EFFECT OF ZINC AND MOLYBDENUM ON THE MICROSTRUCTURE AND CORROSION BEHAVIOR OF MAGNESIUM-BASED ALLOYS PRODUCED BY POWDER METALLURGY TECHNIQUE

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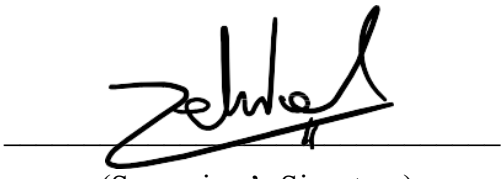

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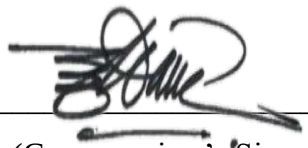

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ABSTRAK

Magnesium dan aloinya menawarkan sifat bahan yang ringan dan sangat baik serta bermanfaat bagi komponen automotif, elektronik, dan aplikasi bioperubatan. Namun, disebabkan struktur kristal HCP, magnesium umumnya menunjukkan kemuluran yang terhad pada suhu rendah. Penambahan elemen aloi dan tetulang boleh menjadi pendekatan yang berkesan bagi mengatasi masalah ini, tetapi ia juga dapat mempengaruhi tingkah laku karatan secara drastik. Di dalam industri automotive, kadar karatan dijangkakan sebanyak 8.5 μm/tahun. Kajian ini bertujuan untuk mengkaji perkembangan struktur mikro sampel magnesium dengan penambahan elemen zink (Zn) dan molibdenum (Mo). Tingkah laku karatan sampel Mg juga dinilai berdasarkan hubung kait dengan perkembangan struktur mikro sampel. Kesemua sampel dihasilkan menggunakanteknik metalurgi serbuk, dan sampel padatan dihasilkan berdasarkan 10, 20 dan 30 wt.% komposisi Zn dan Mo yang ditetapkan. Struktur mikro dikaji menggunakan mikroskop optik dan mikroskop imbasan elektron (SEM) dan, analisis fasa ditentukan dari analisis belauan sinar-x (XRD). Penilaian tingkah laku karatan dilakukan melalui ujian evolusi hidrogen dan ujian pengutuban dinamik upaya di dalam larutan air garam (NaCl) berkepekatan sebanyak 3.5 wt.%. Berdasarkan ujian evolusi hidrogen dan ujian pengutuban dinamik, pengikatan dan taburan Zn yang baik dalam matriks Mg telah dicapai melalui pengaloian dengan Zn, yang meningkatkan ketahanan karatan Mg-Zn berbanding aloi Mg-Mo. Kadar ketahanan karatan aloi Mg-Zn adalah lebih tinggi berbanding aloi Mg-Mo. Sampel-sampel mudah retak apabila diperhatikan ketika ujian evolusi hidrogen. Keadaan ini menyebabkan peningkatan kadar karatan Mg-30Zn, berbanding Mg-10Zn dan Mg-20Zn semasa ujian tersebut. Penambahan Mo di dalam sampel berfungsi sebagai zarah tetulang dalam Mg, mendorong berlakunya keliangan di dalam sampel, seterusnya mempengaruhi kadar karatan Mg melalui perubahan berat ketika terdedah kepada larutan air garam (NaCl) berkepekatan 3.5 wt.%. Ketahanan karatan bagi sampel Mg-Mo juga meningkat dengan peningkatan jumlah komposisi Mo, berkaitan dengan pengurangan keretakan aloi tersebut. Sampel Mg-5Zn-Mo mempunyai kadar karatan yang lebih rendah berbanding sampel Mg-Mo tetapi lebih tinggi jika dibandingkan dengan sampel Mg-Zn. Kadar karatan yang tinggi pada sampel Mg-Zn-Mo adalah disebabkan kompilasi daripada jumlah zarah Mo dan kehadiran mendakan $MgZn_2$ seterusnya menyebabkan kerapuhan dan mudah untuk retak semasa ujian karatan. Kesimpulannya, potensipengaloian elemen dipertimbangkan boleh menjadi penyelesaian bagi merekabentuk aloi magnesium yang memenuhi sifat mekanikal dan karatan untuk kegunaan aplikasi kejuruteraan yang lebih meluas. Oleh itu, kajian ini dilakukan untuk mengenal pasti kesan penambahan Zn dan Mo terhadap perkembangan struktur mikro dan tingkah laku karatan aloi Mg yang dihasilkan melalui teknik metalurgi serbuk.

ABSTRACT

Magnesium and its alloys offer lightweight and excellent material properties that are beneficial for automotive components, electronics, and biomedical applications. However, due to their hexagonal close-packed crystal structure, they generally exhibit limited ductility at low temperatures. The addition of alloying elements and reinforcement can effectively address this limitation, but the corrosion behavior can be significantly affected. In automotive industry, the estimated corrosion rate was about 8.5 μm/year. This study aims to investigate the microstructure development of magnesium (Mg) with the addition of zinc (Zn) and molybdenum (Mo). The corrosion behavior of Mg samples was evaluated with a correlation to their microstructure development. All of the samples were produced using the powder metallurgy technique, and the compact samples were produced based on 10, 20, and 30 wt. % of Zn and Mo compositions. The microstructure was investigated by optical and scanning electron microscopy, while the phase analysis was determined from X-ray diffraction analysis. The corrosion behavior was evaluated by the hydrogen evolution test and potentiodynamic polarization test in 3.5 wt.% sodium chloride (NaCl) solution. From the microstructure observation, great bonding and distribution of Zn in the Mg matrix were achieved when alloying with Zn, compared to Mg with Mo addition. Based on this finding, the corrosion resistance of Mg-Zn alloys is higher than Mg-Mo alloys. However, the samples were easily crack when observed during hydrogen evolution test. This condition has led to the enhancement of Mg-30Zn corrosion rate compared to Mg-10Zn and Mg20Zn. The addition of Mo serves as reinforcement particles in the Mg, inducing porosity in the sample and affecting the corrosion rate of the Mg sample by weight loss during exposure in the 3.5 wt. % NaCl solution. The corrosion resistance of Mg-Mo alloys increased with the increasing amount of Mo composition, which is associated with the less crack of the alloys. The Mg-5Zn-Mo sample has a lower corrosion rate than MgMo samples but a higher corrosion rate than Mg-Zn samples. The high corrosion rate of Mg-Zn-Mo samples is due to the compilation from the amount of Mo particles and the presence of MgZn2 precipitates thus causing easily crack or fracture during the corrosion test. In conclusion, considering the potential of alloying elements, it is possible to design a Mg alloy that satisfies both mechanical and corrosion properties for more extensive engineering applications. Therefore, this study is conducted to identify the effect of Zn and Mg addition towards the microstructure and corrosion behavior of Mgbased alloys produced by powder metallurgy technique.

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