بسم اللّه الرحمن الرحيم

HOSSAM MAGHRABY

شبكة المعلومات الجامعية

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

HOSSAM MAGHRABY

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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بالرسالة صفحات

لم ترد بالأصل

HOSSAM MAGHRABY

SUEZ CANAL UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

MECHANICAL BEHAVIOUR OF POWDER METALLURGICAL MATERIALS

A THESIS

Submitted to the Faculty of Engineering and Technology

Suez Canal University for the Ph.D. Degree in

Mechanical Engineering

By

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ABSTRACT

Different powder metallurgy (P/M) production techniques for some widly used metal componds, primarily to take advantage of possibility to produce technical parts with near net shape technique instead of the usual way of casting usually followed by expensive machining to achieve the desired geometry of the work piece.

The selection of investigated P/M alloys 316L, Udimet-700 and Stellite alloy No. 6, were chosen because of wide spectrum of their technical application and because of the fact - with some exceptions - that they are up to now, normally not produce parts by the powder metallurgical route.

The manufacturing of the parts are performed by : 1) Metal Injection Moulding (MIM)-debinding - sintering. In this method (MIM), the powder is first binded into a solid "green body" then extruded similarly to the polymers. 2) Wet Powder Pouring (WPP) - debinding and sintering in one process . In both cases ultimate densification to solid density is performed by subsequent "HIPing" of the sintered bodies. The new methodology (WPP) of mixing the powder with the binder and liquid suspension have been poured on a rubber mold without appling pressure. The process has been carried out at room temperature. The new technique has been developed as a fast and economic nearest net shape forming. 3) Hot Isostatic Pressing (HIP), only, HIPing of the powder alloy poured into an adequate formed capsule, which is then evacuated before sealing.

Widely optimised "programs" for debinding and sintering have been performed to achieve 95 % of the solid desity of the end products. The subsequent containerless "HIPing" of part alloy have attributed due to the 95 % of the solid density.

The samples of the different alloys are produced in differtent ways:

1) In the case of 316L steel samples are prepared via MIM-sintering and HIPing and compared with samples prepared by HIP and by conventional metal forming processes as hot rolling. Three different time functions for heating during the HIP process and six different heat treatments were applied to optimize the properties. High temperature creep tests were carried out on the P/M material with the different production and treatment condition. In addition a commercial hot-rolled material was heat treated and tested

under the same creep conditions. The comparison showed that the powder metallurgically produced material has at least the same creep resistance as the rolled one.

2) Udimet-700 samples are produced via the route WPP-sintering and HIPing plus different production heat treatments. As superalloy, the production of this material is much more difficult than the first one. By using this method, the material shows clearly higher creep resistance properties as those of the rolled alloy and those determined in previous investigation using other powder metallurgical methods (HIP).

3) Stellite alloy No. 6 samples were prepared again just via HIP and these samples were compared to those produced via WPP-Sintering-HIPing and those commercially available. Rotating bending fatigue tests were carried out and fatigue limit statistically evaluated according to the Weibull analysis. The material was studied at different stress amplitude levels in order to determine the Weibull curves for 10, 50 and 90 % survival probability. In comparative tests, the corresponding curves were determined for the commercially available wrought material. The comparison showed that the P/M processing materials have higher endurance limit than the commercial one in its as delivered condition. Similar results were obtained for hardness at low and high temperatures.

The materials producing by the WPP-Sintering and HIPing, usually have lower strength and toughness values than capsule-HIPed ones, different cycles of heat treatments were tried out in order to improve the microstructure. Metallurgical study and elevated temperature tension tests showed that strength and ductility can be seriously increased after using an adequate heat treatment.

Nomenclature

$A\,a$	are constant depending on the test creep conditions
B	creep stress constant
$b > 0$	Weibull shape (or 'slope') parameter
bcc	body-centred-cubic
C	Larson Miller constant (C=20)
$Conv.$	conventional
d	particle size
$d_{(RT)}$	diagonal at room temperature
d_T	diagonal at test temperature
$F(N)$	the cumulative function for the fracture of population failed
fcc	face-centred-cubic
HIP	Hot Isostatic Pressing
$H.T.$	Heat Treatment
HV	Vickers Hardness at room temperature
K_1,K_2	creep constants
MIM	Metal Injection Molding
m	stress exponent for rupture results
N	specimen fatigue life
$N_0 \geq 0$	minimum fatigue life parameter
N_a	characteristic fatigue life parameter
n	creep stress exponent
P	Pressure
P/M	Powder Metallurgy
Q_c	activation energy
R	universal gas constant (8.314 KJ/(mol. K))
RT	Room Temperature
r	rate approach to steady state creep
T	Temperature