A LABORATORY EVALUATION OF TUNGSTEN CARBIDE INSERTS FOR SNOWPLOW BLADES

Final Report
For
MLR-95-6

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Project Development Division

Iowa Department of Transportation

A Laboratory Evaluation of Tungsten Carbide Inserts for Snowplow Blades

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by

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8. ABSTRACT

Tungsten carbide used in snowplow blades was studied from three manufacturers. The carbides were measured for common industry properties including specific gravity and hardness. In addition, an abrasion resistance was performed. There was no significant difference found in abrasion resistance between the Kenametal and the Valk carbides. The Bucyrus carbides showed improved abrasion resistance, but were outside industry specifications for specific gravity.

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DISCLAIMER

INTRODUCTION

This study was initiated due to some complaints from the field that the carbide snowplow blades used in the winter of 1993-94 were not lasting as long as the blades from previous years. The blades seemed to be wearing faster than normal. This was a "gut feeling" of some of the plow drivers, but there was no hard data to back up the claim.

Tungsten carbide is made from small grains of tungsten carbide that are cemented together with a cobalt binder. The carbide grains and the cobalt are put into a mold, then the mold is pressed and heated. The cobalt binder melts and flows between the carbide grains and cements all the grains together.

The tungsten carbide grains provide the hardness and wear resistance. They are also heavier than the cobalt so they contribute to higher specific gravities of the end product. The cobalt on the other hand is softer and lighter, but it provides the toughness and impact resistance to the carbide.

Generally, the harder and heavier a carbide, the more resistant it is to wear. However, the harder and heavier carbides are also more brittle and subject to breaking from impact. So, there is a balance that must be struck between the abrasion resistance and impact resistance.

The correlation between hardness and abrasion resistance is further influenced by other factors such as the tungsten carbide grain size, and the porosity of the overall product.

Since there is not a simple relationship between abrasion resistance and one single property, it seemed to me the most straight forward way to determine abrasion resistance was by an abrasion resistance test.

ASTM B611, abrasive wear resistance for cemented carbides, outlines such a test. Basically, a steel wheel with an abrasive grit on it rubs against a piece of carbide. The carbide is measured for weight loss, then this weight loss is converted into a volume loss.

We were able to get snowplow blades from three different winters which represented three different manufacturers.

Winter	Carbide Manufacturer
92-93	Kennametal Inc. Latrobe, PA
93-94	Valk Mfg. Carlisle, PA
94-95	Bucyrus Blades Bucyrus, OH

Listed in the tables below are the abrasion resistance (volume loss), hardness, and specific gravities for carbides from three different manufacturers. Five carbide pieces were tested from each manufacturer. One carbide piece from Kennametal had an unusually high volume loss, so a second set of 5 pieces was tested.

Abrasion Resistance - Volume Loss in cm^3

	Bucyrus	Kennametal 1	Kennametal 2	Valk
Sample 1	0.1451	0.2455	0.1806	0.1841
Sample 2	0.1506	0.2105	0.1698	0.2011
Sample 3	0.1578	0.1710	0.1693	0.2200
Sample 4	0.1637	0.1730	0.2158	0.2312
Sample 5	0.1608	0.1680	0.2108	0.1706
Average	0.1556	0.1936	0.1893	0.2014
Std Dev	0.0076	0.0338	0.0225	0.0249

Hardness - Rockwell A

	Bucyrus	Kennametal 1	Kennametal 2	Valk
Sample 1	88.2	87.4	87.9	88.2
Sample 2	88.1	88.8	88.1	87.6
Sample 3	87.9	86.8	88.5	88.9
Sample 4	88.2	87.2	88.0	88.0
Sample 5	88.1	88.1	88.7	85.9
Average	88.1	87.7	88.2	87.7
Std Dev	0.14	0.81	0.33	1.09

Specific Gravity

	Bucyrus	Kennametal 1	Kennametal 2	Valk
Sample 1	15.3699	14.8095	14.5094	14.4042
Sample 2	15.0835	14.1821	14.8413	14.4038
Sample 3	15.6477	14.5436	14.7192	14.7230
Sample 4	15.5966	14.4895	14.5173	14.5974
Sample 5	15.2650	14.5497	14.3150	14.7633
Average	15.3925	14.5149	14.5804	14.5783
Std Dev	0.2340	0.2237	0.2042	0.1705

DISCUSSION

The most pressing question we wanted to answer from this research is, do the Kennametal carbides have better abrasion resistance than the Valk carbides? The abrasion resistance data shows that Kennametal carbides perform slightly better than Valk. However, the difference is small enough so that the standard deviation in the testing procedure could account for the difference.

Kennametal-1 showd an average volume loss of 0.1936 cm^3 which is 3.9% less than the 0.2014 cm^3 average volume loss from Valk. Kennametal-2 showed an average volume loss of 0.1893 cm^3 which is 0.0121 cm^3 or 6.0% less than Valk. These differences are too small to be significant since they are less than one standard deviation of the volume loss measurements. The standard deviation of the volume loss is 0.0338, 0.0225 and 0.0249 cm^3 for Kennametal-1, Kennametal-2 and Valk samples respectively.

The Bucyrus carbides showed the best abrasion resistance with an average volume loss of 0.1556 cm^3. However, these carbides also had a much higher specific gravity. The average specific gravity for the Bucyrus carbides was 15.3925. This is quite a bit higher than the industry standard range of 14.1 to 14.6. However, since Iowa has no upper limit on the specific gravity, these carbides comply with the Iowa specification.

I am concerned that these carbides may be more brittle than the lower specific gravity carbides. The high specific gravity indicates that the carbides are high in tungsten carbide, but low in cobalt binder. It is the binder that provides toughness and breaking resistance due to shock.

I spoke with three maintenance supervisors about the Bucyrus snowplow blades. They all said the Bucyrus blades this last winter did about the same as the Valk blades from the winter before. So, there was no indication that the blades wore longer, or no indication that the blades broke more often. However, I think that unless a person is specifically looking at the carbide performance, it would be easy to miss small changes and possibly even large changes.

I spoke with the three manufacturers of the carbides and asked them how our specifications compare to the industry standard. Listed below is a summary.

Property	Industry Standard	Iowa Specification
Cobalt Content	11.0 to 12.5%	11.0 to 12.5%
Hardness	87.5 to 89.0	87.5 to 88.2
Specific Gravity	14.1 to 14.6	14.0 minimum
Transverse Rupture Strength	350,000 psi minimum	330,000 psi minimum

I propose that we change our carbide specifications to match the industry standard. By doing this, we will widen the range for acceptable hardness. Currently, we have a very narrow range, and 7 of the 20 pieces of carbide we tested would fall outside this range. Under the industry standard, only one piece would fall outside the range. In addition, by allowing the harder carbides, we may be able to get more wear resistance from them.

Secondly, we should put an upper limit on the specific gravity. This would reduce the chance of accepting carbides which are too brittle.

Thirdly, we should increase the transverse rupture strength to 350,000 psi minimum. This is a measure of the impact resistance of the carbide, but we do not run this test because it is very difficult to grind the carbide pieces to the correct size for this test.

By adopting the industry standard, we would most likely get a less costly product, since it is more widely specified and more widely used.

I asked the manufacturers about the abrasion resistance test. They said this is not a routine test they perform on their carbides. Because this is not a routine test, and because there was not a large difference in abrasion resistance between the Valk and Kennametal carbides, I do not recommend specifying this test at this time. (I believe the reason the Bucyrus carbides showed an increase in abrasion resistance was because they were out of industry specification for specific gravity.)

Additional research may show that a harder, longer wearing carbide could survive the impact and abuse of plowing. But, until a more thorough field study can be done, I believe we should adopt the industry standard specification.

CONCLUSIONS

The Kennametal and the Valk carbides have approximately the same abrasion resistance.

The Bucyrus carbides showed a significant improvement in abrasion resistance. However, they do not meet industry standard specifications for specific gravity.

The carbide specifications should be changed to coincide with industry standard specifications.