Karakteristik balistik komposit pelat tebal Al-9Zn- 6Mg -3Si berpenguat 5 vol,% ZrO2 dengan penambahan paduan mikro berupa Sr. Ti dan Cr hasil squeeze casting = Ballistic characteristics of Al-9Zn-6Mg-3Si composite thick plate reinforced by 5 vol.% of ZrO2 with microalloying of Sr. Ti and Cr fabricated by squeeze casting

Rio Kharizma Agrista , author

Abstrak

[Baja digunakan sebagai material penyusun pada badan pelindung kendaran taktis karena ketahanan balistiknya yang baik. Tetapi, densitasnya yang tinggi memicu dilakukannya penelitian material pengganti, salah satu alternatifnya adalah komposit aluminium dengan penguat ZrO_2. Pada penelitian penulis sebelumnya, tiga lapis pelat komposit Al-13,1Zn-6,1Mg-6,7Si-1,4Cu – 7.5 vol.% ZrO_2 dengan tebal masing-masing pelat 10 mm terbukti mampu untuk menahan penetrasi peluru pada pengujian balistik tipe III.

Pada penelitian ini, dibuat komposit pelat tebal dengan ketebalan 25 mm dengan matriks Al-9Zn-6Mg-3Si berpenguat 5 vol.% ZrO_2 dan variasi penambahan paduan mikro berupa 0,001 wt.% Sr, 0,1 wt.% Ti, dan 2 wt.% Cr yang difabrikasi melalui metode squeeze casting. Untuk meningkatkan sifat mekanis, dilakukan laku pelarutan pada temperatur 450 oC selama 1 jam yang dilanjutkan dengan laku penuaan pada temperatur 200 oC selama 1 jam. Beberapa karakterisasi yang dilakukan adalah pengujian komposisi kimia menggunakan Optical Emission Spectrometer (OES), analisis struktur mikro dengan mikroskop optik (OM), Scanning Elecron Microscopy (SEM), dan Energy Dispersive X-Rays (EDX), perhitungan persentase porositas menggunakan perangkat lunak ImageJ, pengujian kekerasan Rockwell B, serta pengujian impak metode charpy. Pengujian balistik tipe III dilakukan pada pelat komposit setelah diberi perlakuan permukaan berupa thermal spray High Velocity Oxygen-Fuel (HVOF) menggunakan material pelapis 88WC-12Co dengan ketebalan ±200 μm.

Hasil penelitian menunjukkan bahwa nilai kekerasan yang paling tinggi dimiliki oleh pelat komposit dengan paduan mikro Cr, yaitu mencapai 77,75 HRB. Pelat komposit dengan paduan mikro Ti memiliki harga impak yang paling tinggi yaitu mencapai 15,77 x 10-3 J/mm2. Seluruh pelat komposit memiliki nilai kekerasan yang relatif rendah bila dibandingkan dengan kekerasan teoritisnya, yang terjadi akibat proses fabrikasi yang tidak sempurna. Partikel ZrO_2 yang ditambahkan pada lelehan paduan aluminium bereaksi sehingga membentuk Al_3Zr yang ditemukan dalam jumlah yang banyak di dalam mikrostruktur komposit. Pada hasil pengujian balistik, pelat komposit Sr memiliki karakteristik balistik yang paling baik, yang terlihat dari jejak peluru pada bagian depan pelat dan diameter terperforasi pada bagian belakang pelat yang relatif kecil. Karakteristik balistik yang relatif baik ini didapatkan dari kombinasi nilai kekerasan dan harga impaknya yang relatif tinggi, yaitu 62,6 HRB dan 14,65 x 10-3 J/mm2 secara berurutan.;Steel has been used as the constituent material of tactical vehicle’s body due to its high ballistic resistance. But, steel has high density that triggered research for material substitution. One alternative is aluminium composite that reinforced by ZrO_2. Previous research has shown that three plies of Al-13.1Zn-6.1Mg-6.7Si-1.4Cu – 7.5 vol.% ZrO_2 composite, each with the thickness of 10 mm, could withstand bullet penetration on type III ballistic testing.

In this research, Al-9Zn-6Mg-3Si composite thick plates of 25 mm reinforced by 5 vol.% ZrO2 with the variation of 0.001 wt.% Sr, 0.1 wt.% Ti, and 2 wt.% Cr microalloying are fabricated by squeeze casting method. To improve the mechanical properties, the composite plates were solution treated at 450 oC for 1 hour then aged at 200 oC for 1 hour. The characterizations are consisted of chemical composition testing by using Optical Emission Spectrometer (OES), microtructure analysis by using Optical Microscope (OM), Scanning Elecron Microscopy (SEM), and Energy Dispersive X-Rays (EDX), porosity calculation by using ImageJ software, hardness testing by using Rockwell B, and impact testing by using charpy method. Type III ballistic testing was conducted on the composite plates after High Velocity Oxygen-Fuel (HVOF) thermal spray with 88WC-12Co of ±200 μm thickness.
The results showed that the highest hardness was owned by the Cr-added composite plate with the value of 77.75 HRB. The Ti-added composite plate had the highest impact value of 15.77 x 10-3 J/mm2. The hardness of all composite plates was relatively low compared to the theoritical hardness, which was due to imperfect fabrication process. The ZrO2 particles added to the molten aluminium alloy reacted to form Al3Zr, which was found in a considerable amount in the microstructure. From the ballistic testing, Sr composite plate was found to have the best ballistic characteristic compared to the other three, which was shown by small trace of bullet on the front part of the plate, and also small perforated diameter on the back part of the plate. This relatively good ballistic characteristic was believed to be due to combination of high hardness and impact values, with the value of 62.6 HRB and 14.65 x 10-3 J/mm2, respectively., Steel has been used as the constituent material of tactical vehicle’s body due to its high ballistic resistance. But, steel has high density that triggered research for material substitution. One alternative is aluminium composite that reinforced by ZrO2. Previous research has shown that three plies of Al-13.1Zn-6.1Mg-6.7Si-1.4Cu – 7.5 vol.% ZrO2 composite, each with the thickness of 10 mm, could withstand bullet penetration on type III ballistic testing.
In this research, Al-9Zn-6Mg-3Si composite thick plates of 25 mm reinforced by 5 vol.% ZrO2 with the variation of 0.001 wt.% Sr, 0.1 wt.% Ti, and 2 wt.% Cr microalloying are fabricated by squeeze casting method. To improve the mechanical properties, the composite plates were solution treated at 450 oC for 1 hour then aged at 200 oC for 1 hour. The characterizations are consisted of chemical composition testing by using Optical Emission Spectrometer (OES), microtructure analysis by using Optical Microscope (OM), Scanning Elecron Microscopy (SEM), and Energy Dispersive X-Rays (EDX), porosity calculation by using ImageJ software, hardness testing by using Rockwell B, and impact testing by using charpy method. Type III ballistic testing was conducted on the composite plates after High Velocity Oxygen-Fuel (HVOF) thermal spray with 88WC-12Co of ±200 μm thickness.
The results showed that the highest hardness was owned by the Cr-added composite plate with the value of 77.75 HRB. The Ti-added composite plate had the highest impact value of 15.77 x 10-3 J/mm2. The hardness of all composite plates was relatively low compared to the theoritical hardness, which was due to imperfect fabrication process. The ZrO2 particles added to the molten aluminium alloy reacted to form Al3Zr, which was found in a considerable amount in the microstructure. From the ballistic testing, Sr composite plate was found to have the best ballistic characteristic compared to the other three, which was shown by small trace of bullet on the front part of the plate, and also small perforated diameter on the back part of the plate. This relatively good ballistic characteristic was believed to be due to combination of high hardness and impact values, with the value of 62.6 HRB and 14.65 x 10-3 J/mm2, respectively.]