CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

High Speed Machining (HSM) is one of the many advanced manufacturing technologies that had been developed over the years. It has enabled the increase in efficiency, accuracy and quality of workpieces while at the same time decreasing costs and machining time (Schulz, H., 2003). There is no particular definition of high-speed machining because it has been defined differently by various authors. According to Longbottom (2006), the first definition of HSM was proposed by Carl Salomon in 1931. He assumed that HSM referred to machining that has cutting speed which is 5–10 times higher than conventional machining. Coromant, S., (1999), Ekinovic, S. and Ekinovic, E., (2000) defined HSM differently as high cutting speed machining, high rotational speed machining, high feed machining, high speed and feed machining or high productive machining. Thus, it is apparent that HSM may be recognized as a relatively new production technology which enabled higher productivity, excellent surface finish and dimensional accuracy in manufacturing. The advances in machine tool performances (main spindle, feed drives, etc.), high-speed machining, particularly high-speed milling, became one of the factors which contributed towards cost-effective manufacturing processes. These enabled the manufacturing of products with high surface quality, economical alterations in machined surface and dimensional accuracy (Fallbohmer, P. et al., 2000; Becze, C.E. et al., 2000; Begic-Hajdarevic, D. et al., 2014).

However, high-speed machining can result in numerous dynamic problems. One of them was a form of self-excited vibration known as chatter. Chatter is a self-excited vibration that can occur when an overly large volume of material was removed for a
particular spindle speed. A recent study by Palpandian P. et al. (2013) found that chatter was an undesirable phenomenon which can limit the productivity of the machine and reduce the material removal rate (MRR). It had also been reported that the occurrence of chatter can lead to a waste of materials and energy plus poor surface finish of the end products. The development of strategies to control the chatter has been done by a number of researchers and these will be described in the next chapter of this thesis. Stability lobe diagram (SLD) is an efficient tool which helps to select specific spindle speeds during production to avoid chatter in machine. Stability lobes are plotted against depth of cut versus spindle speed which shows a boundary between stable and unstable cutting regions. Figure 1.1 displays the SLD curve for stable and unstable zones.

![Stability Lobe Diagram](image-url)

**Figure 1.1**: Example of a stability lobe diagram (SLD)

Source: Palpandian, P. et al. (2013)

Tang, W.X. et al., (2009) reported the steps involved in the prediction of stability lobe diagram in their study. Initially, the dynamic characteristics and milling process parameters were obtained using modal testing. Then, the frequency response functions (FRFs) were determined by selecting the natural frequency and exciting frequency. Using FRF, stability milling limits were estimated and the stability lobe diagram was obtained.
The dynamic properties and FRFs of cutting tools were required for the use of modal testing. An impact hammer was traditionally used to excite the system at the tip of the tool and the response was measured with a co-located accelerometer shown in Figure 1.2. However, this configuration had a number of disadvantages such as:

(i) The cutting edge of the tool can easily be damaged by the hammer strike.
(ii) On large machines, the test engineer must work within the machine itself which can pose a health and safety hazard.
(iii) The tool cannot be rotated during the test. The FRF during rotation could differ due to gyroscopic forces and bearing loads (De Lacalle, et al. 2009). Furthermore, some CNC machines automatically modified the tool drawbar force as a function of spindle speed which may influence the tool’s FRF.
(iv) In practice, the mechanical interfaces in the system have led to some nonlinearity in the FRF. During machining, the tool load differed substantially from the forces induced by an impact hammer. Therefore, these nonlinearities cannot be considered.

Figure 1.2: Experimental set-up for hammer excitation