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SINTERED ALLOY POWDER CARBIDE AND TUNGSTEN CARBIDE MATERIALS FOR SHREDDER HAMMER TIPS

DUTTAGUPTA J

IMCO Alloys Pvt Ltd, India
jdgupta@imcoalloys.com imco@vsnl.com

Abstract

This abstract reports the processing of shredder hammer tips, and metallurgical aspects related to improve the life prolonging factors that can achieve maximum crushing ratio and increase the preparatory index. An investigation conducted on typical shredder hammer tips revealed the cutting edges getting worn out in service because the sugarcane is typically mixed with silica sand and rocks. This leads to enhanced erosion, and increased abrasion and impact causing catastrophic failures.

In extreme cases a composite comprising sintered carbide vacuum fused between a mild steel backup plate and a high chrome alloy powder block, is used as a replaceable tip. This geometry acts as a twin cutter, where the initial compressive load is divided by the top sintered alloy, which enables the tungsten carbide to take the balance load with much higher efficiency, better cutting ratio and longer edge retention. The geometry also considerably enhances the resistance to cracking. As per the performance reported by M/s Godavari Sugar Mill, Sameerwadi, the tool exhibited a life exceeding 950 000 tons of cane.

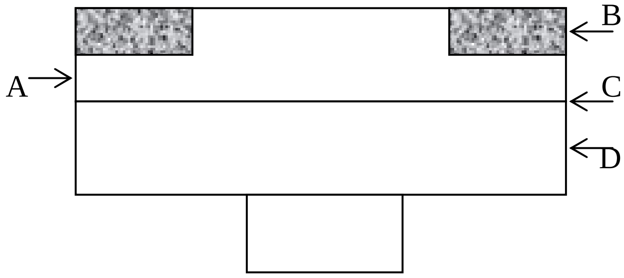
Keywords: general factory, front end operations, analysis, value addition, general

Introduction

In many Indian sugar factories, cane is prepared in a heavy duty shredder. Preparation is achieved by over 100 shredder hammers rotating at more than 1000 rpm. The shredder hammer tip strikes the cane at a speed of almost 100 m/s. The cane is smashed into fibers ranging in size from 1080 mm in length. The cane is delivered with soil and other foreign matter that can include crowbars, nuts, bolts and pins. This additional material causes wear and sometimes fracture of the shredder hammer tips.

To address the problems of wear and fracture, there has been considerable development of the shredder hammer tips. Mason *et al.* (1979), Dolman (1983), Lakeland *et al.* (1992) and Ostlund *et al.* (1996) reported on the use of white iron metal and tungsten carbide castings made from conventional foundry processes. They investigated metallurgical aspects of tips and conducted experiments with different shredders. Loughran *et al.* (2005) studied sintered tungsten carbide tips using various thermal analytical techniques.

The design of the shredder hammer tip employed by Loughran *et al.* (2005) (tungsten carbide tip) brazed directly on top surface area as shown in Figure 1, signifies the following;



A = white cast iron; B = intered tungsten carbide; C = copper filler; D = ferrous baseplate

Figure 1. White cast iron block brazed with tungsten carbide block.

Considering the above difficulties it was found that during shredding of cane along with the mentioned impurities, the tungsten carbide segment 'B' having grade (93% Wc, 7% Cobalt) was found to be under heavy impact directly, and this resulted in chipping and premature damage of the tungsten carbide tip, rendering it ineffective. Due to the direct load acting upon the segmented tungsten carbide 'B' the quality of impact material carried along with the cane would cause the failure to occur any time between 7 to 30 days into the crushing period. This could be due to the low toughness and high hardness of the tungsten carbide (Wc 93%, 7% Co) grade causing excessive fractures when impacted dynamically by metal objects mixed in sugarcane. Thus the need emerged for an alternative design and metallurgy.

Manufacturing process for the sintered alloy powder and tungsten carbide tip

The manufacturing process, water or gas atomisation is a versatile method of producing metal and prealloyed powders containing chromium, molybdenum and carbon (Cr-Mo-C). The liquid metal is induced by high velocity water or gas (such as air, nitrogen or argon) jets. Atomisation occurs by kinetic energy transfer from the atomising medium to the metal, as shown in Figure 2.

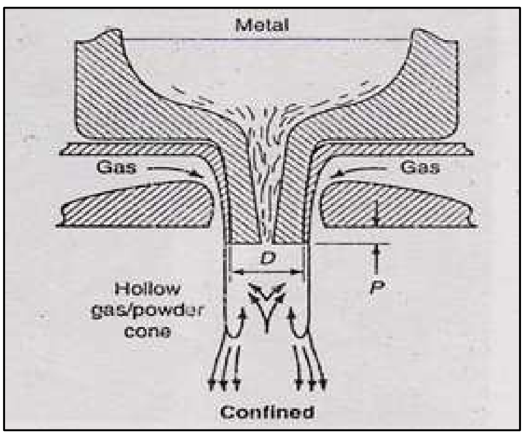


Figure 2. Gas atomisation (from Dunkley, 1991).

For manufacturing shredder hammer tips, the alloyed powder block 'A' (Figure 1) is manufactured by melting chromium, molybdenum and carbon along with iron, atomising the melt to create alloy powders, compacting the mixture in a die, forming briquettes and then melting in a controlled atmosphere to achieve the required shapes as shown in Figure 1**.** Similarly, tungsten powders are blended with cobalt and then compacted and sintered into segments as in 'B' in Figure 1.

The composite blocks 'A' and 'B' are placed on the weldable ferrous base 'C' using copper based binders at temperatures from 1050 to 1150 °C, followed by a controlled gas quench to achieve a unique diffusion-aided metallurgical bond. The final product is shown in Figure 3.

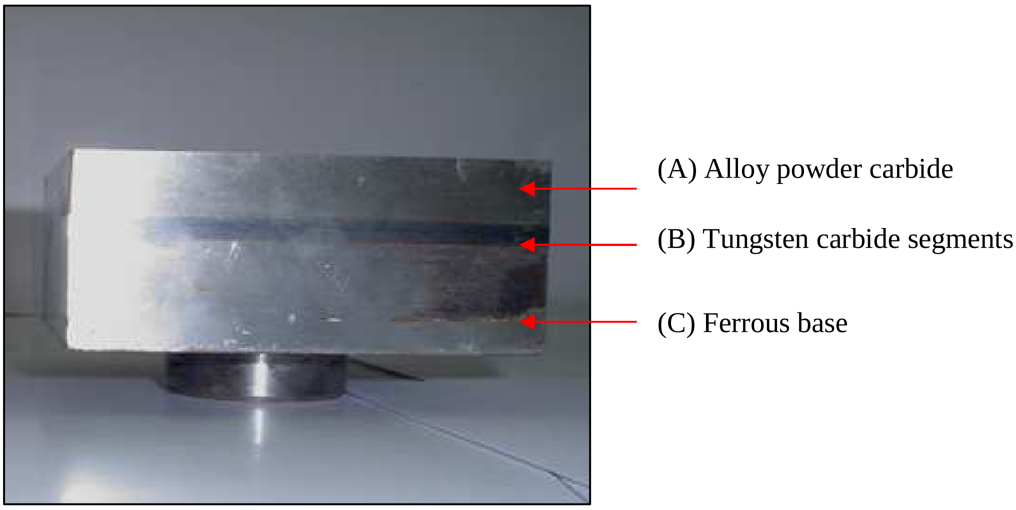
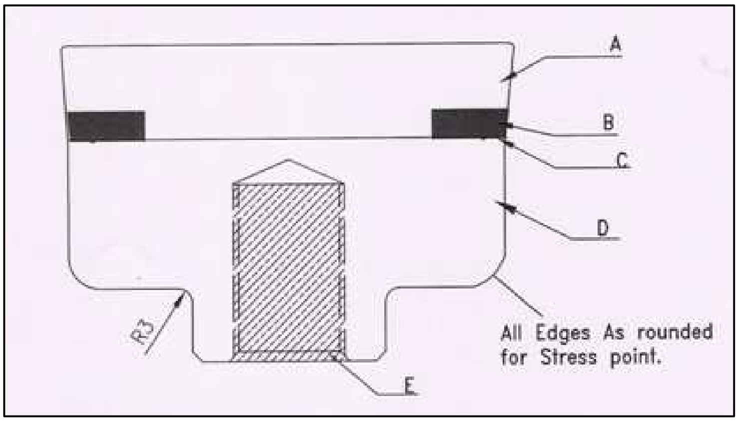


Figure 3. Alloy powder carbide block.

The composite microstructures show a uniform dispersion of fine carbides resulting in increased high hardness (62-64 HRc) and greater wear resistance. During brazing, the grain boundaries are active sites that contribute to enhanced diffusion and enhanced brazing causing the carbide formation at micro-levels that result in excellent hardness and wear resistance with adequate ductility, compared to the white iron castings which exhibit dendritic, coarse segregation, uneven grains, chill crystals and equiaxial grains. Such structures are relatively brittle and lead to the early initiation of wear processes.

Design of alloy powder carbide shredder hammer tips

This paper describes the development of an alternative tip made from a sintered alloy powder carbide and tungsten carbide. This novel design divides the initial comprehensive load between the top alloy powder carbide (A) and the sintered tungsten carbide (B) sandwiched between the alloy powder carbide 'A' and ferrous base plate 'D', making it function like a twin cutter, as shown in Figure 4.



A = alloy powder carbide; B = sintered tungsten carbon;
C = copper base allow; D = ferrous baseplate

Figure 4. Design of a typical alloy powder carbide block.

Figure 5. The IMCO sintered tungsten carbide block.

Technical construction

1. The tungsten carbide segmented tip as shown in Figure 4 is made out of a tougher grade (87% tungsten carbide and 13% cobalt) to withstand heavy impact loads.

2. In order to avoid direct impact and subsequent damage caused to the tungsten carbide segmented tips earlier, this design was constructed where a tungsten carbide segment ‘B’ was sandwiched in between the alloy powder carbide ‘A’ and ‘D’ mild steel backup plate as shown in Figure 4.

3. A taper relief as shown in Figure 4 is given on both the alloy powder carbide ‘A’ as well as tungsten carbide tip ‘B’ for the expected behavior of the shredder hammer tip in service as shown in Figure 6.

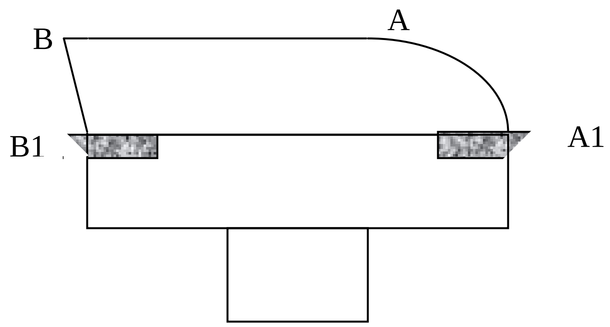
Experimental investigation

Experiments were performed to assess the wear on the new alloy powder carbide shredder hammer tips over the entire crushing period on tandem no. 1 at M/s Godavari Sugar Mill, Karnataka State, India.

Details of the shredder configuration are presented below:

Number of hammers	= 120
Number of tips used	= 120
Diameter across tips of shredder hammers	= 2400 mm
Crushing rate	= 8000 tons per day
Cane fibre content	= 11% to 14%
Mix of debris generally found	= bearings, wheel covers, truck parts, chains, crowbars and sand silica
Silica content in the soil	= 63% to 70%
Shredder speed	= 1100 rpm
Mass of a hammer	= 21 kg
Type of hammer	= Swing

It was found during trials at the sugar factory due to the continuous impact of the sugarcane, the top alloy powder carbide 'A' (as shown in Figure 6) wears down by 8 to 10 mm after crushing about 250 000 to 300 000 tons of cane.



A and B = alloy powder carbon; A1 and B1 = sintered tungsten carbide

Figure 6. Typical wear pattern observed on alloy powder carbide block.

Effectively as observed the tungsten carbide segment starts crushing as shown in Figure 6 'Side A1' acting as twin cutter and increasing the crushing by another 150 000 to 200 000 tons.

The tip had crushed a total of 900 000 to 1 000 000 tons from both the edges. This was possible by using a tougher grade of tungsten carbide as well as minimising the impact load on the tungsten carbide.

Results

- The tonnage achieved with the new sintered alloy powder tungsten shredder hammer tip was 950 000 tons.
- Both the edges wore out uniformly, hence proving effective crushing.

Conclusion

1. The use of alloy carbide powder block on the top of the shredder minimized the wear due to impact and also resulted in shredding of about 150 000 to 200 000 tons of cane from side 'A' of the tip.
2. The tungsten carbide tip sandwiched between the alloy carbide and mild steel was protected from impact related damage and this had resulted in shredding of 150 000 to 200 000 tons of crushing from side 'A1', as shown in Figure 6.
3. The superior performance of carbide alloy powder tip can be attributed to the fine micro-structure and micro-segregation observed in atomised sintered pre-alloyed tips.

4. The improved behavior of carbide tips with regards to shredding can be attributed to the choice of the tougher grade of tungsten carbide 87%, 3% Co, as well as due to the sharing of the impact load by the alloyed carbide block.

5. The concept of a twin cutter incorporated with the design has resulted in a shredder hammer tip with improved yields.

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