Intisari

Gamelan merupakan alat musik tradisional yang dapat dijumpai di beberapa wilayah Propinsi di Indonesia seperti Jawa Tengah, D.I.Yogyakarta, Jawa Barat dan Bali. Selain besi tuang dan kuningan, bahan baku gamelan juga menggunakan paduan perunggu timah. Selama ini untuk memproduksi gamelan menggunakan teknik tempa. Pemilihan komposisi timah merupakan faktor terpenting untuk menghindari terjadinya retak saat ditempa. Teknik tempa manual juga membutuhkan banyak tenaga dan waktu produksi yang lama. Pengecoran logam dapat menjadi metode alternatif yang dapat diterapkan dengan memperhatikan parameter utama seperti fluiditas, sifat fisik, sifat mekanik dan akustik komposisi timah perunggu.

Penelitian diawali dengan membuat komposisi paduan perunggu timah Cu(20,22 dan 24)wt.%Sn dengan perbandingan berat antara Cu dengan kemurnian 99,9% dan Sn dengan kemurnian 99,9%. Fluiditas paduan perunggu timah Cu(20,22 dan 24)wt.%Sn dibuat melalui metode *sand casting* dan *investment casting* dengan variasi temperatur lebur (T_L), temperatur tuang (T_{S1}) =1000°C dan temperatur tuang (T_{S2}) =1100°C. Cetakan mempunyai panjang 400 mm, lebar 10 mm dan rongga cetakan divariasikan 1,5 s/d 5 mm. Spesimen dilakukan pengamatan struktur mikro, pengukuran densitas dan porositas, pengujian sifat mekanis meliputi kekerasan, kekuatan tarik, kekuatan bending dan uji akustik.Uji akustik disimulasi menggunakan *Finite Element Analysis*/FEA, dimana hasilnya dibandingkan dengan *Experiment Method Analysis*/EMA.

Hasil penelitian terhadap kedua metode pengecoran menunjukkan panjang fluiditas untuk paduan perunggu timah Cu20wt.%Sn dan Cu24wt.%Sn lebih tinggi dibanding Cu22wt.%Sn. Penurunan panjang fluiditas paduan perunggu timah Cu22wt.%Sn akibat terbentuknya fase α + β *intermetallic.* Peningkatan komposisi timah dan temperatur tuang menyebabkan perubahan struktur mikro bulat kasar menjadi kolumnar dendrit halus. Densitas paduan menurun rata-rata 0,52% - 0,68% . Kekerasan paduan meningkat 6,2% - 11,4%, kekuatan tarik menurun 22,8% pada metode *sand casting*. Kekerasan paduan meningkat 11,6% - 11,7%, kekuatan tarik menurun 18,6% pada metode *investment casting*. Paduan Cu20wt.%Sn menghasilkan kapasitas redaman lebih rendah dengan frekuensi fundamental lebih tinggi. Deformasi tempa dan *heat treatment* setelah pengecoran terhadap paduan perunggu timah Cu20wt.%Sn mengubah fasa α + δ menjadi α + β ditandai dengan peningkatan sifat fisis dan sifat mekanis. Densitas paduan meningkat 6,05%, kekuatan tarik meningkat 70,8%, kekuatan bending meningkat 24,3%, modulus elastisitas meningkat 112,1% dan uji akustik mempunyai intensitas bunyi 40-50dB dengan kapasitas redaman $y = 62{,}321e^{-481{,}8x}$ pada metode *investment casting*. Densitas paduan meningkat 4,09%, kekerasan meningkat 40,6%, kekuatan tarik meningkat 152,3%, kekuatan bending meningkat 29,6%, modulus elastisitas meningkat 11,9% dan uji akustik menunjukkan intensitas bunyi 50-60dB dengan kapasitas redaman lebih rendah $y = 66{,}091e^{-143{,}2x}$ untuk metode *sand casting*. Teknik produksi dengan metode *sand casting* lebih disarankan karena memiliki keunggulan sifat mekanis dan akustik.

Kata kunci : perunggu timah, gamelan, temperatur tuang, *sand casting*, *investment casting*, fluiditas, sifat mekanis, akustik.

Abstract

Gamelan is a traditional musical instrument found in several provinces in Indonesia such as Central Java, DI Yogyakarta, West Java and Bali. Apart from cast iron and brass, the raw material for making gamelan also uses tin bronze alloy. So far, the forging is used to produce gamelan musical instruments. The choice of tin composition is the most important factor to avoid cracking when forging. Manual forging also require a lot of effort and a long production time. Metal casting can be an alternative method that can be applied by taking into account the main parameters such as fluidity, physical properties, mechanical and acoustic properties of tin bronze composition.

The research was started by making an alloy composition of tin bronze Cu (20.22 and 24) wt.% Sn with a weight ratio of Cu pure 99.9% and Sn pure 99.9%. The fluidity of tin bronze Cu (20.22 and 24) wt.% Sn alloys was made by means of sand casting and investment casting methods with variations in melting temperature (T_L), pouring temperature (T_{S1}) = 1000°C and pouring temperature (T_{S2}) = 1100°C. The mold has a length of 400 mm, a width of 10 mm and the mold cavity is varied from 1.5 to 5 mm. The specimens were subjected to microstructure observations, density and porosity measurements, mechanical properties testing including hardness, tensile strength, bending strength and acoustic. Acoustic test was simulated using Finite Element Analysis / FEA, where the results were compared with Experiment Method Analysis / EMA.

The results of the research on both casting methods showed that the length of fluidity for tin bronze Cu20wt.% Sn and Cu24wt.% Sn was higher than Cu22wt.% Sn. The decrease in fluidity length of the Cu22wt.% Sn tin bronze alloy is due to the formation of the intermetallic α + β phase. The increase in tin composition and pouring temperature caused changes in the microstructure of coarse grains to become fine dendrite columnar grains. The density decreased by an average of 0.52% - 0.68%. Hardness of the alloy increased 6.2% - 11.4%, the tensile strength decreased by 22.8% in the sand casting method. The hardness of the alloy increased 11.6% - 11.7%, the tensile strength decreased by 18.6% in the investment casting method. Tin bronze alloy Cu20wt.% Sn produces lower damping capacity with higher fundamental frequency. Forging deformation and heat treatment of tin bronze Cu20wt.% Sn after casting can change the α + δ to α + β phase which is characterized by increasing physical and mechanical properties. The density of the alloy increased by 6.05%, the tensile strength increased by 70.8%, the bending strength increased by 24.3%, the modulus of elasticity increased by 112.1% and the acoustic test had a sound intensity of 40-50dB with a damping capacity of $y = 62.321\ e^{-481,8x}$ on the investment casting method. The density of the alloy increased by 4.09%, the hardness increased by 40.6%, the tensile strength increased by 152.3%, the bending strength increased by 29.6%, the modulus of elasticity increased by 11.9% and the acoustic test showed the sound intensity was 50-60dB with damping capacity. lower $y = 66.091e^{-143.2x}$ for sand casting method. The production with the sand casting method is more suitable because it has the advantage of mechanical and acoustic properties.

Keywords: tin bronze, gamelan, pouring temperature, sand casting, investment casting, fluidity, mechanical properties, acoustics.