Horizon 2020 - The EU Framework Programme for Research and Innovation
Project Co-funded by the European Commission
Grant Agreement Number 952119 — KITT4SME
platform-enabled KITs of arTificial intelligence FOR an easy uptake by SMEs

Quality Control of manufacturing operations in the Pilot Line GAMHE 5.0: Macro-mechanical milling

1. General Description

Quality is defined as the extent to which a product conforms to the design specifications and how it complies with the requirements of component functionality. For some industries, such as automotive and aeronautical, the quality of their parts is very important given the high requirements to which they are subject. However, difficulties arise from the fact that a measure of quality can only be evaluated ‘‘out-of-process”, resulting in losses because there is no alternative to removing defective parts from the production line. Therefore, it is necessary to incorporate AI-based kits/solutions that provide in-process estimation to predict quality from some measured variables.

The main goal of these datasets is to monitor the final quality of the manufactured components or parts by estimating surface roughness from vibration signals and cutting parameters information. Surface roughness is an essential feature in quality control defined by the deviation in the direction of the normal vector of a real surface from its ideal form. Because the roughness measurement is an offline and post process procedure, being able to estimate this value online brings a series of benefits in terms of time and cost reduction in manufacturing lines, energy efficiency, unnecessary wear of tools and machines, etc. Once a part has been detected with a surface quality below what is desired, a series of corrective measures can be applied for the following operations, such as: reducing the feed rate percentage, increasing the percentage of spindle speed or reducing the axial depth per pass, etc.

Several parameters of cutting processes are recorded according to specific characteristics of the corresponding manufacturing process. The monitoring system is equipped with 2 Kistler 8152B118 Acoustic Emission Sensors, 2 accelerometer B & K4371 (XY), 1 accelerometer B & K4370 (Z), 1 Endevco 5253A-100 triaxial accelerometer, 3 Kistler 5011 amplifiers, 2 Kistler 5125B frequency amplifiers, 1 Nexus 2693 Amplifier and 1 Kistler Model 9257B triaxial piezoelectric Force Sensor. Nevertheless, the The main measured variable is the acceleration signal, specifically the RMS value of the accelerometer.

The most used index to characterize quality of manufactured parts related with the surface roughness is the roughness average, Ra that represents the arithmetic mean of the absolute ordinate values $G(w)$ within a sampling length (L) as follows:

$$Ra = \frac{1}{L}\int_{0}^{L} \left|G(w)\right| \, \mathrm{d}w$$

The unit of measurement of roughness is the micrometre (um), and, according to ISO:1302 4288:1996, machining processes are able to produce ranges of Ra from 0.006 um to 50um. This parameter is mainly used to monitor the production process, which may gradually change the surface due, for example, to the wear of the cutting tool. As Ra is an average, the defects on the surface do not have much influence on its results.

Once each manufactured part is finished, the surface quality is measured. Measures were captured by an Surfcom 130 Roughness Meter. This device brings a flexible and highly accurate metrology solution in surface analysis features, specifically developed for the optics industry, operates with micrometric accuracy.

2. Macromilling Dataset

Dataset ID: Macromilling_dataset_1

Dataset Title: Surface quality data in macro-milling process

Dataset description:

Workstation 1 (WS1) is The Deckel Maho DMC 75 V Linear high-speed machining centre (Figure 2) is a vertical CNC machining centre with high speed linear drives in 3 axis and in double column design for high precision work. The table moves only in x axis and allows a comfortable loading of heavy workpieces. The main features are 750 x 560 x 600 mm working region. 1000 kg max. table load and 18000 rpm max. spindle speed. The Computerized numerical control is a Siemens 840D.
Data correspond to milling process of 170 x 100 x 25 aluminium AL7075-T6 (UNS A97075) work pieces that were used with hardness ranging from 65 to 152 Brinell. This material is commonly used in automotive and aeronautical applications. Roughness labels may be allocated according to the average value of surface roughness (um) defined in ISO:1302 (2002), as follows: Mirror (0.10, 0.25), Polished (0.25, 0.35), Ground (0.35, 0.75) and Smooth (0.75, 1.50).

Each column of the dataset has stored the following cutting parameters: the resulting acceleration applied to all directions of cutting plane (*AcelR*, RMS value in m/s^2), feed per tooth (f_Z, mm/tooth), tool diameter (*diam*, in mm), the depth of cut (*ae*, in mm), material hardness (*HB*, in Brinells) and the type of geometry (geom, in mm). The average value of surface roughness, *Ra*, is available for each set of cutting parameters and measured variables. The dataset in CSV/TXT format has the following content: Number of input variables, Variable names separated by space, Number of output variables, Output variable names, Data number and Matrix of (number of input + output variables) x (number of data). After that, each column is used to represent the corresponding parameter/variable. The description is summarized in Table 2.

Column	Data Name	Definition
Column1:	*AcelR* [m/s^2]	Resulting acceleration applied to all directions of cutting plane.
Column2:	f_Z, [mm/tooth]	Feed per tooth (milling cutting tool)
Column3:	*diam* [mm]	Tool diameter.
Column4:	*ae* [mm]	Axial depth of cut during the milling.
Column5:	*HB* [Brinells]	Material hardness
Column6:	*geom* [mm]	Type of geometry (pockets and island).
Column7:	*Ra* [um]	RMS value of surface roughness.
Column6:	*geom* [mm]	Type of geometry (pockets and island).
Column7:	*Ra* [um]	RMS value of surface roughness.

Table 1. Variables and parameters of the macromilling dataset

Figure 1. Deckel Maho DMC 75 V Linear

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement № 952119. The herewith information reflects only the author's view. The European Commission is not responsible for any use that may be made of the information herewith included.