P-ISSN 0126-3188
E-ISSN 2443-3926

BRIN
BADAN RISET
DAN INOVASI NASIONAL

METALURGI

VOLUME 38 No 2 2023

SCIENTIFIC JOURNAL ACCREDITATION NO.3/E/KPT/2019

National Research and Innovation Agency

METALURGI

VOLUME 38 NUMBER 2 2023

P-ISSN 0126-3188
E-ISSN 2443-3926

ACCREDITATION : SK No. 3/E/KPT/2019

Publisher :
National Research and Innovation Agency (BRIN)
B.J. Habibie Sains and Technology Area, Banten, Indonesia 15314

E-mail: metalurgi@brin.go.id

Science and technology journal, regularly published every year; one volume consists of 3 editions

PREFACE

The author gives thanks to Allah for bestowing His blessing and direction, allowing the **Metalurgi Journal Volume 38, Edition 2**, **2023** to be successfully published.

The first article results from Safitry Ramandhany and colleagues research activities on *Synthesis of NiCrAlx Microparticles using Dry Milling and Wet Milling Processes*. Lia Aryani and colleagues presented the second article, *The Effect of Bakelite Binders on Magnetic Properties and Hardness Values of MQP-Type Bonded NdFeB Magnets*. Miftakhur Rohmah and colleagues showed *The Effect of Hot Rolling and Solution Treatment on the Microstructure and Mechanical Properties of Fe-Mn-Si-Cr-Ni Shape Memory Alloy* in the following article. For the fourth article, Yeni Muriani Zulaida and colleagues discussed *The Effect of Al_2O_3 and Strring Time on Density and Porosity of Aluminum ADC 12 Foam*. The fifth article by Toni Bambang Romijarso and his colleagues discussed *The Influence of Cooling Variations on Mechanical and Microstructural Properties in the Manufacture of Dual Phase Steel by Annealing Intercritical Process.*

The publication of this volume in Metalurgi Journal will benefit the advancement of research in Indonesia.

EDITORIAL

METALURGI

ISSN 0126 – 3188 Vol. 38 No. 2, 2023

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UDC (OXDCF) 621.74

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Metalurgi, Vol. 38 No. 2, 2023

Synthesis of NiCrAlx Microparticles using Dry Milling and Wet Milling Processes

The characteristics of synthesized NiCrAlY and NiCrAlZr composite powders produced by the milling process were investigated to understand the particle size, the shape of particles, and the properties of crystalline structure. The milling process was carried out by combining dry milling with the wet milling method to prevent agglomeration, produce a homogeneous alloy powder, and reduce the particle size. Ethanol was used during the wet milling process as a process control agent. The PSA (particle size analysis) showed that the particle size was effectively reduced from ±70 µm to less than 30 µm. In addition, surface structure analysis characterized by SEM (scanning electron microscope) revealed that particle shape changed from blocky particles after dry milling into flaky, flattened, and fragmented particles after wet milling. An XRD (x-ray diffraction) was used to identify the phases of powders before and after the mechanical milling process. Crystal structure analysis was calculated from the change of peak broadening in XRD peak spectra. The Williamson-hall method has been performed to calculate the strain and crystallite size of synthesized NiCrAlY and NiCrAlZr composite powder in the present study. The findings in this study show the characteristics of powders, which are important information for producing coatings with good performance.

Keywords: Dry milling, wet milling, particle size, crystallite size, NiCrAlY, NiCrAlZr

METALURGI

ISSN 0126 – 3188 Vol. 38 No. 2, 2023

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UDC (OXDCF) 621.3678

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Metalurgi, Vol. 38 No. 2, 2023

The Effect of Bakelite Binders on Magnetic Properties and Hardness Values of MQP-Type Bonded NdFeB Magnets

Permanent magnets are important in modern society as components in various devices used by many industries and consumers, especially in generators and electric motors. Bonded magnet technology allows combining powdered magnetic materials with polymers as a binder to produce magnetic components that can be applied to certain applications, such as SynRM (synchronous reluctance) motors. Bonded magnets are easy to form without sacrificing their magnetic properties, which are too large, and also reduce costs, making them more effective and efficient. This paper reports the results of a study on the manufacture of bonded magnets NdFeB using bakelite binder on MQP-type NdFeB magnets with a bakelite variation of 0.5 - 2 wt.%. The characterization included testing magnetic properties with Permagraph, morphology with SEM (scanning electron microscope), and hardness values with micro Vickers hardness tester. The results of this study obtained remanence values in the range 5.53 - 6.44 kG and hardness values in the range 341.8 - 507.9 HV for NdFeB bonded magnets. According to SEM observations, the bakelite polymer matrix has successfully bound NdFeB grains, and no porosity is visible.

Keywords: Magnet, bonded, NdFeB, bakelite

METALURGI

ISSN 0126 – 3188 Vol. 38 No. 2, 2023

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UDC (OXDCF) 669.1

Miftakhur Rohmah[a], Emmanoela Carissa Sendouw[b], Rifqi Aulia Tanjung[b], Dedi Pria Utama[a], Efendi Mabruri[a] ([a]Research Center for Metallurgy, National Research and Innovation Agency, [b]Department of Materials and Metallurgical Engineering, Kalimantan Institute of Technology)

Metalurgi, Vol. 38 No. 2, 2023

Effect of Hot Rolling and Solution Treatment on the Microstructure and Mechanical Properties of Fe-Mn-Si-Cr-Ni Shape Memory Alloy

Fe-14Mn-4Si-8Ni-11Cr SMA (shape memory alloy) was designed as a smart material because of its specific properties, which can memorize the original shape, so it has the potential to dampen vibration in seismic structures. Memory effect is triggered by SIM (stress-induced martensitic) transformation from γ-austenite to ε-martensite (hexagonal close-packed / HCP) structure, and it is recovered by heating after unloading. This study investigated the effect of hot rolling and solution treatment on the microstructure and its relationship with hardness and SME (shape memory effect) properties. The as cast of Fe-14Mn-4Si-8Ni-11Cr was hot rolled (900 and 1000 °C) and solution treated (1000 and 1100 °C). After the thermomechanical process, all microstructures consist of γ-FCC (face-centered cubic), the annealing twins, and a fine band of ε-martensite. The grain size of the γ-phase is 29.43, 41.96, 42.44, and 45.57 μm for samples B, C, D, and E, respectively. The higher the temperature of hot rolling and solution treatment applied, the larger the grain size obtained, indirectly reducing the hardness to 299.93 BHN and 286.52 BHN for samples D and E. The coarsened austenite grain, a lower number of annealing twins, and the pre-existing line band of ε-martensite are favorable to obtain the enormous recovery strain, up to 8.26% for sample E.

Keywords: Fe-Mn-Si-Ni-Cr, SMA (shape memory alloy), SME (shape memory effect), strain recovery

METALURGI

ISSN 0126 – 3188 Vol. 38 No. 2, 2023

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UDC (OXDCF) 669.721.5

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Metalurgi, Vol. 38 No. 2, 2023

The Effect of Al_2O_3 and Stirring Time on Density and Porosity of Aluminum ADC 12 Foam

The instability of the foam forming during metallic foam manufacture commonly occurs, which will cause undesirable pores. The stability of the foam structure is one of the important factors. A stabilizer can maintain the foam cell during the melting process. In this study, the metal used is ADC12 with a 12 wt.% of Si element content, and the foaming agent is $CaCO_3$. $CaCO_3$ will produce gas to form bubbles in the melt during the solidification process and use a stabilizer to strengthen cell walls so that foam does not easily fall off or collapse. The stabilizer uses Al_2O_3 with the variation of Al_2O_3 are 1 to 3 wt.%. The stirring time is as variable as well. A stirring process is conducted to distribute foaming agents so that the foam distribution is more homogeny throughout the aluminum foam. The variation of the stirring time is carried out for 60, 120, and 180 seconds. The results show that as the time of stirring and the addition of stabilizer increases, the porosity will rise, but the density decrease. Compressive strength results show it has no significant relation with increasing the stabilizer and stirring time. The highest compressive strength is obtained in the sample with a stirring time of 120 seconds with an Al_2O_3 content of 1wt.%.

Keywords: Metal foam, foaming agent, stirring, Al_2O_3

METALURGI

ISSN 0126 – 3188 Vol. 38 No. 2, 2023

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UDC (OXDCF) 669.14

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Metalurgi, Vol. 38 No. 2, 2023

The Influence of Cooling Variations on Mechanical and Microstructural Properties in the Manufacture of Dual Phase Steel by Annealing Intercritical Process

The present research focused on determining the effect of cooling-medium-induced initial structure before the intercritical annealing induced dual-phase structure in the low alloy steel. Low carbon steel, which consists of containing 0.09 wt.% C was heated at 920 °C for 30 minutes to austenitization and then cooled in various media to provide the different initial structures before the IA (intercritical annealing) process. After austenization, the cooling process in the furnace and open-air provided a ferrite-pearlite phase, while the cooling process in water generated full martensite as the initial structure. Afterwards, the sample was intercritical-annealed at 750 °C (temperature between Ac1 and Ac3 lines or intercritical zone) for 10 minutes and then quenched in water. The water quenching after the austenitizing process improved the mechanical strength of steel (919 MPa), compared to the as-received state (519 MPa) due to martensite formation. As the cooling rate increased after the austenitizing process, the tensile strength increased and the elongation decreased. The different structures before intercritical annealing affected the martensite volume fraction and further correlated with improving mechanical properties. The ferrite and pearlite, as the initial structure before the IA process, provide a smaller fraction of martensite (18.36 vol.% for furnace cooling and 27.85 vol.% for open-air cooling). In contrast, the full martensite as the initial structure before IA generates a higher fraction of martensite (39.25 vol.%). The tensile strengths obtained were 512, 516, and 541 MPa with elongations of 29.8%, 30.1% and 32.6% for cooling furnace, open air and water, respectively. The strain-hardening behavior during the intercritical annealing is not affected by the initial process of the structure.

Keywords: Dual-phase steel, intercritical anealing, low-alloy carbon steel, fraction of martensite