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The influence of heat treatment on the sliding wear behavior of a ZA-27 alloy

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ABSTRACT

The effects of heat treatment, involving solutionizing at temperature of 370 °C for a relatively short period of time (3 or 5 h), followed by quenching in water, on tribological behavior of ZA-27 alloys were examined.

Dry sliding wear tests were conducted on as-cast and heat-treated ZA-27 samples using block-on-disk machine over a wide range of applied loads. To determine the wear mechanisms, the worn surfaces of the samples were examined by scanning electron microscopy (SEM). The tribological results were related to the microstructure and mechanical properties.

The heat treatment resulted in reduction in the hardness and tensile strength but increase in elongation. The heat-treated alloy samples attained improved tribological behavior over the as-cast ones, both from the aspects of friction and wear. The improved tribological behavior of the heat-treated alloys, in spite of reduced hardness, could be the result of breaking the dendrite structure, when the fraction of interdendrite regions was considerably decreased and a very fine α and η mixture was formed at the same time. The wear response of the samples has been corroborated through characteristics of worn surfaces and dominant wear mechanisms.

1. Introduction

Zinc–aluminum alloys (ZA alloys) over the past few decades are occupying attention of both researchers and industries, as a promising material for tribological applications. At this moment, commercially available ZA alloys have become the alternative material primarily for aluminum cast alloys and bearing bronzes due to good castability and unique combination of properties [1–11]. They can also be considered as competing materials for cast iron, plastics, and even for steels when being applied for operation under conditions of high mechanical loads and moderate sliding speeds (moderate operation temperatures) [12,13]. Interest for extending the practical application of these alloys is grounded by tribological, economical and ecological reasons. These alloys are relatively cheap and can be processed efficiently with low energy consumption without endangering the environment [14–17].

In the real casting conditions the ZA alloys have the typical dendritic structure, wherein the dendrite size and interdendritic spacing depend on the casting parameters. The cooling speed imposes a strong influence on the grain size during the cooling. The consequences of the dendritic structure primarily result in lower ductility, as well as in relatively high heterogeneity of mechanical properties of the cast alloy [18]. The second important problem relating to zinc–aluminum alloys refers to dimensional instability, which is caused by the presence of metastable phases [19,20].

One of the possible measures for overcoming these deficiencies is heat treatment of the castings. The following procedures of heat processing are used: (a) artificial ageing of samples at temperatures from 90 to 150 °C, mainly for optimizing the strength to specific elongation ratio [14,21]; (b) solutionizing (usually from 320 to 400 °C) followed by artificial ageing (T6 type of heat treatment) [19,20]; (c) solutionizing with subsequent quenching [22,23]; (d) solutionizing by rapid water quenching and ageing at elevated temperatures [24] and (e) solutionizing followed by ageing at elevated temperatures and water quenching [25]. Partial replacement of copper by other alloying elements (such as nickel and/or silicon) has also been found useful to reduce the problem of dimensional instability [19,24,25].

Heat treatment of the conventional zinc–aluminum alloys improves dimensional stability [14] and ductility [3,20,26,27]. However, the majority of the heat treatments lead to a reduction in hardness and tensile strength [19,20,23]. In spite of reduced hardness, the heat-treated alloys attain improved tribological properties [20,23,25]. Thermal softening problem of zinc–aluminum alloys may be reduced or overcome by addition of alloying elements such as silicon or nickel [24,25].

The duration and temperature of solutionizing and ageing play dominant role in controlling the structural, mechanical and

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