Machining and its Effects on Final Material Properties

Presenter: Trevor Nienaber

Faculty Mentor: Dr. Julius Schoop

Department of Mechanical Engineering, University of Kentucky

University of Kentucky

Introduction

During machining, a part under goes immense forces that can alter its material properties and grain structure. Having the ability to predict these changes can vastly increase the efficiency of any machining process.

This research aims to develop models that can accurately predict final material properties. These models will enable manufactures to better determine what process and tool to use to get as close as possible to the final desired material properties; eliminating the need for extensive post-processing.

Overview

The Machine

- The machine has 4-axes capable of cutting material at 4 m/s
- A high-speed camera will be used to observe the material's deformation in real time
- The camera will be focused on the region shown in figure 1
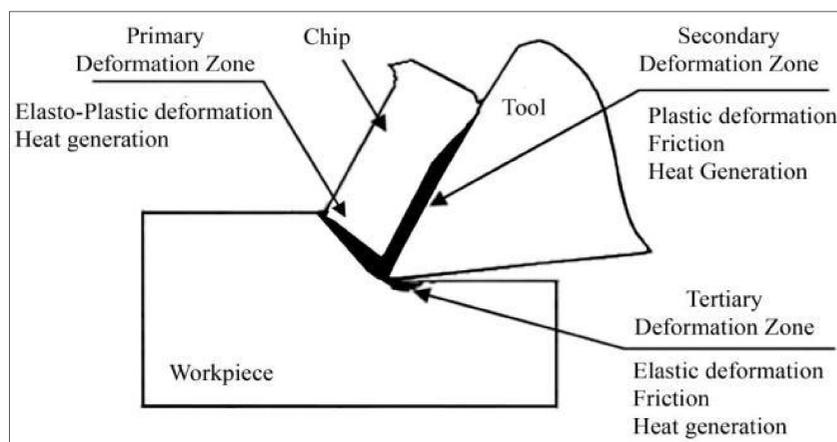- Stability is key to collecting clear and usable data

Figure 1: https://www.researchgate.net/figure/Fig-1-Cutting-zone-in-turning-machine_fig1_320930549

Overview Continued

Rail Alignment

- To collect usable data the guide rails for each axis must be parallel to each other
- Any fluctuations could result in blurry and unfocused images
- The x-axes shown in figure 2 was aligned to within 1-2 microns
- Similar tolerances were used on the y and z-axes.

Figure 2: x-axis guide rails

Material Properties

- Tests using various tool heads and feed rates were used to practice determining final properties
- A total of 16 titanium discs were tested
- Each test contained four discs with four data points collected per disc
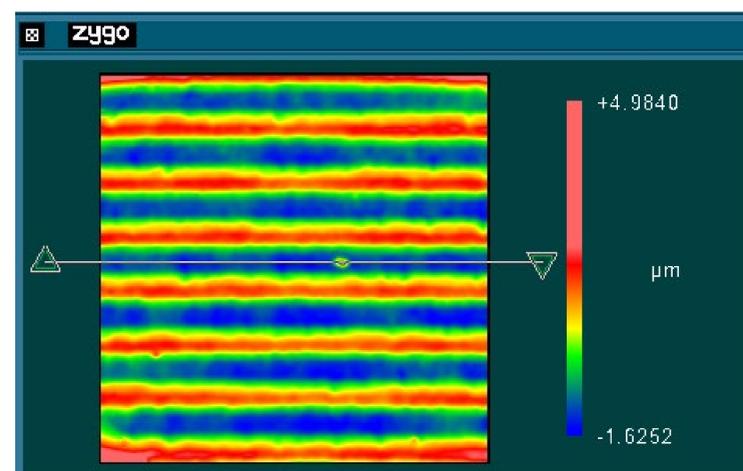- Samples of the data collected can be seen in Figure 3 and 4.

Figure 3: Topographic image of a discs surface

Implications

- Develop a deeper understanding of the behavior of material during machining
- This knowledge can be used to develop more accurate models predicting final material properties
- Limit the need for post-processing
- Ultimately reducing the cost of any machining process
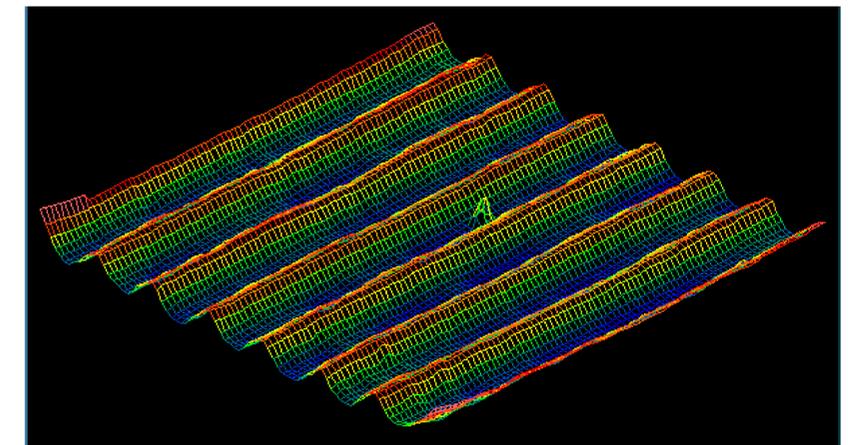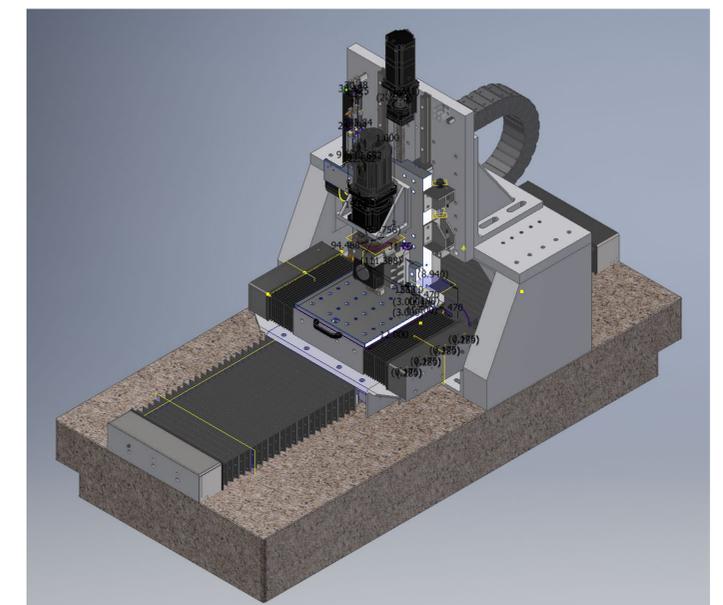

Figure 4: 3D rendering of Figure 3

CAD Model

Figure 5: CAD Model of the machine