Metal matrix composites are one distinct from the existing materials in terms of composition, structure and properties. Al-(SiC)$_p$ composites are of the futuristic metal matrix composite material finding a wide range of applications in automobile, aerospace and engineering industries. It finds wide spread usage due to their attractive properties such as high strength to weight ratio, high wear resistance, high temperature stability etc. Although near net shape processing is the preferred choice with metal matrix composites, machining /finishing is required due to surface and assembly requirements. From the machining point of view, these are one of the difficult to machine materials. The machining is difficult due to the presence of ceramic reinforcements. The ceramic reinforcements cause excessive wear on the cutting tools during machining. Even though, many studies were conducted on machining of Al-(SiC)$_p$ composites, but the data available is not adequate and also not suggestive enough to identify suitable machining parameters. Hence it is essential to study the machinability of Al-(SiC)$_p$ composites. In this study attempts were made to evaluate the performance of various advanced cutting tools in machining Al-(SiC)$_p$ composites, innovative approaches such as rotary EDM, hot machining were also experimented.

Machining tests were conducted on 6061 and 6025 Al base alloys reinforced with (SiC)$_p$ reinforcements with various cutting tools. Carbide, Coated carbide, Cermets and diamond in turning and H.S.S, Cryogenic treated H.S.S and Cryogenic + TiN coated H.S.S cutters in milling were used to machine Al-(SiC)$_p$
composites. The flank wear of the cutting tool and surface finish of the machined surfaces were observed. The performance of these cutting tools were analyzed while varying the volume % of SiC in the Al-(SiC)p composites and the cutting speeds. Similarly the effect of feed rate of carbide tool on surface finish was also analyzed. On comparing between the performances of the carbide, multilayered coated and diamond tools, the carbide and coated carbide tools wear faster than diamond tools. The major factors affecting the tool life is the SiC volume fraction. The more the volume fraction of the SiC, the more severe is the flank wear and consequently, the shorter is the tool life. After a high initial wear rate, the coated carbide subsequently wears very uniformly, hence it can be used for machining. The flank wear on cermet tool was less when machining the Al-(SiC)p composites in comparison with coated carbide tools and also the wear occurs at a constant wear rate with good dimension tolerance and surface finish. The effect of TiN coating on H.S.S milling cutters either with or without cryogenic treatment decreases the flank wear marginally. The wear areas were observed by scanning electron microscope and the wear mechanisms were identified.

Machining Al-(SiC)p composites with conventional tools resulted in excessive tool wear due to the abrasive SiC reinforcement. To further enhance the machining of Al-(SiC)p composites, advanced machining has to be adapted. EDM, owing to easy control in operations is one of the methods to machine hard to machine materials. The conventional EDM techniques lack axial rotation during machining which reduces the debris removed at the machining gap and its efficiency. Hence a revised facility of EDM which imparts a rotation to the solid and tube electrode with lateral and injected flushing. With the imparted rotary motion to the electrode in EDM, the MRR is improved nearly 40% in comparison with stationary electrode with lateral flushing. The effect of EDM drilling with
rotating tube electrode produced 30% higher MRR than rotating solid electrode. The electrode tube hole diameter affects the MRR, EWR and SR. The decrease in hole diameter produces a better MRR, SR and higher EWR. The increase in rotating speed of the tube electrode produces higher MRR, EWR and better SR. The EDM parameters were optimized for better MRR, less EWR. The EDM surfaces were analyzed with scanning electron microscope.

To further enhance the machining efficiency of Al-(SiC)p composites, hot machining was used. The material removal by cutting process is mainly by shear deformation which is dependent on the behaviour of the material. Under the conditions of machining such as depth of cut, cutting velocity and temperature. The above parameters are analogous to strain, strain rate and temperature envisaged in the deformation of the work materials at the tip of the tool. By evaluating the constitutive behaviour of the material, the machinability of the material can be optimized. Dynamic Material Model (DMM) which finds extensive use in metal forming was used for evaluating the constitutive behaviour of the material in hot machining condition. Using the strain rate sensitivity parameter (m) and temperature sensitivity of the flow stress of the material during deformation and Lyapunov DMM stability criterion, the favourable region for hot machining was identified.

In summary, detailed investigations were carried out on machining of Al-(SiC)p metal matrix composites. In the first part, the performance of carbide, coated carbide, cermet, PCD tool in turning and TiN coated and cryogenic treated TiN coated cutters in milling were evaluated on machining Al-(SiC)p composites with varying SiC volume content. In the second part the machinability of these composites in EDM was investigated. The efficiency of EDM was improved by
improving the debris removal at the machining gap with rotary motion of the solid and injection of dielectric through the tube electrode. In the third part the effect of hot machining on the machinability of these composites was studied. A new methodology DMM was used to identify the suitable parameters of hot machining.