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EFFECT OF COOLANT ON GRINDING OF15%Al/SiCp COMPOSITES

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ABSTRACT

Metal matrix composites are the emerging materials due to their ability to obtain the required mechanical properties with sufficient strength and lightweight. This accelerates the transfer of use of aluminum alloys to aluminum matrix composites. Even though metal matrix composites are manufactured with near net shape processing techniques, still it requires a number of secondary operations. Grinding is the final finishing process which is employed to produce close dimensional accuracy, smooth surface finish quality and reliability than other machining process. For soft materials, the grinding process is not recommended for machining because machining of soft materials like aluminum produces clogging of materials on the wheel. Since the grinding of soft aluminum metal matrix reinforced with SiC composites materials may also exhibit similar phenomenon. The wheel loading affects the forces and surface finish of the work piece; it also produces centrifugal stresses in the grinding wheel. So it was decided to study the wheel-loading phenomenon, various forces and Surface Roughness in dry and coolant condition. In this study the influence of various grinding wheels like Silicon carbide (SiC), Cubic Boron Nitride (CBN) and Diamond on the grinding of metal matrix composites (Al/SiCp), and the various input parameters are wheel speed, work speed, and depth of cut and No of passes.

1. INTRODUCTION

The composite materials are generally made by placing the dissimilar materials together in such a manner that they work as a single mechanical unit. The properties of the new material so produced are different in kind possible to incorporate and alter properties or introduce a combination of properties like high strength and stiffness. The metal most used as metal matrixes are aluminum, titanium and magnesium. The reinforcing constituent is normally a ceramic, although occasionally a refractory metal is preferred.The commonly used reinforcement materials are SiC ,Al_2O_3,TiB_2,Zr_2O_3, graphite etc [1].

Aluminum metal matrix reinforced with Sic particles gives Al/SiC_p Metal matrix composites. It exhibits high wheel loading while grinding. The wheel loading affects the surface finish of the work piece [2-5].

The input parameters involved in grinding also more than other types of machining operation. The wheel speed, work speed, depth of cut or down feed, cross feed, dressing conditions like truing and dressing speed, types of wheels like Sic, CBN and Diamond wheels, the hardness of the abrasive grains, their size etc all influence the finished products.

2. METAL MATRIX COMPOSITES:

Metal matrix composites are engineered combinations of reinforcement of two or more materials, which are often fabricated with near net shape processing techniques. Very stringent requirements of supersonic aircrafts, gas turbines, high temperature reactors, missiles, spacecraft etc have forced the emergence of combination of materials that weak points of one are covered by the strong points of other.

The composite materials are generally made by placing the dissimilar materials together in such a manner that they work as a single mechanical unit. The properties of the new material so produced are different in kind possible to incorporate and alter properties or introduce a combination of properties like high strength and stiffness low specific gravity, desirable coefficient of thermal expansion etc. The metal most used as metal matrices are aluminum, titanium and magnesium. The reinforcing constituent is normally a ceramic, although occasionally a refractory metal is preferred. The composite micro structures may be subdivided according to whether the reinforcement is in the form of continuous fibers, short fibers or particles. The commonly used reinforcement materials are SiC ,Al_2O_3, ,Zr_2O_3,graphite etc.

The incorporation of reinforcement improves both yield stress and ultimate tensile stress. Whiskers provide more effective reinforcements than particles. Yield stress rises with increasing volume fraction. For whisker reinforced composites increases in yield strength are often much greater in compression than in tensile yield strength are greater transverse to the whisker alignment than parallel to it.

3. APPLICATIONS AND ADVANTAGES OF MMCS

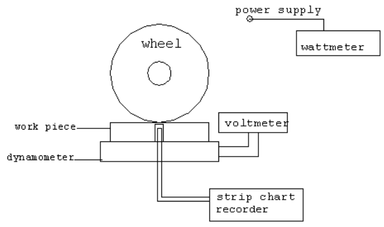
- It has several superior characteristics such as high strength, greater stiffness, superior fatigue, creep, wear resistance, excellent dimensional stabilities , the ability to operate at elevated temperature, good corrosion resistance and improved mechanical properties at high range of temperature
- In an Aerospace (Space shuttle, air craft)
- In Defence (Armour plates, ballistic Armour precision applications)
- In Automotives (Pistons, connecting rods, drive shafts, cylinders, valve lifters)
- In Sports (golf stick, Tennis racquet),
- In Precision applications (missile guidance systems)
- Alloy with a dispersed phase are used in impellers Gear box bearing, differential bearing, calipers (in brakes) are made by composites

4. MATERIALS AND EXPERIMENTAL SETUP

Work piece material, Light metal-25 Aluminum metal matrix particulate composites with reinforcement of Sic of volume percentage 15% was supplied by the Regional Research Laboratory(RRL), at Trivandrum, India. The properties of the composite material are given below. The experiments were carried out with LM -25 Al/SiCp composite with 15% Sic by volume work piece dimensions are 205 * 80 * 30mm^3.

LM25 Al/SiC$_p$ - Properties

Yield stress - 329MN/m^2
Ultimate tensile stress - 336MN/m^2
% Elongation -0.3
Elastic Modulus - 91GN/m^2



The experiments were carried out in a horizontal hydraulic surface grinder with a wheel speed and the work speed can be varied infinitely with in a range.The loaded material in the wheel is measured by conventional method. The loaded materials were removed by dressing the wheel at the end of each test using a single point diamond dresser, and collected in a specially designed box like container coated with petroleum jelly for collecting all the debris. The collected loaded material along with petroleum jelly was dissolved in tri-chloroethylene solution to remove petroleum jelly. Then the solution is filtered, dried and then weighed accurately in a chemical balance. Then the abrasives and metallic materials were dissolved in a sulphuric acid solution to separate the abrasive particles and again it is dried and weighed to know the abrasives present. The difference between the two values gives the amount of material loaded after making necessary correction for possible abrasive additions from the composite materials. The surface roughness values were measured using 'Surf Test' III MIYUTOYO, moving magnet system pick-up.

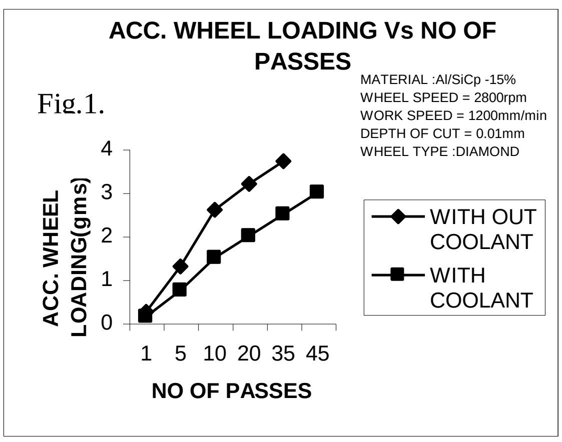
Different wheels were used to carryout the experiments. The diamond wheel with grit size 100/120 with concentration 50 with resin bond of size 175 * 10 * 2 were used. The CBN wheel with grit size 120/140, with concentration 50 with resin bond of size 150 * 10 * 2 were used. SiC wheel with grit size 46/60 with vitrified bond of size 150 *31.75*13 mm^3 were used. The following dressing procedures were carried out in every test. A single point diamond dresser tilted 15^0 inclined to the wheel radius and all the traces of wheel loading were removed. Then two consecutive pass with radial dressing at depth of 20μ_m were carried out followed by five sparks out passes. The lead was kept constant. The same procedure was repeated for all tests. For each measurement, three readings are taken to certain the repeatability and the average of the values is taken.

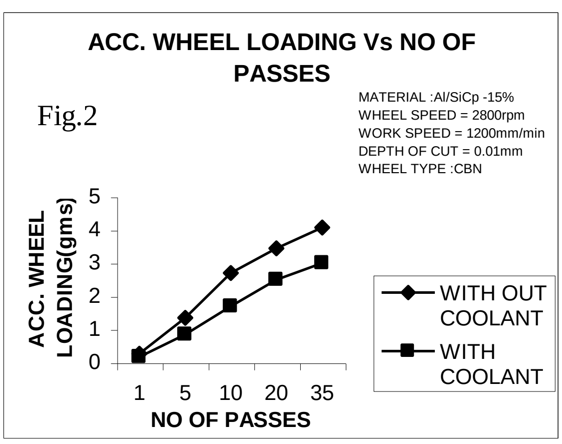
5. RESULT AND DISCUSSION

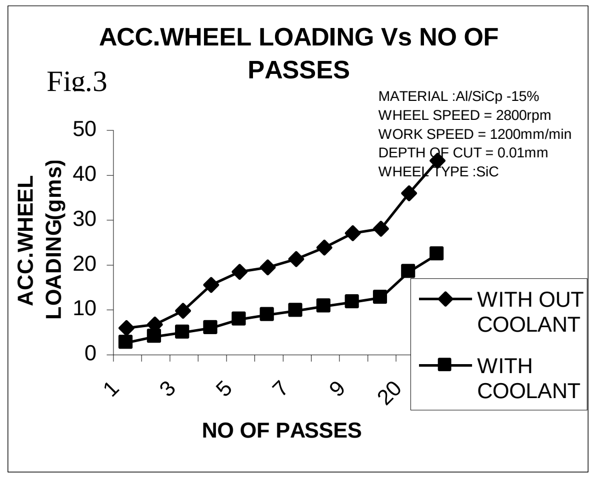
5.1. WHEEL LOADING IN GRINDING OF COMPOSITES

While grinding composite materials, improved due to the presence of reinforcement compared to base metal matrix [16] there is a metal built up in the grinding wheel and the built up edge formation leads to deterioration of surface.

The experiments were carried out to ascertain the influence of the coolant(vegetable oil) with effect of number of passes on accumulated wheel loading with different types of wheels on AlSiCp composite with 15% SiC. Fig1-3 shows the rate of accumulated wheel loading on number of passes. At less number of passes the wheel loading is less, as number of passes increases the rate of wheel loading also increases while grinding with Diamond wheel. Fig.1 shows the wheel loading increases with increase in number of passes while grinding with CBN wheel and Sic as depth of cut 0.01mm and work speed 1200mm/min were used. The rate of wheel loading increases with increase in number of passes while grinding with SiC wheel. In all wheels the rate of accumulated wheel loading is higher in SiC wheel than other wheels. The difference between the dry and coolant conditions the accumulated wheel loading is higher for all wheels.



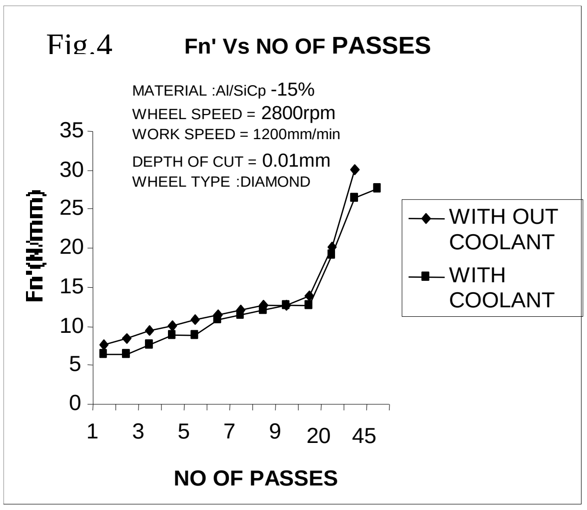


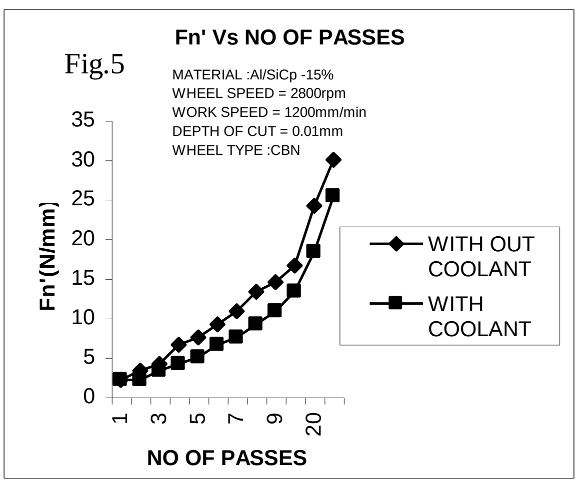


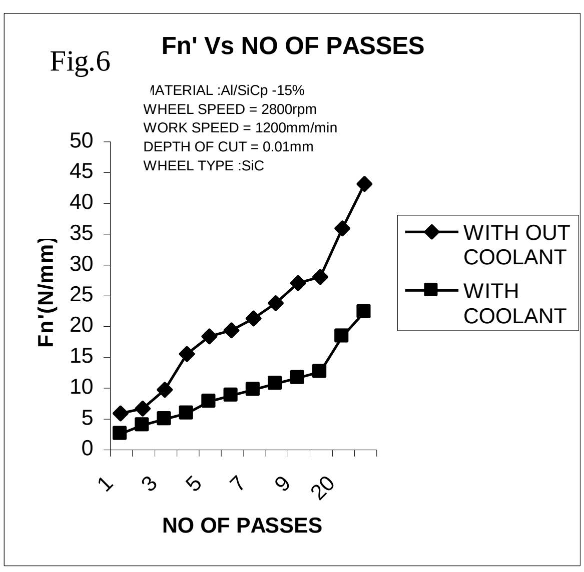
5.2 EFFECT OF COOLANT ON GRINDING FORCES:

5.2.1 Number of Passes on Normal Force (Fn'):

Fig. 4 - Fig. 6 shows the effect of normal force on number of passes phenomenon. Fig.4 shows the normal force increases with increase in number of passes while grinding with Diamond wheels as the depth of cut 0.01mm and work speed 1200mm/min were used. The different between the dry and coolant condition are less when compared with the effect of number of passes. Fig 5shows the normal force increases with increase in number of passes while grinding with CBN wheel. Fig.6 shows the rate of normal force increases with increase in number of passes while grinding with SiC wheel as the depth of cut 0.01mm and work speed 1200mm/min were used. In all wheels the normal force increases with increase in number of passes. In SiC wheel the normal force difference is higher than the other two wheels. In dry conditions the normal force is higher than coolant for all wheels.

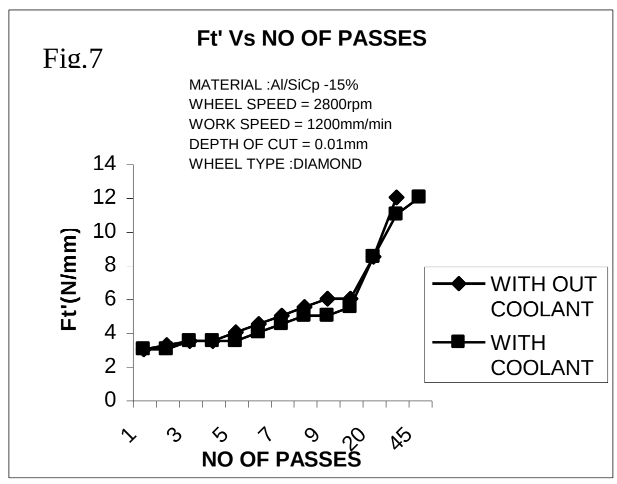


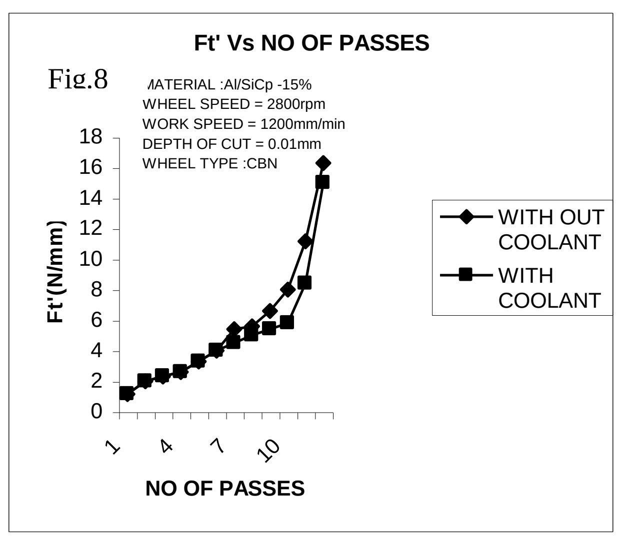


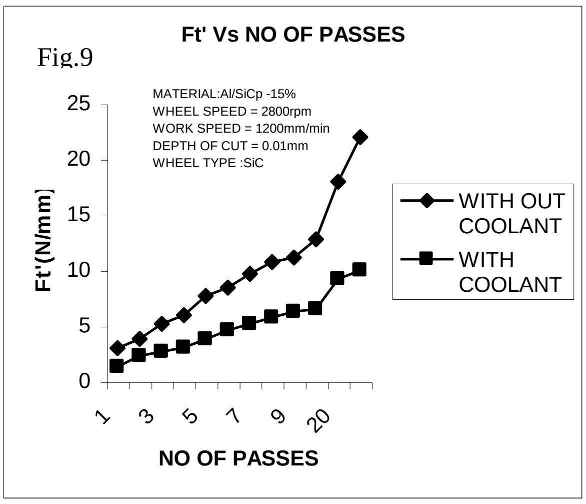


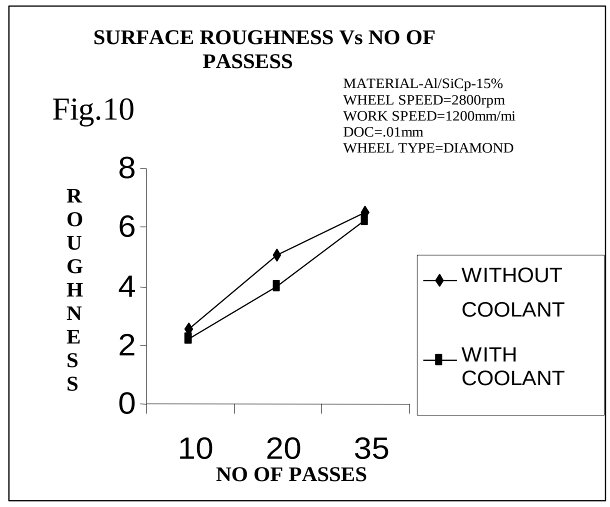
5.5.2 Number Of Passes On Tangential Force:

Fig.7 – Fig.9 shows the rate of tangential force on number of passes. Fig.7 shows the rate of tangential force increases with increase in number of passes while grinding with Diamond wheel as the depth of cut 0.01mm and work 1200mm/min were used. Fig.8 show the same phenomenon as the tangential force increases with increase in number of passes while grinding with CBN wheel as the depth of cut 0.01mm and work speed 1200mm/min were used. Fig.9 shows the rate of tangential force increases with increase in number of passes while grinding with SiC wheel. In dry conditions the rate of tangential force is higher than coolant condition for all wheels. In SiC wheels the tangential force is more than other wheels.



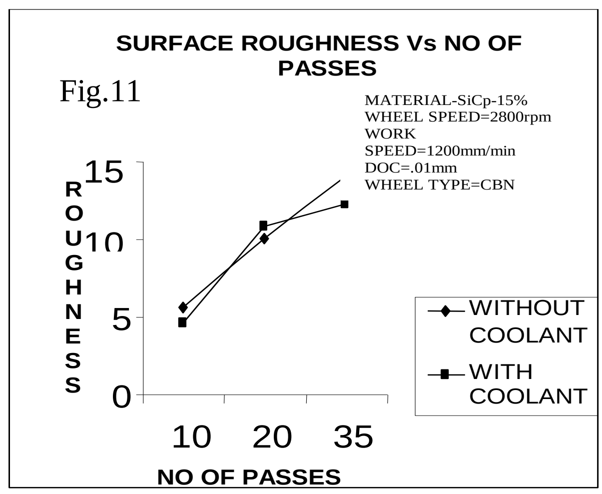


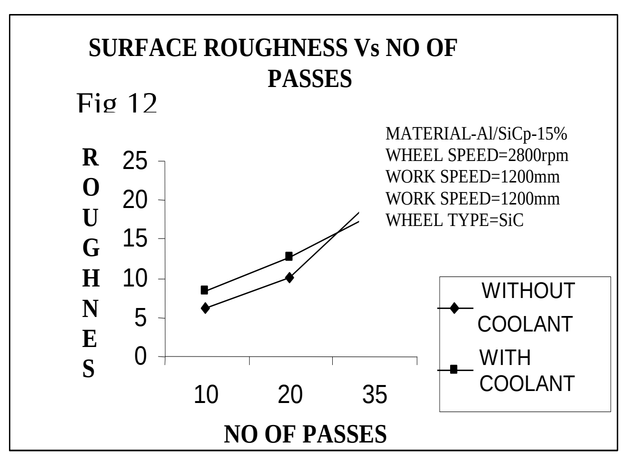




6.2 NUMBER OF PASSES ON SURFACE ROUGHNESSS

The surface roughness is influenced by all the grinding parameters. The variation of surface roughness with number of passes for various grinding wheels are shown in Fig.10– Fig.12 Fig.12 shows the effect of surface roughness increases with increase in number of passes while grinding with SiC wheel of depth of cut 0.01mm work speeds 1200mm/min were used. In Coolant condition the surface meshes better than the dry condition. Fig.11 show the rate of surface roughness increases with increase in number of passes while grinding with CBN wheel of depth of cut 0.01mm and work speed 1200mm/min were used. Fig.10 shows the rate of surface roughness increases with increase in number of passes while grinding with Diamond wheel**.** In all SiC wheel have higher surface roughness values than other two wheels. In all conditions the Diamond wheel show lower surface roughness values followed by CBN and SiC wheel in order in dry condition the surface roughness increases (i.e., surface finish is poor) with increase in number of passes than coolant.





4. CONCLUSION

The wheel loading is due to thermal and mechanical effects and the increase in No of passes increases the wheel loading, normal force and tangential forces. Increased wheel loading deteriorate the surface finish in both the conditions. But if we use the coolant during grinding the Wheel loading, normal force, tangential force and Surface roughness is Marginal.

5. REFERENCES

[1].Clyne.T.W, and Withers.P.J, (1993), An introduction to metal matrix composites, Cambridge University press.

[2].Nee.A.Y.C and Tay.A.O,(1981), On the measurement of surface grinding temperature, Int.J.Mach.tool.Deg.Res.Vol 21, No34, pp 279-291.

[3]. Di.Ilio.A, Paoletti.A, Tagliaferri.V, and Veniali.F, (1996), A experimental study on grinding of silicon carbide reinforced aluminium alloys, Int.J.Mach, Tools Manufacturing, Vol 36, No 6, pp 673-685

[4]. Komanduri.R, (1975), The mechanism of metal built up on aluminium oxide abrasive, wear, 33, pp 191-196

[5]. Yossifon.S, and Rubenstein.C,(1982), Wheel wear when grinding workpieces exhibitinghighadhesion, Int.J.Mach.Tool.Des.Res, Vol 22, No 3, pp 159-176.

[6]. Hwang.T.W, Evans.C.J, and Malkin.S,(2000), High speed grinding of the silicon nitride with electroplated diamond wheels, Part 2-Wheel Topography and grinding mechanisms, Transaction of the ASME, Vol 122, pp 42-50.

[7]. Marinescu.L.D, Dimitrov.B, Gheorghiu.Z and Grigorescu. Al,(1983), Some aspects concerning wear and tool life Diamond wheels, Annals of the CIRP,Vol 32/1, pp 251-254.

[8]. Razali.S.M, Suto.T, Waida.E, and Noguchi.H, (1992), Creep feed grinding of advanced ceramics, Proc Inst. Mech.Engrs, vol 206, pp 93-99.

[9]. Triemel.J, (1974), Grinding Cubic boron nitride, 14th MTDR conference, pp 645-651.

[10].Malkin. S, 'Burning limit for surface and cylindrical grinding of steels, Annals of the CIRP Vol. 27/1/1978. pp233-236.

[11].Kovach J.A and Malkin. S, 'Thermally induced grinding damage in super alloymaterials, Annals of the CIRP Vol. 37/1/1998. pp309-313.

[12]. Malkin S. Grinding Technology – Theory and Application of Machining with abrasive,Ellis Haward Ltd., 1989.

[13]. Di.Ilio. A, Paoletti. V, Tagliaferri and Veniali F, 'An experimental study on grinding of Slicon carbide reinforced aluminium alloys'. Int. J. Mach tools Manufacture, Vol.36,No.6, pp673-685,1996.

[14].Sundaram. S, Karthikeyan. R,Naagarazan. R, Anantharaman . N and Pai B.C, 'A Study on the influence of cutting parameters in grinding Al/SiCp composites.proceedings of International Conference on Manufacturing, Bangaladesh, pp 29- 338, 2000.

[15]. Sundaram S and Anantharaman . N, 'Temperature and wheel loading in grinding of Al/SiCp composites, National seminar in Advances in Integrated Manufacturing systems,MIT, Chennai, pp 140-149. 2001.

[16]. Srivastava A. K, Sriram. K and Lal G. K, ' A Simple analysis for evaluating Grinding wheel loading". Industrial Journal Machine Tools Manufacturing Vol. 28, No.2, PP 181 – 190, 1988.