APPLICATIONS OF THE BINDER TREATED Mo-PREALLOYED PREMIXES AS ALTERNATIVES TO DIFFUSION BONDED POWDERS.

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The binder treated premixes, named FLOMET 44A & 44B, were introduced as lower cost alternatives to the diffusion bonded powders. The premixes, using 0.85%Mo pre-alloyed ATOMET4401 as the base powder and mixed with nickel, copper and graphite, are binder treated to prevent the nickel and copper segregation and to improve the premix flow rate, thus resulting in characteristics similar to diffusion bonded powders. The FLOMET 44A & 44B have been used in manufacturing auto, power tool and agricultural machine parts, and their compressibility, weight consistency, mechanical properties and microstructures were studied in comparison to mixes of diffusion bonded powders containing 1.75% and 4.0% nickel respectively. The binder treated premixes reproduced the dimensional changes, consistency and mechanical properties of the diffusion bonded blends at lower costs.

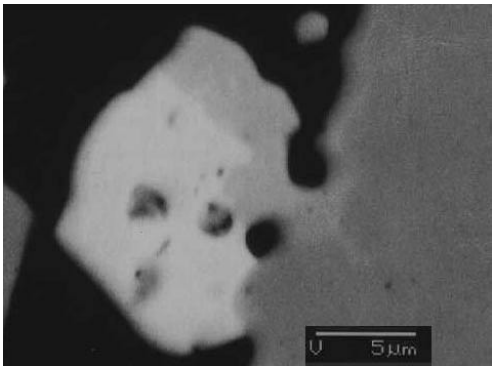
KEYWODRS: BINDER TREATMENT, DIFFUSION BONDED POWDERS, PREALLOYED POWDERS

1. INTRODUCTION

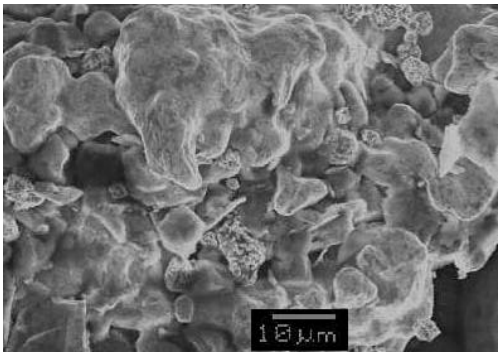
Diffusion bonding is a thermal treatment process to create superficial bonds between iron particles and alloying additives by high temperature diffusion in an annealing furnace. Figure 1.a shows a nickel and copper particle diffusion bonded to an iron particle. Alternatively, the superficial bonds can be effected by polymeric adhesion using a binder treatment process in the blender (Figure 1.b). Although the two technologies provide very different routes in the powder manufacturing, they have the same technical objectives of improving powder mix homogeneity, flow and preventing the dusting during powder handling, thus enhancing the stability, particularly the dimensional stability, of the sintered products. Therefore, the binder treated mixes can be considered as an alternative to the diffusion bonded powders at lower costs. By using the patented binder treatment technology [1], QMP developed FLOMET 44A and 44B in 1996, the first two press-ready mixes with diffusion bonded characteristics [2-4].

2. FLOMET 44A and 44B

A binder treatment technology, FLOMET, has been developed to produce press-ready mixes with advantages of improving powder mix homogeneity, flow rate and product consistency, and also reducing dusting during powder handling [5, 6]. To produce FLOMET 44A or 44B, the 0.85%Mo pre-alloyed ATOMET4401 is used as the base powder and mixed with nickel, copper and graphite, and then binder treated to produce a press-ready mix. The FLOMET mixes are formulated in such way to reproduce the same dimensional changes and mechanical properties as the diffusion bonded powder mixes, FD0205 and FD0405 (MPIF Standards 35, 1997), respectively. Table 1 lists the comparison of various properties between the binder treated and the diffusion bonded premixes. The apparent densities are all very similar for all mixes, but the flow rates of FLOMET 44A & 44B are improved by 6 sec, which would enhance the die-filling performance. FLOMET 44A & 44B have the same compressibility and green strength as the diffusion bonded mixes respectively.



(a)



(b)

Figure 1. Micrographs of diffusion bonded particle (a) and binder treated particle (b)

For the sintered properties (Table 1), in comparison, FLOMET 44A & 44B show better hardness, strength and similar impact energy, but slightly lower elongation than the diffusion bonded powders. Summarizing the properties in Table 1, FLOMET 44A & 44B could be used as alternatives to the diffusion bonded powders to meet application requirements. By adjusting the mix formulation, FLOMET 44A and 44B can reproduce the same dimensional changes as the diffusion bonded mixes, hence they can be used as drop-in replacements to the diffusion bonded mixes with no need for modifying existing dies. In recent years, the FLOMET 44A and 44B have been used to replace the diffusion bonded mixes in the production of parts for cars, power tools, appliances, business and agricultural machines (Figure 2). Furthermore, part manufacturers have started to design new parts with FLOMET 44A and 44B rather than the traditional diffusion bonded powders.

Figure 2. Parts manufactured with FLOMET 44A & 44B

Table 1. Properties of FLOMET 44A & 44B versus the diffusion bonded premixes

PROPERTY	FD-0205 (MPIF)	FLOMET 44A	FD-0405 (MPIF)	FLOMET 44B
MIX COMPOSITION, (%)				
Mo	0.50	0.85	0.50	0.85
Ni	1.75	1.50	4.00	3.50
Cu	1.50	1.25	1.50	1.20
Graphite	0.60	0.60	0.60	0.60
Lubricant	0.75	0.75	0.75	0.75
PHYSICAL				
Apparent density, g/cm^3	3.12	3.12	3.12	3.16
Flow rate, sec/50g	33.0	27	33.0	27
METALLURGICAL				
GREEN				
Green density, g/cm^3	7.0	7.0	7.0	7.0
Compacting pressure, MPa	556	549	542	534
Green strength, MPa	11.03	11.03	11.34	10.62
SINTERED*				
Sintered density, g/cm^3	6.97	6.97	6.98	6.98
Trans. Rup. Strength, MPa	1303	1420	1586	1675
Hardness, HRC	10	16	20	25
UTS, MPa	621	627	793	827
Yield strength, MPa	427	462	483	531
Elongation, %	2.0	1.3	1.8	1.2
Impact energy, J	16.3	14.9	21.7	20.3

* Sintered at 1120^{o}C, 25 min in a $90N_2/10H_2$ atmosphere.

3. CASE STUDIES

The following are two case studies in the successful application of FLOMET 44A & 44B as an alternative to the diffusion bonded mixes.

3.1 CASE 1 - BUSINESS MACHINE PARTS

Figure 3 shows one of gears manufactured with FLOMET 44A. The gear was used in business machines and traditionally produced with diffusion bonded material. To qualify FLOMET 44A for the gears, parallel tests were carried out between FLOMET 44A and diffusion bonded FD-0205. The gears were pressed to a green density of 6.88-6.89 g/cm3 for both FLOMET 44A and FD-0205 materials, and then sintered at 1125 ?C for 30 min in a mesh belt type furnace with an endothermic atmosphere. Subsequently, the gears were heat-treated and tempered. The green, sintered and heat-treated properties are listed in Table 2.

Figure 3. A gear manufactured with FLOMET 44A

FLOMET 44A showed very similar sintered and heat-treated properties to the diffuison bonded FD-0205 in terms of the hardness, torque and dimensional change. The dimensional stability of FLOMET 44A was well controlled with a variation of 0.07-0.08mm in the outer diameter, the same as or slightly better than that of FD-0205. The substantial saving on the material cost was achieved by using FLOMET 44A for manufacturing gears.

3.2 CASE 2 - SYNCHRONIZER HUB

The synchronizer hub, as shown in Figure 4, was produced using diffusion bonded FD-0205. To reduce the material cost, a program was initiated to qualify the FLOMET 44A as an alternative in manufacturing this auto part used in small cars. The synchronizer hub weighs 250 grams and has a sintered density of 6.80–6.90 g/cm3.

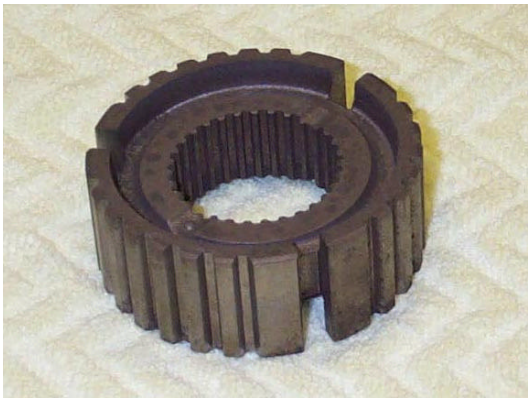


Figure 4. A synchronizer hub used in small cars

As shown in Table 3, FLOMET 44A was as compressible as the diffusion bonded FD-0205 and met the part specifications. FLOMET 44A successfully reproduced the mechanical and dimensional properties of the diffusion bonded FD-0205 and qualified as a low cost drop-in alternative to the diffusion bonded material in manufacturing the synchronizer hubs.

4. SUMMARY

Using binder treatment technology, FLOMET wtih Mo pre-alloyed AT4401, QMP pioneered the development of FLOMET 44A & 44B as lower cost alternatives to the diffusion bonded, FD-0205 and FD-0405, respectively. The binder treated premixes, with much improved powder homogeneity, flow and dust resistance, result in the physical characteristics that are similar to the diffusion bonded mixes.

In comparison, FLOMET 44A & 44B have the same compressibility and green properties as, and exhibit very similar sintered mechanical properties to the diffusion bonded powders respectively. The same dimensional changes were reproduced by the means of formulating FLOMET 44A and 44B, so they could be used as drop-in replacements to the diffusion bonded mixes without the need of modifying existing dies.

FLOMET 44A & 44B have been well received by the manufacturers in making parts for cars, power tools, appliances, business and agricultural machines. They have also been used as press-ready premixes for new part developments, as well as replacements for the diffusion bonded mixes.

Table 2. Results of the gear – CASE 1

		Density, g/cm3		Apparent Hardness		Tooth Crush Load Kgf		Outer diameter, mm	
Specification		6.8 min.		HRC 30 min		-		28.65 – 28.80	
Material		F44A*	FD-0205	F44A	FD-0205	F44A	FD-0205	F44A	FD-0205
Green	Min.	6.88	6.88	-	-	-	-	28.726	28.723
	Max.	6.89	6.89	-	-	-	-	28.732	28.732
Sintered	Min.	6.85	6.85	82 HRB	78 HRB	879	840	28.760	28.750
	Max.	6.87	6.87	87 HRB	83 HRB	941	974	28.768	28.760
Heat Treated	Min.	6.85	6.85	35 HRC	34 HRC	1028	1018	28.776	28.756
	Max.	6.87	6.87	37 HRC	37 HRC	1093	1139	28.783	28.774

* FLOMET 44A

Table 3. Results of synchronizer hub – CASE 2

Material	Compacting load, tons	Sintered Density *, g/cm3	Apparent Hardness, HRB	Dimensional Change, % vs. Die Size
Specification	-	6.80+0.10	65 - 80	0.36 – 0.45
F44A	112	6.80 – 6.90	69 – 72	0.38 – 0.42
FD-0205	112	6.80 – 6.90	70 – 74	0.38 - 0.42

* Sintering at 1120 ?C, endothermic atmosphere, in the mesh belt furnace with a belt speed of 145mm/sec.

5. ACKNOWLEDGEMENT

My sincere thanks go to Mr. U. L. Yang of Trinity Metallize Co., Ltd., Taiwan, for his efforts testing and qualifying FLOMET 44A for the business machine parts and his permission using the information in the present paper in Section 3.1 CASE 1.

6. REFERENCE

[1] F. Gosselin, "Segregation-Free Metallurgical Powder Blends Using Polyvinyl Pyrrolidone Binder", U.S. Patent No. 5,069,714.

[2] FLOMET FLXD2774 (44B), a binder treated mixture of ATOMET4401 with 1.20%Cu, 3.50%Ni and 0.60% graphite, sent to Uni-Tech Metallurgy Co., Ltd., via Sydkenn Corporation, Taiwan, in November 1995.

[3] FLOMET FLXD2869 (44A), a binder treated mixture of ATOMET4401 with 1.25 %Cu, 1.50% Ni and 0.60% graphite, and also FLXD2774 (44B), a binder treated mixture of ATOMET4401 with 1.20% Cu, 3.5%Ni and 0.60% graphite, sent to Korea Powder Metallurgy Co. Ltd., Korea, in April 1996.

[4] J. P. Poirier, "FLOMET 44: the original alternative to diffusion-bonded powder ", QMP Notes, Quebec Metal Powders, Volume 10, No. 1, Spring 1999.

[5] F. Gosselin, M. Gagne and Y. Trudel, "Segregation-Free Blends: Processing Parameters and Products Properties", Word Conference on Powder Metallurgy, The Institute of Metals, London, 1990, Vol. 1, pp. 297.

[6] C. Gelinas, F. Chagnon and Y. Trudel, "Optimizing Properties of Binder-Treated Ferrous Powder Premixes", Advances in powder Metallurgy & Particulate Materials, MPIF, Princeton, 1995, pp.3-45.