

INTISARI

Porositas dan karakteristik permukaan *commercially pure* titanium (CP-Ti) *femoral stem* hasil pengecoran berpengaruh pada aplikasinya. Berbagai usaha dalam proses pengecoran sentrifugal perlu dilakukan untuk mengurangi porositas *femoral stem*. Perlakuan permukaan *femoral stem* perlu dilakukan untuk meningkatkan kecepatan terjadinya osteointegrasi dan sifat mekanis. Tujuan penelitian ini adalah untuk mengurangi porositas *femoral stem* hasil pengecoran sentrifugal dan mengetahui pengaruh parameter *surface mechanical attrition treatment* (SMAT) terhadap karakteristik permukaan dan kekerasan *as-cast femoral stem*.

Upaya pengurangan porositas *femoral stem* dilakukan dengan penentuan desain sistem saluran dan pemilihan kecepatan putar pengecoran sentrifugal. Desain sistem saluran dibuat tiga desain dengan luas penampang total saluran masuk setiap desain 364 mm². Desain A terdiri dari tiga saluran masuk dengan luas penampang sebesar 78,5; 157; 128,5 mm². Desain B terdiri dari empat saluran masuk dengan luas penampang sebesar 78,5; 78,5; 78,5; 128,5 mm². Desain C terdiri dari empat saluran masuk seperti pada desain B namun posisi *femoral stem* terbalik. *Femoral stem* hasil pengecoran dikarakterisasi porositas, kekasaran permukaan, *wettability*, struktur mikro, dan kekerasan. Selain itu, simulasi pengecoran dengan tiga desain sistem saluran digunakan untuk memprediksi porositas yang terjadi. Desain sistem saluran dengan porositas terendah digunakan untuk pengecoran sentrifugal *femoral stem* dengan variasi kecepatan putar 35, 45, dan 55 rpm. *Femoral stem* hasil pengecoran dikarakterisasi porositas, kekasaran permukaan, *wettability*, struktur mikro, dan kekerasan. Kecepatan putar dengan porositas *femoral stem* terendah dipilih pada pengecoran sentrifugal *femoral stem* untuk bahan perlakuan permukaan. Perlakuan permukaan *as-cast femoral stem* menggunakan SMAT dan desain eksperimen Taguchi L₉ (3⁴) *orthogonal array* (OA). Parameter yang divariasi adalah durasi, diameter dan jumlah bola serta frekuensi getaran. *Femoral stem* hasil SMAT dikarakterisasi kekasaran permukaan, *wettability*, dan kekerasan.

Pengecoran sentrifugal vertikal dengan tiga saluran masuk menghasilkan *femoral stem* dengan porositas, kekasaran permukaan, *wettability*, dan ukuran butir struktur mikro terendah namun kekerasan tertinggi. Hasil simulasi pengecoran menunjukkan prediksi porositas terendah pada pengecoran *femoral stem* dengan tiga saluran masuk. Peningkatan kecepatan putar menurunkan porositas, rerata kekasaran permukaan, dan *wettability* pada *femoral stem*. Kecepatan putar 35-55 rpm belum memberikan pengaruh jelas terhadap struktur mikro dan kekerasan *femoral stem*. Peningkatan durasi, diameter bola, jumlah bola, dan frekuensi getaran SMAT meningkatkan kekerasan *as-cast femoral stem* namun menurunkan kekasaran permukaan dan *wettability*. Urutan pengaruh parameter SMAT untuk mengubah *wettability* dan kekerasan *as-cast femoral stem* dari tinggi ke rendah adalah diameter bola, frekuensi, durasi, dan jumlah bola.

Kata kunci: *femoral stem*, pengecoran sentrifugal, *surface mechanical attrition treatment*, sistem saluran, kecepatan putar

ABSTRACT

Porosity and surface characteristic of commercially pure titanium (CP-Ti) femoral stem have effects on its application. The porosity correlates to its mechanical properties whereas the surface characteristic correlates to its osseointegration in body. The porosity of the femoral stem produced by centrifugal casting have to be minimized to get a soundness casting. The osseointegration between tissue and the femoral stem surface should be increased by modification on the femoral stem surface. The aims of this research are to reduce porosity of the femoral stem in the centrifugal casting and to study the effect of surface mechanical attrition treatment (SMAT) on surface characteristic and microhardness of the as-cast femoral stem.

Determination of gating system and rotational speed in the centrifugal casting were done to reduce porosity of the femoral stem. Three gating systems have total cross section area of ingates 364 mm². "A" type of gating system has three ingates which have cross section area 78.5; 157; 128.5 mm²; "B" type has four ingates which have cross section area 78.5; 78.5; 78.5; 128.5 mm²; while "C" type was designed similar to "B" design and the position of the femoral stem was inverse. All the designs were measured their porosity, surface roughness, wettability, microstructure, and microhardness. In addition, these designs were simulated by Solid Cast to predict their porosity. The design which has lower porosity was used in casting of the femoral stem in rotational speed variable. The mold rotational speed of centrifugal casting was choosed 35, 45, and 55 rpm. All the femoral stems were measured of their porosity, surface roughness, wettability, microstructure, and microhardness. The femoral stem which has lower porosity was used in SMAT process. L₉ (3⁴) Orthogonal array of Taguchi design was applied in SMAT of the as-cast femoral stem with duration, size and number of ball steel, and frequency parameters. The SMATed as-cast femoral stems were measured their surface roughness, wettability, and microhardness.

Simulation and experiment of the femoral stem casting result in a similar trend which the "A" gating system design has the lowest porosity. This design also results in the lowest surface roughness, wettability, and microstructure size while its microhardness is the highest. The centrifugal casting of the femoral stem which used 55 rpm of rotational speed results in the lowest of porosity, surface roughness mean, and wettability. The rotational speed 35-55 rpm is not enough yet to achieve a clear effect in microstructure and microhardness. The surface roughness and wettability of the as-cast femoral stem decrease as the increase of duration, size and number of ball steel, and frequency of SMAT while its microhardness increases. The size of the steel ball, frequency, duration, and number of steel ball have effect on the change of wettability and microhardness from high to low respectively.

Key words: femoral stem, centrifugal casting, surface mechanical attrition treatment, gating system, rotational speed