CHAPTER 1

INTRODUCTION

The current need of manufacturing industries is to improve productivity and to ensure quality. These demands require stable processes with higher material removal rates and less processing time. In many mechanical systems, hardened parts are used to achieve certain design objectives, and these parts are to be machined and finished. The conventional methods of manufacturing such parts is through machining when the material is soft with suitable allowance for hardening and grinding, hardening and finish grinding. However, the total cycle time of manufacturing by this route is long.

1.1 HARD TURNING PROCESS

Over the last few decades, machining, particularly turning of hardened components has become a reality. In hard turning, components having hardness in the range of 45 to 70 HRC are turned in a suitable machine tool. The advantage of hard turning over the conventional machining – hardening – grinding is many. Some of the significant advantages are: high flexibility and ability to manufacture complex profiles in one setup, less cycle time, lower cost of manufacturing and environment friendliness (Tonshoff et al 2000, Gaurav and Choudhry 2012). In recent years, hard turning technology is finding increasing application in manufacturing industries, as an attractive alternative to grinding, leading to higher material removal rates,
process simplification, low total processing cost, flexibility in manufacturing and greener manufacturing.

The primary objective in hard turning operations is the production of high-quality parts. Particular consideration must be given to the levels of surface quality, dimensional and form accuracy, and subsurface structure. When hard turning is unable to produce the quality required, this technology cannot stand as a real alternative to grinding. It is certainly not true to say that hard turning will completely replace grinding in all areas and for all parts. However, considerable advantages in terms of cost and time are frequently achieved, with the machining of work materials like X155CrMoV cold work steel (AISI D2), X38CrMoV5 (AISI H11) hot work steel, 100Cr6 (AISI 52100) bearing steel, etc. Due to its favorable effects on the machined surface, hard turning processes are replacing grinding for finishing mechanical components of hardened steels, such as transmission shafts, precision steel roller bearings and gear wheels for the automotive industry, as well as landing gear struts for the aerospace industry.

Since hard turning involves turning materials of high hardness, the machine tool used must have very high rigidity and capable of withstanding high dynamic cutting forces. Similarly, the cutting tool material used for hard turning must also have high indentation hardness, high fracture toughness, high stability against abrasive particle, high resistance to mechanical stress and the ability to maintain its shape at elevated cutting temperatures. (Tonshoff et al 2000). Cubic Boron Nitride (CBN) has emerged as a cutting tool material for the hard turning of steel.

During hard turning, the Cubic Boron Nitride (CBN) is exposed to a very severe environment. The specific cutting stresses and the temperatures are high due to the hardness of the machined steels and the small contact area between the tool and the workpiece. For a tool to perform successfully under
these severe conditions, factors such as the cutting tool edge geometry (chamfer angle and hone radius), feed rate, and cutting speed have to be carefully selected.

1.2 APPLICATIONS OF HARD TURNING

Steel parts which are exposed to a high level of load, such as gear wheels, roller bearing rings or ball screws, are frequently hardened in order to improve their wear and strength characteristics. Particularly where geometrically complex parts are concerned, impermissible form changes are likely to occur as a result of distortion due to hardening. When the workpiece is required to meet exacting quality requirements (surface quality, dimensional and form accuracy), end machining operations must be conducted when the parts are in a highly tempered and/or hardened state.

A major application of the hard turning process is the bearing industry, where a sequence of production steps, including heat treatment and grinding, are traditionally required to produce bearing races out of medium- and high-carbon steels. The trend today is to replace the slow and cost-intensive grinding process with the turning process, to directly rough and finish machining hardened bearing components prior to super finishing. Also, automobile makers have started to use hard turning for semi-finished and finished transmission shafts, axles, and engine components, while aircraft manufacturers have applied the technology to the production of flap gears, landing struts and aerospace engine components.
Another example of a hard turning application is the manufacturing of die and mold or maintenance components. This application is characterized by a limited number of parts to be machined with different geometries, which requires a large number of inserts, rendering such expensive tools economically unfeasible. Therefore, alternative tool materials that significantly reduce tool costs without affecting the machining performance are crucial for further developments in hard turning.

1.3 ORGANISATION OF THE THESIS

Chapter 2 consists of the review of literature. The literature survey is carried out on (i) understanding the hard turning process, (ii) various monitoring techniques employed in hard turning and (iii) acoustic emission
monitoring and associated signal processing employed in the conventional turning operation.

Chapter 3 describes certain preliminary experiments carried out to study the process of hard turning and the attempts to monitor the hard turning, using vibration signals.

Chapter 4 explains the hard turning experimental set up and the details of experiments carried out for monitoring the hard turning process, using acoustic emission signals.

Chapter 5 discusses the various results obtained in monitoring the hard turning process using the acoustic emission signals.

Chapter 6 outlines the major conclusions reached, and the scope for further study.