**PhD Thesis Title:** ULTRASONIC VIBRATION ASSISTED GRINDING OF Ti-6Al-4V ALLOY AND MODELING OF SURFACE ROUGHNESS

**Student Name:** RAJESHKUMAR MADARKAR

**Entry Number:** 2014MEZ8342

**Abstract:**

The present work aims to perform the ultrasonic vibration assisted grinding (UVAG) on titanium alloy (Ti-6Al-4V), and the ultrasonic vibration assisted minimum quantity lubrication (UMQL). An indigenous UVAG setup has been developed for the study to provide longitudinal ultrasonic vibration to the Ti-6Al-4V workpiece. Similarly, the UMQL setup has been developed to atomize the cutting fluid droplets into fine and uniform-sized droplets and also to feed these droplets into the grinding zone effectively. The ultrasonic horns for these studies have been indigenously developed using the theoretical and FEM approach. The grinding performance of Ti-6Al-4V alloy in conventional, as well as in ultrasonic vibration assisted grinding (UVAG) under dry, wet, and minimum quantity lubrication (MQL) grinding environments are evaluated and then compared. The influence of various process parameters under different grinding environments in UVAG has been studied. The results have been analyzed and also compared with the respective grinding environment in conventional grinding using the same process parameters. The possible improvement mechanisms in UAVG have been discussed in detail based on the obtained cutting forces, surface roughness values, and ground surfaces, as well as grinding chips morphology and wheel topography. Analysis of variance has also been carried out to capture the variability in the experimental data for grinding forces and mean surface roughness.

Nowadays, MQL is widely used in machining/ grinding as a competent cooling-lubrication technique owing to its advantages in terms of better cooling, lubrication, and lower coolant consumption. Ultrasonic vibration can be used to enhance the efficiency of the MQL

system by atomizing the cutting fluid into ultra-fine and uniform droplets. This work presents the experimental investigations carried out to evaluate the improvement in grinding performance of Ti-6Al-4V alloy using ultrasonic vibration assisted minimum quantity lubrication (UMQL) technique. The vegetable oil in water emulsion has been used as cutting fluid due to its capacity to provide better lubrication, and the biodegradable and environmentally friendly nature. The grinding performance during UMQL has been evaluated and compared with the grinding forces, surface roughness, and the ground surface and grinding chips topography obtained during conventional MQL (CMQL) techniques. The UMQL grinding results in smaller grinding forces, and improved surface quality as compared to CMQL grinding. The experimental findings demonstrate that the UMQL has a strong potential to enhance the grindability of Ti-6Al-4V.

Further, a pseudo analytical model has been developed to envisage the surface roughness obtained during dry UVAG of the Ti-6Al-4V using the SiC grinding wheel. The kinematic grinding condition, material properties, the contact lengths during UVAG, and the grinding wheel structure have been considered in this model. Further, an established relationship between the surface roughness and the modified undeformed chip thickness has been used for the reliable prediction of the surface roughness. Finally, the predicted surface roughness values from the developed model have been validated by the experimentally observed surface roughness values. The predicted values of surface roughness using the developed model shows similar trends with the experimentally observed surface roughness values under different process parameters during UVAG of Ti-6Al-4V alloy. Hence, the proposed model can be reliably used to assess the surface roughness during the ultrasonic vibration assisted grinding of the Ti-6Al-4V alloy.