Green Machining of the Warm Compacted Sinter Hardenable Material

Chao-Hsu Cheng[1,a], Ken Chiu[2,b] and Ray Guo[3,c]

[1] Chung Chou Institute of Technology, Department of mechanical and computer-aided engineering
No.6, Lane 2, Sec. 3, Shanjiao Rd., Yuanlin Town, Changhua County 510, Taiwan
[2] Yin King Industrial Company, Ltd.; No.620-1, Sec.6, Chunghua Rd., Hsinchu City, Taiwan
[3] QMP Metal Powders (Suzhou) Co. Ltd. Suzhou Industrail Park, Suzhou, China
[a] chaohsu@dragon.ccut.edu.tw, [b] kenchiu@at-yinking.com.tw,
[c] ray.guo@qmp-powders.com

Abstract

High hardness of P/M parts can be obtained in the cooling section of the sintering furnace by using sinter hardenable materials, thus the post-sintering heat treatment can be eliminated. However, the sinter hardened materials would have difficulties in secondary machining if it is required, which will limit the applications of sinter hardenable materials in the machined parts. Recent development in warm compaction technology can enable us not only to achieve the high green density up to 7.4 g/cm^3, but also the high green strength which is needed for green machining. Therefore by using warm compaction technology, the green machining can be applied to sinter hardenable materials for the high density, strength and hardness P/M parts. In the present study, a pre-alloyed steel powder, ATOMET4601, was used by mixing with 2.0 % copper, 1.0 % nickel, 0.9% graphite and a proprietary lubricant using a binder treatment process – FLOMET. The specimens were compacted and green machined with different machining parameters. The machined surface finish and part integrity were evaluated in selecting the optimal conditions for green machining. The possibility of applying the green machining to the high-density structural parts was explored.

Keywords : green machining, sinter hardening, warm compaction

1. Introduction

Sinter hardening materials enable the P//M parts to achieve high hardness (>HRC30), thus the secondary heat treating can be eliminated for the cost saving and better part dimensional control. The benefits of sinter hardening have been widely recognized for the parts without secondary machining operations. However, there are applications that the secondary machining is needed, which would limit the sinter hardening applications.

The present study was to search for a new way of machining the sinter hardenable materials at the green stage – green machining. A prealloyed powder, ATOMET4601, was selected for green machining and sinter hardening in the present study. The special lubricating system, warm compaction, was used to achieve the high green strength needed for green machining.

2. Experimental and Results

ATOMET 4601 sinter hardening material is a powder prealloyed with Mo and Ni. The premix contains additives, Cu, Ni, graphite and conventional and warm compaction lubricants, as shown in Table 1. The premix was pressed to 6.9 g/cm^3 density. Curing treatment was carried out to achieve the high green strength for warm compaction premix.

Table 1. Composition of the sinter hardening materials.

Premix	Base Powder	Elemental Additions (Wt. %)				Green strength	Cure Strength
		Cu	Graphite	Ni	Lube.		
FLOMET A	ATOMET 4601	2.00	0.90	1.00	1.0 %, ZnSt	12.9 MPa	15.1 MPa
FLOMET WP B	ATOMET 4601	2.00	0.90	1.00	0.6 % WP	13.9 MPa	40.2 MPa

Table 2. The thrust force $_{max.}$at different feed rate and ele ctric power of drilling on different material.

Material	Feed rate	Cold compaction		Cold compaction+200℃ Curing	
		Electric power for drilling	Thrust force $_{max.}$	Electric power for drilling	Thrust force $_{max.}$
FLOMET A	20 mm/min.	12.12	6.15	11.94	6.45
		17.55	4.15	17.55	4.45
		25.92	2.75	27.72	2.75
	40 mm/min.	13.14	8.75	12.84	9.15
		20.25	5.95	18.00	7.20
		28.08	4.35	29.64	5.85
FLOMET WP B	20 mm/min.	12.30	5.60	12.06	6.35
		18.27	3.90	17.46	5.85
		28.80	3.85	27.60	3.30
	40 mm/min.	12.54	8.40	12.60	9.70
		18.45	5.55	18.90	6.95
		29.04	4.90	28.92	5.55

Unit: Electric power: **Walt**; Thrust force: **Kgf.**

Green machining was carried out with a set-up as shown in Fig. 1. A WC drill ofψ5 was used, the feed rate of the drill was controlled at given speed and the rotating speed of the drill was controlled by varying the electric powder input. The detailed test conditions were list in Table 2.

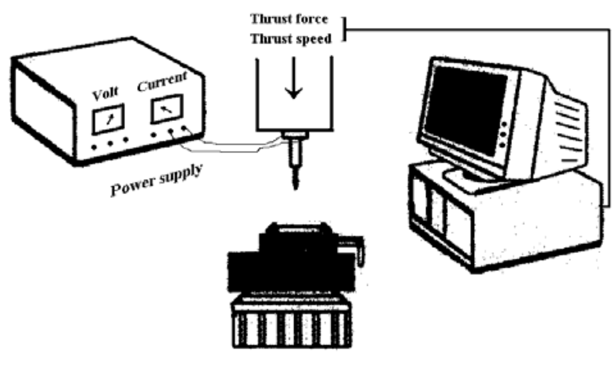

Fig. 1. The set-up for green machining

The integrity of the holes was observed with Microvu Video Measuring System (Fig. 2).

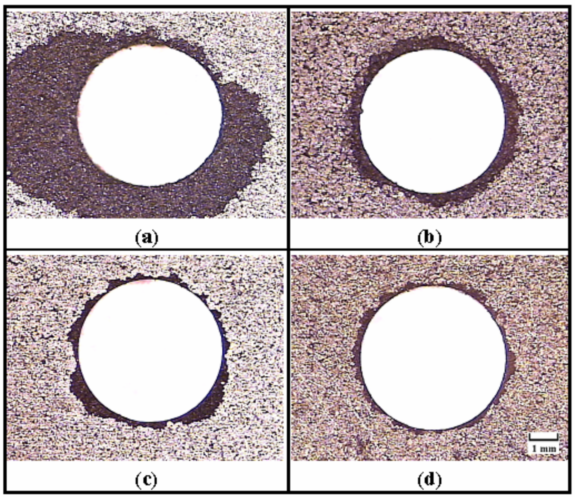

Fig. 2. Integrity of green machined holes at different conditions: (a) FLOMET A, no curing, feed rate of 40 mm/min., low electric powder input; (b) FLOMET A, no curing,feed rate of 20 mm/min., high power input; (c) FLOMET WP B, curing at 200 C, feed rate of 40 mm/min., low powerinput and (d) FLOMET WP B, curi ng at 200 C, feed rate of 20 mm/min., high power i nput.

3. Summary

1. With the curing treatment, FLOMET WP B premix achieve the high green strength needed for green machining.
2. High rotating speed and low feed rate were the optimal conditions for green machined part integrity.