CHAPTER 1
INTRODUCTION

1.1 General

Today’s manufacturing market depends on the quality and productivity. Quality is very important based on customer’s viewpoint because it influences the degree of satisfaction of the consumers during the usage of the procured goods. Therefore, every manufacturing unit should be concerned about the quality of the product. Another existing criterion called productivity which is directly related to the profit level and also to the goodwill of the organization. Every manufacturing industry aims to produce a large number of products within the available time. Quality of a product can be described by surface roughness of the machined part and it can be controlled within the desirable limit by controlling the machining parameters. As manufacturing industries aspires for increasing the tool life and material removal rate by proper selection of cutting tools and process parameters to achieve a high profit and productivity, and this necessitates optimization of the best combination of process parameters for the above said manufacturing process.

1.2 Hard Turning

The hard turning process utilizes single point-turning tool with hardness about 55 – 67 HRC. The advantages of machining components in hardened state is to eliminate the conventional grinding operation, reduction in machining cost and lead time and further to reduce the number of necessary tools so as to manufacture the products with a high degree of accuracy.
1.3 Hot Turning

Hot turning basically consists of applying localized heat, ahead of cutting tool, to reduce the shear strength of the workpiece metal (thus improving its machinability), and to permit the easy formation of the cutting chip. The chip is usually produced in the form of a long smooth one, which does not give much shock to the tool.

Heating Methods

The heating of workpiece has been carried out in different ways. They are

1. High-frequency induction heating

2. Electric arc heating devices mounted on the carriage, by resistance heating with the application of an electric current in the cutting zone.

3. Flame heating

4. Plasma arc heating

Advantages:

1. The process is economical and in many cases has reduced the operating costs.

2. Productivity gets enhanced.

3. Good surface finish can be obtained, superior to that obtained on these materials by conventional turning process.

4. Little evidence of any adverse micro structural change.

Hot turning is defined as the process in which the workpiece is heated to red hot temperature to reduce the shear strength during the turning operation. The hot turning process
can be implemented to the materials possess high strength, wear resistance and toughness and those materials which are difficult to be machined by conventional machining methods.

Stainless steel poses lot of challenges during conventional machining due to their high tensile strength, high hardness, high work hardening rate, low thermal conductivity and abrasive behavior. These properties often lead to high cutting forces which results in high cutting temperature, fast tool wear rate, and high susceptibility to notch wear, difficulties with chip breakability, Built-Up-Edge (BUE) formation and poor surface finish.

AISI 316 stainless steel is one such material and it is not easy to machine even with specific cutting tools. Stainless steel contains Chromium between 12 and 25 percentage which Chromium is responsible for corrosion resistance and levels as high as 25 percentage of Nickel to produce an austenitic structure and thus leads to extreme high work hardening rates. Acid resistance can be obtained with an addition of Molybdenum. AISI 316 stainless steel is widely used to produce critical structural components in chemical industries, storage vessels and tanks for corrosive liquids, mining, pharmaceutical and petroleum industries and nuclear power stations since they provide a unique combination of high mechanical properties and corrosion resistance. Well known unconventional machining process not only have low metal removal rate but also very expensive. In order to have a good metal removal rate without compromising the quality of turned surface, hot machining process is gaining momentum.

1.4 Cutting Parameters in Hard and Hot Turning Process

The four major factors in hot turning are cutting speed (Vc), feed rate (fs), depth of cut (ap) and workpiece temperature.
1.4.1 Cutting speed (Vc)

Cutting speed always refers to the spindle of workpiece and it is stated in revolutions per minute (rpm) that indicates their speed. It is also expressed in meter per minute (m/min) and different diameter of a workpiece will have different cutting speeds, even though the rotating speed remains the same.

1.4.2 Feed rate (fs)

Feed rate always refers to the cutting tool, and it is the rate at which the tool advances along its cutting path. The feed rate is expressed in mm of tool advancement per revolution of the spindle, or mm/rev.

1.4.3 Depth of cut (ap)

It is the thickness of the layer being removed from the workpiece in a single pass and expressed in mm.
1.4.4 Workpiece temperature (°C)

In hot turning, another important parameter is workpiece temperature which can be adjusted by the torch. During hot turning experiments, LPG flame was used to heat the workpiece.

1.5. **Part I Hard Turning of AISI 316 Stainless Steel**

The machining of hardened steel or advanced alloys is widely carried out by the metal removal method that produces high precision parts for the aerospace and nuclear industries. Today, hard turning has replaced the grinding process of hardened steel components in practice. The machining of hardened steels can be achieved by using super-hard cutting tool material, such as tungsten carbide (WC). From an economical point of view, the hard turning is most cost effective as it provides less machining, reduces set-up and machining cost and more over it does not require the use of any coolants. Further, the reduction in machining time is as high as 60% for hard turning when compared to the grinding process.

In the hardened machining process such as hard turning, an ability to predict the technological performance measures such as surface roughness (Ra), tool wear (VB) and cutting forces would be very advantageous for better understanding of hard machining.
Part II  Hot Turning of AISI 316 Stainless Steel

Tigham first innovated the process of hot machining in 1889, since then it has created much interest among various investigations. In early stages, materials difficult to machine under normal conditions such as Stainless steel, S-816 alloy, x-alloy, Inconal-x, Timken 16-25-6 and Navy grade v, Nickel-Chromium steel have been hot machined by Tour and Fletcher.

The production of exotic and smart materials has become highly indispensable to satisfy the robust design requirements for aerospace and defense sector. The machining of these materials considered to be a great challenge in industries. It requires cutting tool of high strength, which is very costly and some times it is even impossible. Non-conventional machining process another viable method is mostly restricted to small-scale removal of material. For bulk removal of material, the growing interest for hot machining process is being developed in industry. In hot machining, workpiece is softened by heating and which reduces the shear strength to ease the machining.