Cutting Ratio Analysis of Glass Fiber Reinforced Polymer Metal Matrix Composite

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Abstract— Abrasive cut off wheels are commonly used in cutting different types of engineering materials, including both ferrous and non-ferrous materials. The parting wheel consists of hard inorganic abrasive held in place by a binder phase or bond. The most common problem faced during abrasive cut-off operation is the premature failure of the cut off wheel due to its low strength. In the present work woven roving type glass fibre reinforced epoxy resin cut off wheels were developed with silicon carbide (120 grit size) as abrasives and the ball mill setup which is made in aluminium and silicon carbide introduced in this project. The reinforcement of glass fibre with epoxy resin provides high strength to the wheel and prevents the premature failure of the parting off wheel. A mild steel die was used for fabrication of the parting off wheel. The developed wheels were used to cut a wide variety of harder materials die steel, copper and aluminium the wear ratio was measured for each material. The glass fibre reinforced epoxy resin parting off wheels were found to have better cutting ratio for cutting of heavy grade materials. The same experiments were conducted using conventional parting off wheel and comparative study was done.

Keywords: Reinforced Polymer, Glass Fiber, Fabrication Processes

I. INTRODUCTION

In fabrication processes, cutting of angle iron strips and plates is very common and that is generally performed by power hacksaw, shearing machine and sometimes by abrasive parting off machines. Abrasive parting off wheels are used extensively for both ferrous and non-ferrous metals and alloys namely stainless steels, sheets of plastics, glass, stone, porcelain etc. Parting wheels are self-sharpening wheels that are thin in width and often have radial reinforcement fibres. The major problem of abrasive parting off wheel, which fails prematurely during the routine sectioning of work piece, which may cause injury to operator. Riga et.al [1], the failure of parting off wheel is takes place due to degradation of mechanical properties and catastrophic brittle fracture from routine sectioning of the work piece. For the evaluation of elemental composition and thermal properties were analysed from thermo gravimetric analysis and wavelength X-ray fluorescence. Rajagopalan R [2], the cutting process involves removal of any material (work piece) by an abrasive parting-off wheel rotating at a high speed while the work piece remains stationery. The abrasive particles released during the process cause the actual cutting. There is a high amount of thermal energy is produced as a result of the friction between the wheel and the work piece. Shaw M.C. [3], a rational approach to abrasive wheel selection was developed which is based on the most important factor in the abrasive parting off operation minimum cost per cut. Since wheel wear has an important bearing on cost, it is of major concern of surface finish and dimensional accuracy, which are frequently of major importance in some other operations. Robertson R.E. [4], reinforcement is combining or joining two layers of similar or dissimilar material with the help of reinforcing agent. In general the reinforcing agent can be fibrous, powdered, spherical, crystalline and organic, inorganic, metallic or ceramic material. Fibre glass is the principal reinforcing agent used owing to its low cost to performance ratio. Sahuet.al [5], conventional abrasive wheels available in market have low wear ratio, low flexural strength and may break or fail well before expected time in many cases. The Glass fibre reinforced parting wheels also have higher tensile and flexural strength than the conventional parting off wheels. Paul et.al [6], abrasive parting-off wheels are to be the new tools for high speed cutting operations. Due to high CZT during the abrasive parting-off wheel operation may lead to thermal damage to the work surface, like introduction of tensile residual stresses and development of micro cracks.

Ebbrell et.al [7], when the cutting temperature within the contact arc reaches 150^0C or more, burnout occurs due to film boiling of cutting fluid and the temperature suddenly increases to over 400^0C. In other words, even being cutting fluid is supplied a similar state to dry cutting appears in the contact area between the wheel and the work piece.

George et.al, Buehler Ltd. [9], in its paper, the analysis of fracture of abrasive material using scanning electron microscope and examining of defects in material takes place.Rajesh [10], the power hacksaw and shearing machines have very heavy construction associated with high investment and maintenance cost. On the other hand, Abrasive parting off machine is simpler in construction and inexpensive to maintain. Abrasive parting off, initially regarded as a tool room method only, has over the last three decades replaced other high speed production operations such as steel saw cutting and flame cutting owing to its high cost to performance ratio. The ball mill is the largest single power consumer in a cement plant. In recent applications 11,500 hp and larger drives have been drives. It is essential that with such large loads all aspects of the application will be subject to evaluations that reflect the best available technology and operating practices. Traditional ball mills exert high starting torque characteristics. This combination with a material charge whose behaviour is difficult to control have resulted with many applications where motors had to be oversized in order to accommodate these characteristics.

Kakuket.al [11], the improvement of previous models of ball mill and determination of impact energy transmitted towards the material during the milling and the milling power. These types of ball mills are used to

decompose the materials for research purpose.Sahooet.al, the ball mill is vital equipment in industries viz. mineral dressing, ore processing, fertilizers, food and diary, pharmaceuticals and many others. In his work, it involves a meticulous study of the effect of the various parameters on the performance of a ball mill [12].Lingurajuet.al [13], the batch studies of raw coal have been conducted in the ball mill process. In his work, the study of effect of feed size, ball size, quantity of charge and ball charge were taken.

From this study, the generation of surface area and energy consumption per specific surface area. Many drawbacks of conventional parting-off wheel such as low cutting ratio, high cutting zone temperature, premature failures of wheel due to low mechanical strength have been eliminated by developing a fibre glass/epoxy reinforced composite parting-off wheel. The abrasive cutting process is associated with high cutting zone temperature (CZT), which may lead to thermal damage of the work surface, introduction of tensile residual stresses, development of micro cracks, enhanced risk of wheel loading and excessive wheel wear. To avoid thermal damage to the work, cutting fluidscan be used during the operation.

II. Experimental Work

The matched die moulding process was adopted for the fabrication of wheel which includes Part (A) as to make a powder mixture which consists of 35 % of aluminium (50 µm), 63 % silicon carbide particulate (120 µm) and 2 % Silica gel (Crystal form) through ball milling process at 8 hours to form powder. The Part (B) is the epoxy resin formed by mixture of 70% resin, 25% hardener, 5% filler material and kept separately. The Part (C), Design and fabricate the die as per requirement size and shape as two apart.1% of magnesium is sprayed on glass fibre and arranges it separately.The oil should be sprayed over die and cleans the inside of the surface of the die. The Part (D) is a separate part which mixes the aluminium composite 70% (Part A) and 30% epoxy resin (Part B) alone and stirring it properly. Apply the Part D portion on the die through the brush and one layer of fibre to place over on die, again the mixer of part D should be pasted on the fibre and repeat for the next three layers of bi-directional method. The dies are closed and compact its parts. The die is kept horizontal and dried for 4 to 5 hours at room temperature. The fabricated cutting wheel is shown in fig.1.

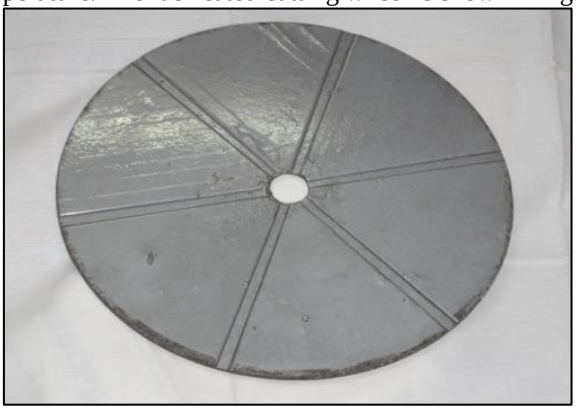


Fig. 1: Photographic view of the cutting wheel

A. Mechanical Properties of the Parting-off Wheel Matrial

The cutting wheel material was fabricated using compression die method. The various properties viz. compressive strength, hardness test and direct tensile strength were measured.

B. Compressive Strength

The compression test was performed on wheel material specimen with length to diameter ratio of 1.5. This test was performed on Universal Testing Machine of 100 KN capacity as per ASTM D6641. The sample was compressed between two flat platens and the maximum failure load was recorded as 265 MPa.

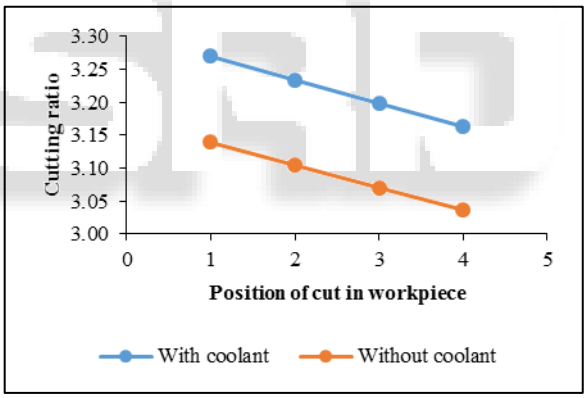
C. Hardness Test

The hardness was also measured for three samples of the each composition of the wheel material. The Brinell hardness was measured on the polished surfaces of the samples using Brinell hardness tester machine. Three readings were taken for the samples of each composition and the average hardness was determined as 90.

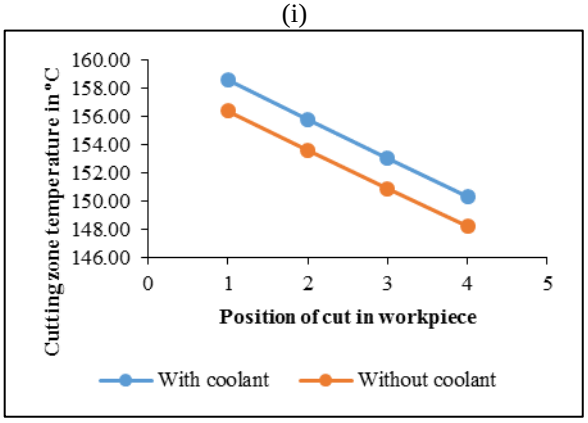
D. Direct Tensile Strength

The direct tensile strength of the wheel material was measured. For this purpose wheel material samples were fabricated as per the ASTM standard. The tensile strength was measured on 100 KN universal testing machine.

III. Results and Discussion

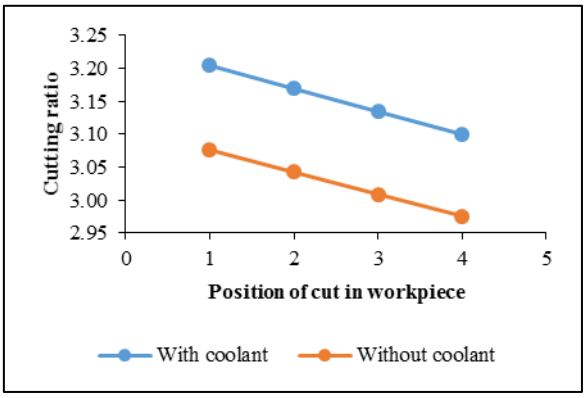


(i)



(ii)

Fig. 2: Cutting performance of the abrasive parting off wheel when cutting Aluminium (i) cutting ratio and (ii) cutting zone temperature



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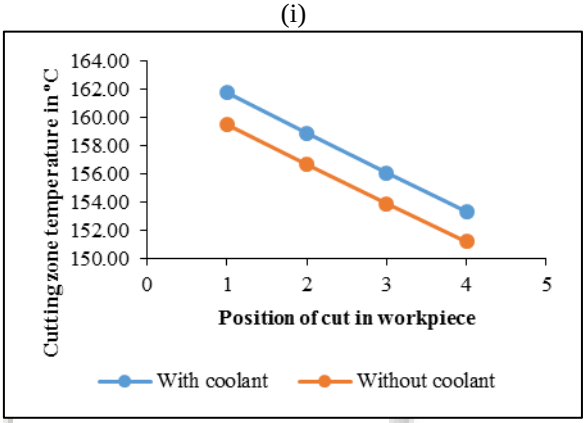
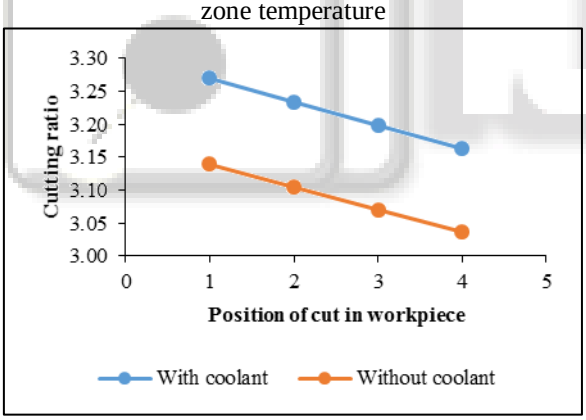


(ii)

Fig. 3: Cutting performance of the abrasive parting off wheel when cutting Copper (i) cutting ratio and (ii) cutting zone temperature



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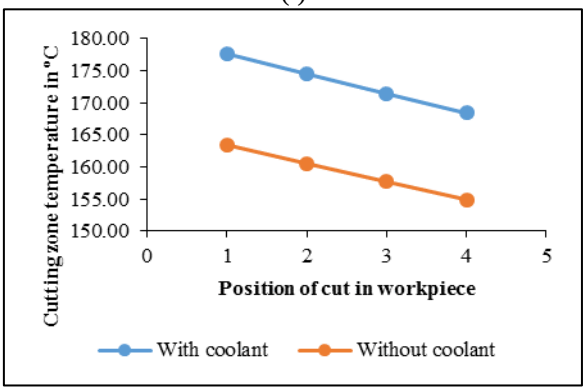

(ii)

Fig. 4: Cutting performance of the abrasive parting off wheel when cutting Mild Steel (i) cutting ratio and (ii) cutting zone temperature

IV. CONCLUSIONS

Glass fibre reinforced epoxy resin parting-off wheels with double lamina was developed, which eliminates several drawbacks of conventional parting-off wheel. The cutting properties (cutting ratio) of the developed wheels have been evaluated and results have been compared with the conventional wheel available in market. The developed wheels were found to have a better cutting ratio for mild steel, copper and aluminium.The manufacturing cost of the reinforced wheel can be reduced by mass production of the parting wheels. Low wheel life and high temperature generation make unpopular the use of abrasive parting wheel for cut-off operation. With the addition of Al metal powder in the SiCp abrasive, low CZT and high wear ratio were achieved. Low CZT ensures less thermal damage to the work piece, even when it cuts mild steel, aluminium and copper. Wear ratio can be improved by providing radial passages on the wheel surface. The mechanical strength can be improved by reinforcing the wheel by glass fibre and ball milling the abrasive mixture. The grooved wheel has longevity by having high wear ratio with high strength, which ensures safety to the operator.

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