Y-12

OAK RIDGE Y-12 PLANT

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INVESTIGATION OF MACHINING DAMAGE AND TOOL WEAR RESULTING FROM DRILLING POWDER METAL ALUMINUM ALLOY

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May 1997

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Prepared by the
Oak Ridge Y-12 Plant
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

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INTRODUCTION

This report documents the cutting of aluminum powder metallurgy (PM) parts for the North Carolina Manufacturing Extension Partnership. Mr. Thomas J. Sefcik of Catawba Valley Community College was the requestor for the work.

The parts, an aluminum powder metal formulation, were supplied by Sinter Metals Inc., of Conover, North Carolina. The intended use of the alloy is for automotive components.

Machining tests were conducted at Y-12 in the machine shop of the Skills Demonstration Center in Building 9737. Testing was done on June 2 and June 3, 1997. Testing was performed by the author and Michael L. Pelfrey assisted by Michael F. Tuck, the shop supervisor. Prior work had been performed by others and is mentioned in the report.

TESTING EQUIPMENT

The machine tool used for the drilling tests was a Cincinnati Milacron Magnum Machining Center.

The test parts were held in a collet holder mounted to an angle plate bolted to one of the pallets of the machining center. All holes were drilled at the 12:00 o'clock position. The collet which had been machined did not, therefore, support the back side of the part.

Parts were inspected using a hand held comparator. It is possible to discern features as small as 0.001" when used in proper light.

Apparently four test specimens had been available for testing at some point in time. When the final testing was done, only three of the specimens were present. The location of Specimen 1 is unknown. Work performed on June 2 and June 3 was performed on Specimens 2, 3, and 4. These specimens are available from the writer.

The following drills were used in the tests and are available from the writer if further investigation is desired:

Greenleaf letter size "F" (0.257") Cobalt Steel

Guhring 6.528mm solid carbide

Guhring 6.528mm solid carbide micro grain

Guhring 6.528mm TiN coated carbide

Guhring 6.528mm TiAlN coated carbide

TESTED MATERIAL

Material for the test was supplied by Sinter Metals Inc., of Conover, North Carolina. Test blanks were 1.625" in diameter by 0.400" thick.

At the time of the June testing, only three of the four blanks supplied were available, labeled Specimens 2, 3, and 4. Specimen 2 had three holes drilled and tapped in it. Specimen 3 had two holes drilled and tapped in it. Specimen 4 had not been machined.

A sketch of the blanks showing the previously drilled and tapped holes as well as the testing that occurred in June is included as appendix 1 of this report.

TESTING PROCEDURE AND SET-UP

The following narrative is a description of the testing that took place on the material during June 1997. Some previous testing had been performed on the parts. Since the protocols followed in the previous testing are unknown, no description of those tests will be listed here.

The test specimens were mounted in a collet holder which had been machined to fit the outer diameter of the part. The test drill was mounted in a precision chuck in the spindle of the Cincinnati Milacron Magnum Machining Center. Spindle speed and feed rate were programmed into the machine by the operator and the part was drilled.

All drilling took place at the top center (12:00 o'clock) position in the collet. The back side of the part was supported by the collet, but the part was not backed up by a sacrificial plug under the drilled area.

With a particular drill mounted in the chuck, a hole was drilled in each of the three specimens. This required that the specimen be changed after each hole. This should alleviate differences in test results due to differences in the specimens. This was possible for the first four drills to be tested, but was not possible in the last drill due to lack of space in Specimen 2. Drill 5, the TiAlN coated drill was used to drill one hole in Specimen 3 and two holes in Specimen 4.

After a drill was used to drill one hole in each part, it was retired and the next drill to be tested was mounted and the procedure repeated. By indexing the parts in a known manner, the location of each hole drilled by each different drill has been documented. This is shown on the sketch included as Appendix 1.

PRIOR WORK AND LIMITATIONS OF TESTING

Prior work had been performed on the test material, as evidenced by the drilled and tapped holes in the specimens. A brief description of that work is included in Appendix 2 in the form of a memo from F. J. Roettger to A. Beasley dated April 1, 1997.

This memo describes briefly the prior work and lists the tests recommended by a cutting tool manufacturer. This is the test that was carried out in June 1997.

No concessions to the accuracy of the testing procedure are known. No unusual conditions occurred during the tests.

CUTTING TEST SPECIFIC DATA

Table 1 lists the hole identification, specimen, cutting parameters, entrance condition, exit condition, and the appearance of the hole produced.

The description "chip" refers to a hole condition generally consisting of discrete area of missing material usually not connected.

The description "breakout" refers to a hole condition where large areas of material is missing in a continuous manner.

No attempt was made to quantify the surface finish of the hole. Descriptions are visual only and are highly subjective--holes described as "OK" to the tester may be unacceptable to the customer, or holes described by the tester as "Rough" may be perfectly acceptable as holes which are subsequently to be tapped.

All holes were drilled in one continuous pass. Withdrawal of the drill was done with the drill turning. No coolant was used in the test--all holes were drilled dry.

Examination of the holes and drills was performed using a hand held comparator. A reticle in the comparator allows features as small as 0.001" to be viewed and measured.

Tools used to drill the holes are listed in Table 2. Also listed is the condition of the tool after drilling three holes. The tools have been retained and are available for examination by contacting the writer.

Each tool except for Tool E (see Table 2 for tool identification) was used to drill three holes, one hole in each of the specimens. Tool E was used to drill three holes, but one hole was drilled in Specimen 3 and two holes were drilled in Specimen 4.

TABLE 1

HOLE CONDITION CHART

HOLE NUMBER	SPECIMEN NUMBER	DRILL USED	SPEED RPM	FEED IPR	ENTRANCE CONDITION	EXIT CONDITION	SURFACE FINISH
-----	-----	-----	-----	-----	-----	-----	-----
1	2	A	2400	0.005	SMOOTH	BREAKOUT, .030W x 180 deg	SMOOTH
2	3	A	2400	0.005	CHIPS, BREAKOUT & RAISED METAL .015W x 360 deg	BREAKOUT .012W x 270 deg	ROUGH
3	4	A	2400	0.005	BREAKOUT, .025W x 360 deg	RAISED METAL .020W x 180 deg	ROUGH
4	2	B	6000	0.006	SMOOTH	BREAKOUT .017W x 300 deg	SMOOTH
5	3	B	6000	0.006	SMOOTH	CHIPS, BREAKOUT 360 deg	SMOOTH, SOME CHATTER IN BANDS
6	4	B	6000	0.006	CHIPS, .020W	CHIPS, .010W	SOME ROUGHNESS
7	2	C	6000	0.006	SMOOTH	BREAKOUT, .025W x 180 deg	OK
8	3	C	6000	0.006	SMOOTH	CHIPS, BREAKOUT .015W x 180 deg	SOME CHATTER IN BANDS
9	4	C	6000	0.006	CHIPS, .040W	CHIPS, .015W	SOME CHATTER IN BANDS
10	2	D	7000	0.0075	CHIPS, .010W	RAISED METAL NO BREAKOUT	ROUGH, TORN
11	3	D	7000	0.0075	CHIPS, BREAKOUT SMALL, 90 deg	BREAKOUT .015W x 180 deg	BETTER FINISH
12	4	D	7000	0.0075	SMALL CHIPS	CHIPS, .015W	OK
13	3	E	7500	0.009	SMALL CHIPS	BREAKOUT, .010W x 270 deg	OK
14	4	E	7500	0.009	CHIPS, .005W	BREAKOUT, .015W x 360 deg	OK
16	4	E	7500	0.009	SMALL SHIPS	BREAKOUT, .020W x 180 deg	OK

TABLE 2

DRILL IDENTIFICATION AND CONDITION CHART

DRILL CODE	MATERIAL TYPE	CONDITION AFTER DRILLING THREE HOLES
=====	=====	=====
A	COBALT STEEL	Flutes cratered and eroded Flank wear on flutes .025 wide Large amount of recast material on point of drill
B	CARBIDE	Start of cratering and erosion on flutes Flank wear on flutes .015 wide Recast material on point of drill
C	CARBIDE (MICRO GRAIN)	Start of cratering on both flutes Flank wear on flutes .012 wide Recast material on point of drill
D	TiN Coated	Coating worn away .020 back from cutting face Flank wear on flutes .010 wide Small amount of recast material on point of drill
E	TiAlN Coated	Coating worn away .025 back from cutting face Start of cratering and erosion on flutes Flank wear on flutes .007 wide Small amount of recast material on point of drill

RESULTS AND CONCLUSIONS

The powder metal alloy tested is very abrasive and tends to wear craters and produce erosion effects on the chip washed face of the drills used. It also resulted in huge amounts of flank wear and degraded performance on the part of most drills.

No cutting parameters were successful in eliminating breakout and chips on the exit surface of the parts. In most cases, some effects were observed on the entrance face of the parts also. The usefulness of sacrificial material to back-up the specimens as the drill breaks through on the exit face was not investigated. Milling of chamfers at the entrance and exit surfaces before drilling could also lessen the amount of breakout, but this was not tested either.

Anti-wear coatings on drills seemed to have an effect. Drills with the coating showed less wear for the same amount of cutting.

The usefulness of coolants and lubricants in reducing tool wear and chipping/breakout was not investigated.

APPENDIX 1

⊘ INDICATES PRIOR WORK DESCRIBED IN APPENDIX 2

⑮ HOLE 15 (SPARE LOCATION) NOT DRILLED

<u>Location to be drilled</u>	<u>Drill</u>	<u>Speed</u>	<u>Feed</u>
1, 2, & 3	Cobalt Steel	2400 RPM	0.005 IPR
4, 5, & 6	Carbide	6000 RPM	0.006 IPR
7, 8, & 9	Carbide(micro)	6000 RPM	0.006 IPR
10, 11, & 12	TiN Coated	7000 RPM	0.0075 IPR
13, 14, & 16	TiAlN Coated	7500 RPM	0.009 IPR
15	Spare location--not drilled		

APPENDIX 2

to Albert Brerley
241-3113

4-1-94

Tests on Special Aluminum Alloy

PART NOT		PART 1		PART 2	
Hole no		Hole no		Hole no	
1		1		1	
Cobalt HSS 200 .0045		Cobalt HSS 200 .0045		Cobalt HSS 200 .0045	
2		2		2	
Cobalt Gold 600 .0015		Cobalt Gold 600 .0015		Cobalt Gold 150 .0015	
3		3		3	
Carbide Chrome 100 .006		Carbide Chrome 100 .006		Carbide Chrome 200 .0015	
PART 2 Drill Tap Rpm Feed		PART 2 Drill Tap Rpm Feed		PART 2 Drill Tap Rpm Feed	
1		1		1	
HSS 500 Hand		HSS 500 Hand		HSS 500 Hand	
2		2		2	
3		3		3	

All the above drills drilled and produced breakout on the back side of the part after one or two holes

Part # 3

We drilled two holes with a cobalt steel drill @ 3000 rpm + 0.007 ipr feed. The first hole was OK and the second hole had some breakout on the back side.

The drilling company was consulted for advice on drilling the material. They suggested three drills (carbide insert, T: N coat and T: A: N coat) and drilling parameters. The following test was designed to test their drills and drilling parameters.

Since we have been unable to drill more than one good hole with a drill, the current emphasis is being placed on trying to drill several holes with one drill. If we can drill several good holes with one drill, we could then try tapping studies.

Drill Test

discs 1.625 dia by .5 thick

drills - .257 Dia.

	speed	feed
cobalt steel	2400 rpm	.005 ipr
carbide	6000 rpm	.006 ipr
carbide (micro)	6000 rpm	.006 ipr
TiN coated	7000 rpm	.0075 ipr
TiAlN coated	7500 rpm	.009 ipr

3 holes / drill

record diameter of holes

check drill wear

Distribution

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