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Development of Vitrified Grinding Wheel with Low Temperature Bond

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ABSTRACT

Material removal during grinding is by sharp abrasive grains on the face or on the sides of bonded grinding wheels. Most commonly used bond is vitrified bond which is made of clay or feldspar that fuses at a high temperature and when cooled forms a glassy bond around each grain. Vitrified grinding wheels, which are fired at temperature greater than 1280ºC, are typically used to remove large volumes of metal and to produce components with very high tolerances. The main disadvantage of high energy consumption during the manufacture of vitrified grinding wheel can be overcome by reducing the firing temperature which will minimize the power consumption, reduces operating cost and save time. This work aims at development and testing of low temperature ceramic bond system for vitrified grinding wheel by varying the frit used and adjusting the composition. The new bond (L bond) composition had a firing temperature of 1050ºC and the prepared wheels had lesser strength than conventional wheels (H bond). Shrinkage was higher, and material removal rate and surface finish were lower in the newly developed wheel. From SEM image it could be observed that the H bond wheels were denser which accounted for its performance.

KEYWORDS: Frit, SEM, Surface grinding, Surface Roughness, Vitrified grinding wheel.

INTRODUCTION

Grinding is the widely used method for the removal processes for achieving high finish and high work piece accuracy. Grinding wheel is a structure used for cutting, grinding and polishing of metals, glass and ceramics. A grinding wheel is a self-sharpening tool composed of discrete abrasive grains held together by a bonding agent with composite structure of many clearance allowances for the cutting edges. The characteristic of a grinding wheel depends upon the combined elements of abrasive grains, grit size, bond, grade and structure. The abrasive grains provide the wheel with its cutting points, which in turn help in cutting the material to the required dimensional accuracy or help impart a fine surface finish. The size of the abrasive grain or the grit is expressed by the size of the screen opening through which the grains are sifted or sorted. The role of bond is to hold the individual grains together. The bonds used in grinding wheel are vitrified bond, resinoid bond, epoxy bond and rubber bond. The type of bond depends on the operating speed of wheel, the type of operation and the surface finish required. Grade is a measure of 'hardness' or bonding strength of the wheel. The arrangement of the abrasive grain and the bond in the grinding wheel gives a definite characteristic known as 'structure' or 'pores'. These pores are designed based on application needs and provide for chip clearance.

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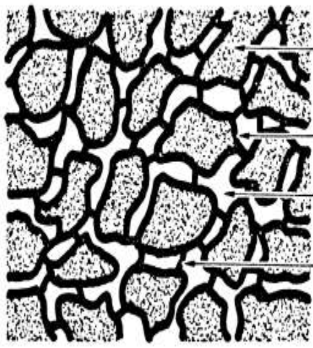

Fig. 1: Structure of grinding wheel

The bond used in a grinding wheel has several functions [1]
•retain the abrasive grain during the process
•wear at a controlled rate with respect to the grain wear
•resist centrifugal forces, especially in high speed grinding
•readily exposes the grain to the work, where possible

Vitrified bonds enable the manufacturer to control the strength, chip clearance and wheel loading by modifying the porosity and structure of the wheel. The flexibility of the vitreous bond system hence makes it possible to condition the topography of this type of wheel to achieve a broad range of metal removal rates and surface finish characteristics. As a result, vitreous bonds are becoming more important in grinding applications [2]. It is strong but breaks down readily on the wheel surface to expose new grains during the grinding operation. This bond is particularly suited to wheels used for the rapid removal of metal. Vitrified wheels are not affected by water, oil or acid and may be used in all type of grinding operations. In spite of its advantages, vitrified bond has the disadvantage of high energy consumption during preparation and consequently high cost as they require firing temperature of 1100^{o}C to 1300^{o}C. Vitrified bonds are composed of glasses that are formed when clays, ground glass frits, mineral fluxes such as feldspars, and chemical fluxes such as borax, melt when the grinding wheel is fired at high temperatures. With reference to raw material nomenclature, a 'frit' is a pre-ground glass with a predetermined oxide content, a 'flux' is a low melting point siliceous clay that reduces surface tension at the bond bridge/abrasive grain interface, a 'pre-fritted' bond is a bond that contains no clay minerals (i.e. clays and fluxes), and 'firing' refers to vitrification heat treatment that consolidates the individual bond constituents together [3]. Many works are being carried out on vitrified wheels to improve its performance and to minimize the firing temperature. Performance of vitrified wheels can be improved by varying the type of abrasive grain used like usage of sintered sol-gel alumina in the place of fused alumina [4], sintered alumina with silica enriched surface [5], alpha alumina with dispersed second phase of zirconia or hafnia [6] and durable sol-gel derived alumina [7], to name a few. The firing temperature for vitrified wheel preparation can be minimized by selecting appropriate contents of boron oxide, alkali oxides and alkaline earth oxides, and by maintaining the correct ratios of boron oxide to alkali oxides, sodium oxide to lithium oxide, and silicon oxide to the combination of alkali oxides and alkaline earth oxides in these bonds [8]. The present work aims to modify the existing bond system in the vitrified grinding wheel, which vitrifies at 1280^{o}C, to develop a low temperature bond system by modifying the frit and bond composition. This is done to minimize the energy consumption during grinding wheel preparation.

MATERIALS AND METHODS

2.1. Preparation of bond:

The bond for vitrified grinding wheel was prepared by mixing raw materials in proportions indicated in Table 1.

Table 1: Composition of Bond

Raw Materials	Weight (%) in Existing Bond (H Bond)	Weight (%) in New Bond (L Bond)
Frit (A)	19.99	-
Frit (B)	-	64.00
Ball clay	33.50	10.00
China clay	-	10.00
Quartz	-	6.00
Feldspar	46.50	10.00

The ceramic bonds were thoroughly mixed using pot mill for 4 Hours with felsites as the grinding media. Dry sieving was performed using 150 mesh and again wet sieving was performed using 200 mesh. Pellets were prepared with the two bonds and were subjected to fusibility test and adherence test by firing in kiln for 48 hours and cooling for 24 hours.

2.2. Preparation of making mix:

The composition of mix taken for grinding wheel preparation is given in Table 2.

Table 2: Composition of Grinding Wheel

Raw Materials	Weight (%)
Alumina Grit 54	21.05
Alumina Grit 60	42.11
Alumina Grit 80	21.05
H Bond or L Bond	11.48
Temporary Binders (Solid + Liquid)	4.31

Alumina in different mesh sizes was thoroughly mixed and the sample was sieve in to 24 mesh size. After that solid binder, H or L bond were added with alumina grains and sieving process was also performed. Liquid binder was then added with the above mix and sieving process was performed again.

2.3. Manufacture of grinding wheel:

The mix prepared was taken for grinding wheel preparation in the following sequence. 5 wheels with H bond and 5 wheels with L bond were prepared.

2.3.1. Molding:

Proper amount of this mixture is placed in a steel mould of desired wheel shape and compressed in a hydraulic press to form a wheel slightly larger than the finished shape. The amount of pressure varies with the size of the wheel and the structure required.

2.3.2. Shaving:

Although the majority of wheels are molded to shape and size, some machines require some special wheel shape and recesses. These are shaped or shaved to size in the green or unburned state on a shaving machine which resembles a potter’s wheel.

2.3.3. Firing:

The green wheels are carefully stacked on cars and are moved slowly through a long kiln 250 to 300 m long. The temperature of the kiln is held at 1280^{o}C. This operation takes place about five days, causes the bond to melt and form a glassy case around each grain. The product is a hard wheel. For L bond wheels firing was done at 1050^{o}C.

2.3.4. Truing:

The cured wheels are mounted in a special lathe and turned to the required size and shape by hardened steel conical cutters, diamond tools or special grinding wheels.

2.3.5. Bushing:

The arbor hole in a grinding wheel is fitted with a lead or plastic type to fit a specific spindle size. The edges of the bushing are then trimmed to the thickness of the wheel.

2.3.6. Balancing:

To remove vibration that may occur while a wheel is revolving, each wheel is balanced. Small, shallow holes are drilled in the light side of the wheel and filled with lead to ensure proper balance.

2.3.7. Finishing:

After firing the grinding wheel is allowed to cool and is taken for finishing process. Dressing of grinding wheel is done to reduce the dimensions of the fired grinding wheel to the required final dimension and also helps to smoothen the surface of the grinding wheel.

2.4. Testing of grinding wheel:

The following tests are carried out to analyze the performance of the grinding wheels:

2.4.1. Ring Test:

Ring testing is a manual test that is used to detect defects in bonded grinding wheels. A wheel that emits a ringing sound when lightly tapped with a tool is likely undamaged and ready to be used.

2.4.2. Shrinkage Test:

Change in dimension to the original dimension on drying and firing gives drying shrinkage and firing shrinkage respectively.

2.4.3. Speed Test:

Wheels are rotated in a special, heavy, enclosed case and revolved at speeds at least 50 percent above normal operating speeds. This ensures that the wheel will not break under normal operation speeds and conditions.

2.4.4. Surface Grinding Test:

Surface grinding test is carried out in grinding machine (Make: Lakshmee Tech & Applied Materials, India) which determines performance in terms of material removal and wear of vitrified grinding wheel. Grinding ratio (GR) is calculated as the ratio of weight loss of material to the weight loss of abrasive wheel for a specific grinding time. Coolant flow was maintained at 2.5 l/min and dressing after three pass was 30 μm.

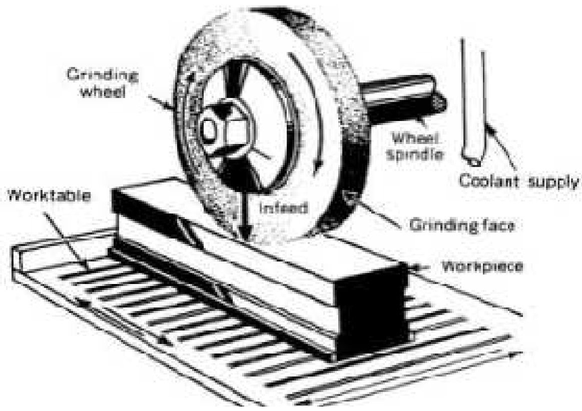

Fig. 2: Surface Grinding Process

2.4.5. Surface Roughness Test:

Roughness is an important parameter when trying to find out whether a surface is suitable for a certain purpose or not. The roughness tester (Make: IPRE, Model: PRSR200) shows the measured roughness depth Rz as well as the mean roughness value Ra in μm.

2.4.6. SEM Analysis:

Microstructure of H bond and L bond wheels were analyzed by scanning electron microscopy (SEM).

RESULTS AND DISCUSSIONS

3.1. Ring test:

All the prepared wheels passed the ring test.

3.2. Shrinkage test:

The dried shrinkage and fired shrinkage values for the H bond and L bond wheels are listed in Table 3.

Table 3: Shrinkage of Grinding Wheels

Sample No.	H Bond Wheel		L Bond Wheel	
	Dried Shrinkage (%)	Fired Shrinkage (%)	Dried Shrinkage (%)	Fired Shrinkage (%)
1.	088	3.2	1.49	3.93
2.	0.92	3.6	1.45	3.88
3.	0.92	3.6	1.40	3.92
4.	0.96	3.7	1.40	3.93
5.	0.92	3.6	1.49	3.92

In low temperature wheel, more shrinkage was found as compared to the high temperature wheel due to more amount of frit which reacts at high temperature causes greater shrinkage.

3.3. Speed test:

Speed test being destructive test, one sample with H bond and one with L bond were subjected to the test. The results obtained are tabulated in Table 4.

Table 4: Speed test results

Type of Material	Breaking Point (rpm)	Allowable Speed (rpm)
L bond wheel	10500	6875
H bond wheel	11500	7625

H bond wheel has higher bond strength as compared to the L bond wheel, but the low temperature bond wheel has nearly achieved the breaking point of high temperature bond wheel.

3.4. Surface grinding test:

The results obtained in the surface grinding test done for 60 min over die steel work piece is given in Table 5.

Table 5: Surface grinding results

Type of Material	Material Loss per Hour (g)	Wheel Loss per Hour (g)	Grinding Ratio
L bond wheel	19.8	0.6	33.0
H bond wheel	22.2	0.4	55.5

Wheel loss was found to be more in L bond wheel and material removal was effective in H bond wheel. Ultimately GR was lesser in L bond wheel and improvements need to be done.

3.5. Surface roughness test:

The results obtained in surface roughness test are indicated in Table 6.

Table 6: Surface roughness results

Type of Material	Surface Finish Ra(μm)
L bond wheel	0.527
H bond wheel	0.472

Surface finish by H bond wheel is slightly better than the L bond wheel but which is within the permissible limit.

3.6. SEM analysis:

The SEM images of H bond and L bond wheels are given in Fig 3 and Fig. 4 respectively.

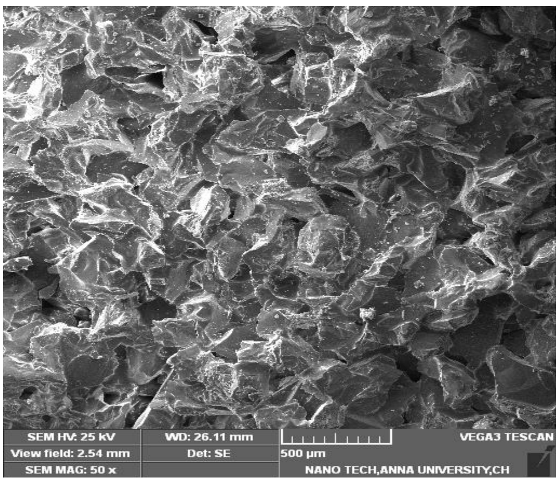

Fig. 3: SEM Image of H bond wheel

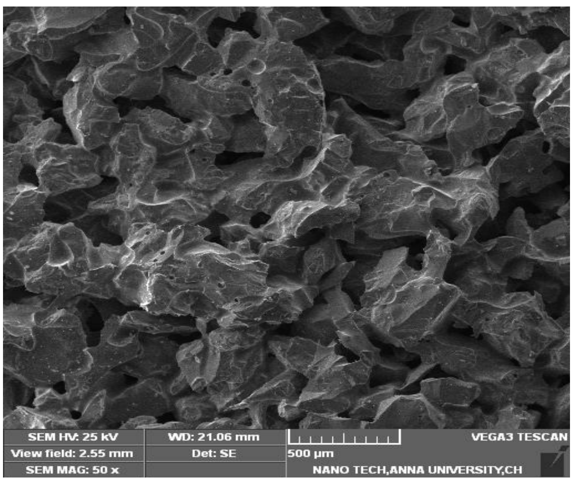

Fig. 4: SEM Image of H bond wheel

From the SEM image it can be observed that H bond wheels are denser than L bond wheels which may account for the high strength and performance of H bond wheels.

Conclusion:

Two grinding wheel of different temperature were prepared by modifying the bond used. From the results it can be observed that the desired efficiency was nearly achieved in L bond wheel fired at 1050^{o}C, however its bonding strength was lesser than H bond wheel fired at 1280^{o}C. This has to be further improved by doing research on the bond strength of the wheel and repeating the work. Final surface finishing done by L bond wheel can be improved by minimizing the depth of the cut and increasing the coolant flow rate.

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REFERENCES

1. Webster, J. and M. Tricard, 2004. Innovations in abrasive products for precision grinding. CIRP Annals-Manufacturing Technology, 53(2): 597-617.
2. Kopac, J. and P. Krajnik, 2006. High-performance grinding—a review.Journal of Materials Processing Technology, 175(1): 278-284.
3. Jackson, M.J., R.T. Wakefield, S.A. Jones, B. Mills and W.B. Rowe, 2001. Materials selection applied to vitrified corundum grinding wheels.British ceramic transactions, 100(5): 229-236.
4. Rue, C.V., 1985. U.S. Patent No. 4,543,107. Washington, DC: U.S. Patent and Trademark Office.
5. Markhoff-Matheny, C.J., J. Hay and D. Rostoker, 1992. U.S. Patent No. 5,131,923. Washington, DC: U.S. Patent and Trademark Office.
6. Leitheiser, M.A. and H.G. Sowman, 1982. U.S. Patent No. 4,314,827. Washington, DC: U.S. Patent and Trademark Office.
7. Schwabel, M.G., 1988. U.S. Patent No. 4,744,802. Washington, DC: U.S. Patent and Trademark Office.
8. Qi, D. and R.S. Lundberg, 1999. U.S. Patent No. 5,863,308. Washington, DC: U.S. Patent and Trademark Office.