (and other components in rolling mills) due to their good combination of properties, e.g. high strength and hardness, excellent high-temperature properties, oxidation resistance and good thermal shock behaviour. Increasingly the switch is being made to such ceramics for extension of life and improvements in surface quality of the rolled product.

In a collaborative project between universities, industrial partners and research centres, rolls made of silicon nitride, supported and clamped by steel rings were tested at the rolling mill of Böhler-Edelstahl in Kapfenberg, Austria. Under low and medium hard loading conditions the suitability of these composite rolls has been very satisfactorily demonstrated. However, under very severe loading conditions one pair of silicon nitride rings failed. In this paper, the failure of these ceramic rings is analysed, and suggestions for further improvements are presented.

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1. Introduction

Due to their good properties, especially the high hardness and strength, the low friction coefficients, the good corrosion resistance, and above all their excellent properties at elevated temperatures, ceramic materials (especially silicon nitride) have been investigated for rolling applications over the last two decades. Ceramics have many potential advantages compared with the conventionally used rolls made of cemented carbide, e.g. an increased lifetime of the tools and a better surface quality of rolled wires [1,2]. It was also found that the strength of sintered silicon nitride is sufficient for cold rolling of austenitic stainless steel wire [3]. Two large German projects on “silicon nitride rolls for the production of wires, tubes and strips” were carried out with participation of ceramic producers, grinding shops, rolling mills and research centres from 2001 to 2004 and from 2006 to 2009. An overview of the project results can be found in [4,5].

During the projects, silicon nitride rolls were tested very successfully at several positions at the rolling mill of Böhler-Edelstahl in Kapfenberg, Austria. Different wire qualities with diameters from 5 mm to 13.5 mm, ranging from very soft

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