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ENHANCEMENT OF MACHINE LIFE OF VSI CRUSHER BY REPLACING ROTOR TIP OF EXISTING MATERIAL WITH A COMPOSITE MATERIAL

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Abstract: This article focuses on enhancing the tool life of the VSI rotor crusher tool by replacing tungsten carbide-cobalt composite materials. The VSI rotor crusher tool life is reduced due to lot of wear during the crushing of stone. This depreciation could be avoided by replacing the existing material of the tool of the rotor with new composite material. In this view, the different proportions of the tungsten carbide-cobalt mixture were taken. Here the cobalt is acting as a binder and the weight proportion of cobalt was considered as 8%, 10% and 12%. The homogenous mixtures of tungsten carbide and cobalt were prepared and examined by SEM images. The specimen was prepared in a circular die with a diameter of 10 mm by applying pressure on the plunger using a powder compacting machine. Then specimen were undergone a sintering process. The wear resistance of the sintered specimen is evaluated by a pin on disc test and the results show remarkable improvement in wear resistance when compared to the existing material used in the tool.

Index Terms **-** Tool life, Tungsten carbide, Cobalt binder matrix, VSI crusher tip.

I. INTRODUCTION

The depreciation or the wear in the tool tip of the rotor in the VSI crusher is a major problem which often forces the user to change the rotor tool tip. This cost more for user and in addition the time required for changing the tip also waste lots of production time and thus results in the net loss in production of crusher and ensures loss for the user. This loss could be reduced by increasing the wear resistance of the tool tip of the rotor so that the tool lasts for long time and so the time for replacement of the tool could be reduced to larger extent as higher wear resistance leads to less depreciation. From this, both the cost of new tool could be saved at long time of production and the saved time because of less change in tool tip results in higher production and better profit. Here the procedure includes the finding material composition of the existing rotor tip which is embraced in the rotor tool with scanning electron spectroscopy and changing the composition with certain reasons from various previous studies and making a new component.

The component thus made is tested for abrasion resistance and wear resistance and thus compared with previous existing metal and thus tool life is improved. And thus it is decided to make a new component with tungsten carbide powder and cobalt matrix at various percentage of cobalt i.e., varying the cobalt percentage to 8%, 10%, and 12% and altering the composition of tungsten accordingly. As the tungsten carbide is a high abrasion resistant material, this could withstand the high abrasion at work and could work for longer time. It is estimated that the present tool could work for only 2.5 hours and thus often require changing the tool tip. But as hardness of tungsten carbide is nearly80hrc double the performance of existing tool is expected. It is decided to check the depreciation of existing tool and the tool to be made by enforcing the tools to actual work for a fixed time and to compare the weight loss between these two tools. The idea is based on various journal papers mentioned in journals in reference as follows. Combined effects of different micro structural parameters, such as WC size, binder volume fraction ,binder interlayer and average distance between carbides determines the wear mechanisms in severe abrasive wear conditions and The optimal mixture of micro structural features to promote wear resistance of cemented carbides resulted to be fine or ultrafine carbides, low to medium binder volume fraction, thin binder inter layer and low carbides average distance [1] and it is noted that Preliminary transmission electron microscopy investigations into the binder regions of the liquid-phase sintered cermets provided observation of fine carbide particulates contained within the binder pools. These particulates are believed to be acting two-fold: (1) pinning the tungsten carbide grains from growing and (2) pinning the dislocation motion within the binder phase.

The former effect accounts for the increased hardness of the material, while the latter effect is believed to account for the increased indentation toughness of the material and, as anticipated, the fracture strength and flexure toughness of larger test specimen [2]. In another paper it is stated that in multi-carbide WC-TiC/FeNi coating, plenty of TiC tiny carbides with a size of 0.24–8.7 μm in-situ grow in both the WC and matrix, known as the precipitation hardening or particle hardening, by which the hardness of carbide WC and matrix are all increased. Benefiting from the structural merits of multi-scale and in-situ hybrid growth, the hardness, the friction stability, and the wear resistance of coating WC-TiC/FeNi are improved obviously in comparison with that of single-carbide WC/FeNi coating.[3]. Also, it is stated that AISI H13 hot work die steel with substitution of tungsten for vanadium (H13–W) exhibits superior red hardness as compared to AISI H13 steel. The increments of hardness as well as yield strength were attributed to the precipitated M6C-type carbides with sizes ranging from 10 nm to 400 nm [4]. In another journal it is mentioned that it was found that the UNSM-treated specimens exhibited better properties compared to that of the untreated specimens at various temperatures under oil-lubricated conditions. The improvements in the hardness may be attributed to the grain size refinement and increase in densification of microstructure. In turn, the improvements in the friction and wear behavior may be attributed [5]. And it is found that the presented worn morphology, including particle deformation, extraction and crushing, revealed that the wear mechanism of the carbide layer was dominant abrasive wear. Nevertheless, the worn morphology of the substrate with plastic deformation, furrow and material removal revealed that adhesive wear was a primary mechanism and accompanied by abrasive wear.[6]. In this view, this project focuses on improving the tool life of the VSI Crusher by Replacing Rotor Tip of Existing Material with a Tungsten Carbide Material. The new composite material was fabricated and were tested for abrasion resistance and wear resistance and compared with previous existing metal. The new composite matreilas with tungsten carbide powder and cobalt matrix at various percentage of cobalt i.e., varying the cobalt percentage to 8%, 10%, and 12% and altering the composition of tungsten accordingly. As the tungsten carbide is a high abrasion resistant material, this could withstand the high abrasion at work and could work for longer time. The hardness of the composite materials were tested by using Pin on disc test

II. Materials and Methods

At first, the embraced tool tip is removed from the rotor blade via wire cut EDM process and the composition of materials in the tool tip of the rotor blade of VSI crusher have to be found and it is done by optical immersion spectroscopy. The element is found to be austenitic steel and the working hours are found to be 2.5 hours. Then structure is identified by the Scanning Electron Microscopy. With these details hardness and toughness tests are done for the existing tool tip. Then with the same tool tip, the wear rate is measured for particular time. This can be done by weighing the tool tip initially and again checking its weight after particular time. The loss of weight gives the wear rate or depreciation rate of the tool tip.

Other tests such as hardness test and toughness test could be done with Rockwell hardness testing machine and also with Universal Testing Machine and the results are recorded for comparison for the future after the tool is made with tungsten carbide cobalt matrix. Then a study has to be made to find the alternate material composition which could have better hardness, toughness and wear resistance. Some of such combinations include tungsten carbide cobalt composite, tungsten carbide titanium carbide cobalt composite, tungsten carbide nickel chromium composition, etc. With these elements, on considering availability, cost, performance the tungsten carbide cobalt metal matrix is been decided to be made. Various research papers shows that change in cobalt composition makes a considerable impact on the performance of the tool. So, it is decided to make the three different samples by varying the cobalt to 8%, 10%, 12% and do abrasion test for all these samples and do an abrasion test and find the best composition for manufacturing the tool.

Now in order to do these samples, a die is essential. So, a cast iron is brought and facing and turning is done to reduce it to 62 mm x 62mm. Then the tool is milled at the four sides and after milling to certain needed amount the tool is drilled to full length at the diameter of 6mm. After which the die should be dissected and a square of dimension 10 mm x10 mm should be made at the centre of the die. In order to get a better finish, it is decided to do wire cut electrical discharge machining process where the sides with bigger milling with be separated from side with smaller milling. Then a square of given dimension is made after screwing it with the Allen screw of 6mm diameter and 40 mm length and then the screw is removed and the die is taken and again turned to make it round again as it turned oval due to loss of material due to wire cut electrical discharge machining process. Then the die is heated up to 800 degrees Celsius and is suddenly quenched to make it hard so that the die does not damage while the samples are made. The fabricated die was shown in figure 1.

After this, metal powders in some specific composition and solidifying the powder composition by the process of palletization. Then the pellets which are weak are sintered at furnace. Sintering, which is also called 'frittage,' is the process of forming a solid mass of material through heat and pressure without melting to the point of liquefaction. This process involves the atoms in materials diffusing across the particle boundaries and fusing together into one piece. sintering is often used on metals with high melting points, since it doesn't rely on reaching melting temperatures to work. Sintering can also be used to reduce the porosity of an object's surface, which can enhance the properties of certain materials.

Here sintering is done as tungsten carbide has very high melting point which makes it difficult to liquefy, so it is easy to sinter it at high pressure inside the die so that the sample pieces of 10 mm x 10 mm x40 mm can be achieved. This can be removed from the die either by using the plunger made or by splitting the die. Now the tool is taken and its microscopic structure is verified by scanning electron microscopy. After which other test like Rockwell hardness test, and wear test are done as like of the manner in which the existing tool tip is tested and the results are recorded. Likewise, four such samples of different material composition are made and are tested in the same manner and all the test results are recorded which includes all change in physical as well as structural changes identified through above mentioned tests like scanning electron microscopy and were shown in figure 2 to 4.

Figure1. Die

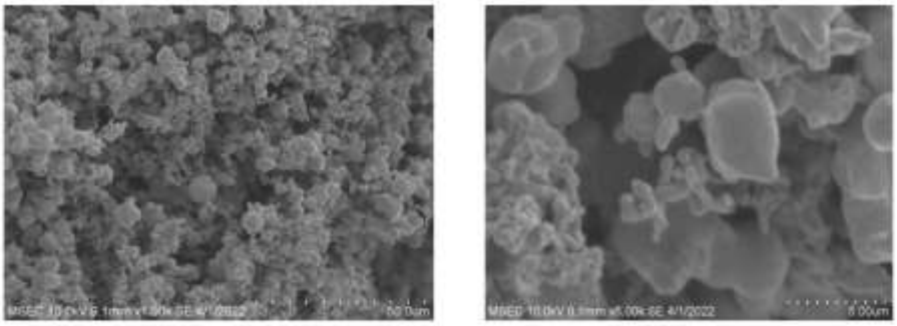

Figure 2 SEM Image of WC 92% and Co 8%

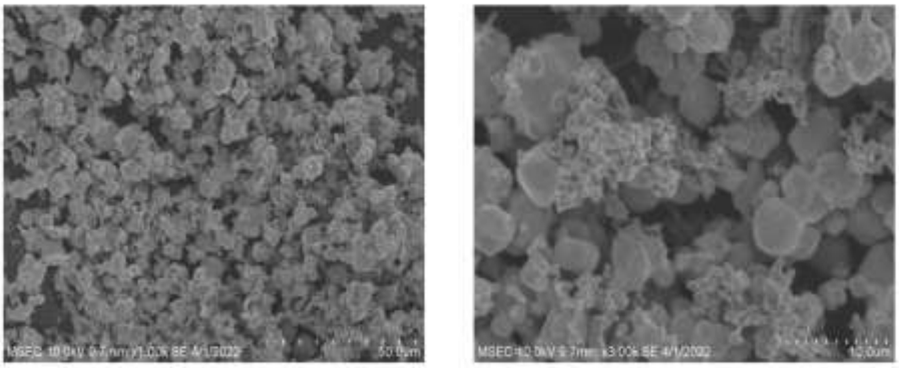

Figure 3 SEM Image of WC 90% and Co 10%

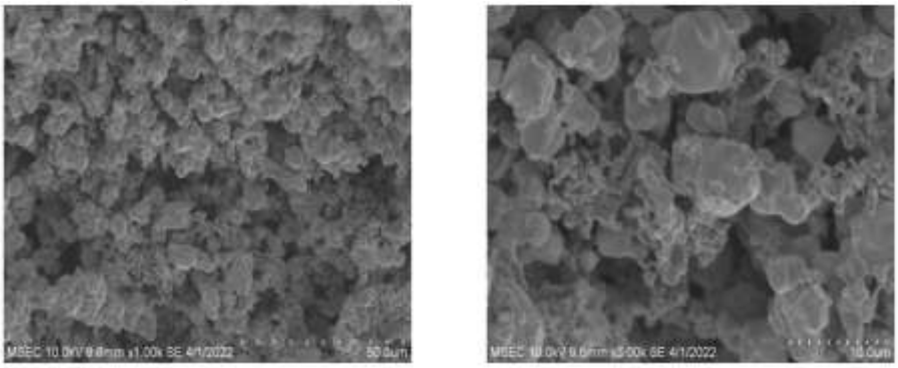

Figure 4 SEM Image of WC 88% and Co 12%

Now all the results are plotted against each other and the best one is chosen for work. The composition of this sample is taken into account a complete tool of required size of VSI rock crusher is made and fitted into machine tool by brazing. Brazing is a process for joining two pieces of metal that involves the application of heat and the addition of a filler metal. This filler metal, which has a lower melting point than the metals to be joined, is either pre-placed or fed into the joint as the parts are heated. The new metal and the old metal are allowed to work for same time and the loss of weight in two metals gives the improvement in the wear resistance of the new metal.

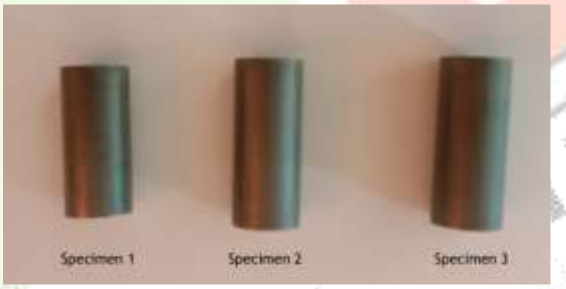

Figure 5. Prepared composite materials specimen by sintering process

III. Testing and Result

3.1 Spectroscopy

The spectroscopy is done on the existing material and it is found to be austentic steel with major metal composition of nickel and chromium and few other elements like carbon and silicon. This is a high corrosion resistant substance with hardness of upto 54hrc.

3.2 Hardness test

The Rockwell hardness test is shown in figure 6 and test was conducted for existing sample and the newly made sample. The existing material has the hardness of about 54 hrc. and the tungsten carbide cobalt composition with 8% Cobalt has about 70 hrc, 10% Cobalt has about 72 hrc, 12% Cobalt has about 64 hrc, and this shows that the new material with 10% Cobalt has the better hardness and so will have better abrasion resistance.

Figure 6. Rockwell Hardness testing machine

Figure 7. Pin on disc test setup

3.3 Pin on disc test

Pin on disc test setup as shown in figure 7 and test was done on the following parameters as given below for the prepared speimen.

Applied load – 150 N
Sliding distance – 2000 m
Speed – 120 m/min
Time – 20minutes

This is the parameter in which all samples were tested and the results were as shown in figure 8. The existing sample shown depreciation of 0.008 grams after 20 minutes while the tungsten carbide cobalt matrix of 12% shows the depreciation of 0.00076 grams and the sample with 8% cobalt shows 0.00045 and the sample with 10% cobalt has the depreciation of 0.0001 grams. Thus this clearly depicts that the matrix with 10% cobalt has highest abrasion resistance.

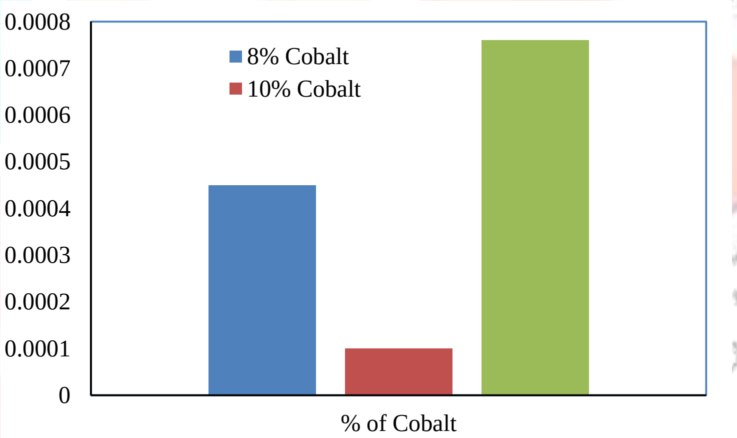

Figure 8 Material lost in grams after wear test

IV. Conclusion

The change in tungsten carbide and cobalt percentage shows significant difference in properties of the final product even if the composition change is minimum. The hardness is no directly proportional to increase in tungsten carbide as the wear increases after the WC is increased from 90% to 92%. Cobalt plays significant role in fabrication and better results could be yielded at some optimum value only. It is proved that the life of tool tip of VSI rock crusher could be improved by replacing the existing material with Tungsten carbide cobalt metal matrix composite.

V. Acknowledgment

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REFERENCES

[1] Federico Bosio, Emilio Bassini, Cristina Gabriela Oñate Salazar, Daniele Ugues, Daniele Peila, The influence of microstructure on abrasive wear resistance of selected cemented carbide grades operating as cutting tools in dry and foam conditioned soil, Wear, 394–395, 2018, 203-216,

[2] Lindstedt U, KarlssonB, Masini R .Influence of porosity on deformation and fatigue behaviour of austenitic stainless steel. Int J Powder Metal 33, 1997, 49–61.

[3] Youlu Yuan, Haihua Wu, Min You, Zhuguo Li, Yi Zhang, Improving wear resistance and friction stability of FeNi matrix coating by in-situ multi-carbide WC-TiC via PTA metallurgical reaction, Surface and Coatings Technology,378, 2019, 124957,

[4] Xiang, S., Wu, R., Li, W. et al. Improved Red Hardness and Toughness of Hot Work Die Steel through Tungsten Alloying. J. of Materi Eng and Perform 30, 2021, 6146–6159.

[5] Auezhan Amanov, Young–Sik Pyun, Jun–Hyong Kim, Shinya Sasaki, Enhancement in wear resistance of sintered silicon carbide at various temperatures, Tribology International, 74, 2014, 28-37,

[6] John J. Pittari, Heather A. Murdoch, Steven M. Kilczewski, Billy C. Hornbuckle, Jeffrey J. Swab, Kristopher A. Darling, Jared C. Wright, Sintering of tungsten carbide cermets with an iron-based ternary alloy binder: Processing and thermodynamic considerations, International Journal of Refractory Metals and Hard Materials, 76, 2018, 1-11