CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Minimum quantity lubrication (MQL) refers to the application of a miniscule quantity of coolant, typically of a flow rate of 10 to 100 ml/hour (Kamata and Obikawa, 2007). Reducing the environmental impacts of machining are required in order to attain the sustainable and cleaner production. As developing alternative manufacturing process technologies for machining is still a prohibitive task, preventing the negative environmental impact of machining can be achieved essentially by operating modification of existing processes (Hanafi et al., 2012). As the manufacturing world is in a continuous pursuit of investigating the methods in order to increase the process performance and to reduce the production costs, in addition to the growing environmental concerns (Fratila, 2013), minimum quantity lubrication process can offer the near-term solution to the problem. Driven by pressure from international environmental protection agencies, energy consumption and natural resources conservation laws enforced by public authorities, manufacturing industry and the concerned research centers are forced to focus their efforts on researching alternative production processes, creating technologies to minimize the use and production of environmentally hostile residues. MQL has demonstrated as a successful near-dry machining technique as well as a globally-acknowledged option compared to complete dry and wet cutting conditions from the perspective of cost, ecological, human health issues and machining process performance (Lawal et al., 2013). MQL is a sustainable manufacturing approach which is vital in the current scenario of manufacturing industry as it incorporates all the issues related to sustainability. The cost of cutting fluids range from 7 to 17% of the total machining cost while another estimate gives this cost as 15-20 % of total machining cost compared to the
tool cost which ranges from 2 to 4% (Attanasio et al., 2006; Lawal et al., 2013; Li et al., 2014). Therefore, the minimization of metal working fluids can serve as a direct gauge of sustainable manufacturing.

Machining with MQL has been extensively applied in many machining processes such as drilling (Filipovic and Stephenson, 2006; Davim et al., 2007), milling (Lacalle et al., 2006; Liao and Lin, 2007), turning (Davim, 2007; Kamata and Obikawa, 2007) and MQL grinding (Silva et al., 2005; Shen et al., 2008). Since no huge power consuming auxiliary equipment such as compressors, chillers and pumps are required as compared to flooded machining, hence a marked reduction in energy consumption in MQL machining. The use of empirical approach together with the implementation of experimental design techniques as well as application of statistical data analysis techniques are gaining recognition on account of the simplicity involved in the model making procedure and the accuracy of the prediction obtained for the specific cutting conditions domain (Kannan and Baskar, 2013).

Aluminium alloys are the most machinable amongst the metals with a wide range of applications due to mechanical and corrosion resistance with lower cutting forces as well as low cutting temperatures (Kelly and Cotterell, 2002; Ariff et al., 2012). However, due to highly adhesive characteristics of aluminium and its alloys more effective lubrication is required for these alloys although these are not hard and difficult-to-cut especially with alloys containing hard inclusions such as aluminium oxide, silicon carbide, or free silicon (Kelly and Cotterell, 2002; Wakabayashi et al., 2007). On the other hand, machining of aluminium alloys results in the generation of very fine metallic particles in the form of ultrafine dust particles with longer air-borne suspension time hence harmful for the health of the operator (Songmene et al., 2011).

Significance of machining processes optimization arises from the prerequisite for an economic and feasible performance of the machining processes. Practical manufacturing processes are illustrated by conflicting and often incompatible measures of performance such as quality and productivity (Kumar and Chhabra, 2014). The multi-objective optimization techniques are used to find out the trade-offs among the conflicting performance measures in a machining process in order to achieve performance
optimization. In such cases, it is not necessary that a single solution may satisfy all the objectives on account of incommensurability and the conflict among the objectives. Multi-objective optimization is different from single objective optimization in that the single objective optimization is used to find the best design from among many and usually best design point is the global maximum or minimum depending on the type of optimization (Ponnala and Murthy, 2012). The investigations carried out in this study are focused on the effects, analysis and parametric modeling of end milling process under conventional minimum quantity lubrication technique through extensive experimentation as well as nanofluid-MQL conditions. Multi-objective optimization is performed in terms of desired performance measures within the defined machining domain.

1.2 PROBLEM STATEMENT

The major challenges faced by the manufacturing industry are the improved quality, enhanced productivity as well as economic production. These challenges are addressed by increasing the material removal rate for enhanced productivity, surface quality and surface integrity as well as longer tool life with consistence performance (Ali et al., 2011). While dealing with these issues, one of the predominating challenges is the mitigation of excessive heat generated in the cutting zone. This generated heat in the cutting zone affects surface quality and integrity as well as tool wear and tool life. Hence it is essential to maintain this cutting temperature at such an optimum level so as to attain superior surface finish and overall machining economy in terms of longer tool life and productivity. Cutting fluids are considered essential for machining operations in order to perform lubrication, cooling and chip flushing. These functions of cutting fluids in machining processes are constantly being reviewed due to cost pressures (Priarone et al., 2014) together with growing global concerns related to occupational and environmental consciousness (Marksberry and Jawahir, 2008) and the need for increased employee satisfaction through healthier environment and cleaner work areas (Ali et al., 2011). The conventional method of application of cooling and lubrication in machining processes involve profuse use of cutting fluids.

Consumption of cutting fluids in the different machining and technological processes often generates aerosols by atomization and the mist thus produced in the work area poses a potential exposure hazard to workers and to the environment (Sujova, 2012).