Cutting Forces

Subjects: General Engineering

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Definition

Monitoring tool-behavior is of utmost importance regarding the machining process's productivity and costs. The machining tool performance can be assessed in several different ways, such as evaluating the machined material's surface roughness, or by analyzing the cutting forces that are developed during the process. The force assessment is achieved by employing cutting force prediction methods or by measuring the cutting forces by using dynamometers or other sensor systems. Thus, it is crucial to know the various advantages and drawbacks of each of the different techniques for this matter.

1. Introduction

Machining process are an unavoidable and valuable technique to produce high-precision parts. There are many ways of monitoring a machining process, one of them being tool-behavior, which is of utmost importance regarding the machining process's productivity and costs. The machining tool performance can be assessed in several different ways, such as evaluating the machined material's surface roughness, or by analyzing the cutting forces that are developed during the process. These cutting forces provide valuable information regarding not only the tool's performance but also the process's stability, proving that knowledge of these cutting forces is a key factor, regarding the optimization of the machining process. Cutting force assessment can be mainly achieved by employing cutting force prediction methods or by measuring the cutting forces by using dynamometers or other sensor systems. Thus, it is crucial to know the various advantages and drawbacks of each of the different techniques for this matter.

2. Methods

Regarding the prediction methods, these are quite used nowadays due to the huge amount of experimental data that was obtained, and that these methods depends on. The main focus of recent research is improving on existing cutting force prediction methods and the creation of predictive methods for complex machining processes that are applied for complex geometries (5-axis machining) or for materials that are hard to machine. One method that is being employed in many studies is the FEM (Finite Element Method) simulation, as it enables for the prediction of cutting forces, tool deterioration and tool/workpiece temperature (including tool/workpiece interface). These methods are quite versatile and can have a low cost (when compared to the force sensor systems that are commercially obtained), however, they are generally time-consuming (simulations take several hours, for example) and highly dependent on previously collected experimental data, with the more novel methods requiring validation.

On cutting force measurement methods, these are the most employed methods on the industry and research on this matter, as they provide reliable cutting force data acquisition with a relatively simple setup. Cutting force sensor systems are used for the obtention of these cutting forces, such as dynamometers, that provide direct cutting force data, developed during the cutting process. There are many other sensors, that can be used to calculate the cutting forces of the machining processes, such as a visual sensor, that can calculate the cutting force generated during the process by using the deviation of the tool. These methods are being employed recently as means to understand some cutting processes that are not yet fully understood. There is also a common research trend for the development of lower cost cutting force sensor equipment, as the commercially obtained force sensor systems have a high cost of acquisition. Cutting force measurement systems are also being coupled with analytical/predictive methods,

to provide more detailed information on the cutting process.

There has been, as well, some research regarding cutting force acquisition in robot machining, as this process is quite relevant nowadays.

3. Conclusions

The main research on this entry seeks to develop a cutting force sensor that can be accumulated to the robot, filtering the interference from the movement of the robot itself. Also, Machine Leaning Methods are being researched, as these provide a high degree of flexibility in terms of cutting force measurement/prediction, using analytical and experimental data, the ML models can quickly adapt and correct the process, enabling its optimization at a much quicker rate.

Keywords

CNC Machining;Cutting Forces;Force sensor systems;Predictive methods;Simulation;Dynamometers;Machine Learning