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Assignment 2 - Descriptive analytics for waterjet cutting

OPM 562 - Business Analytics: Applications of Artificial Intelligence for Data-Driven Decision Making

Deliverables: PDF file including figures and interpretations (max. 6 pages in total) **and** Jupyter notebook with explanations (markdown cells) and commented code cells used to generate the figures

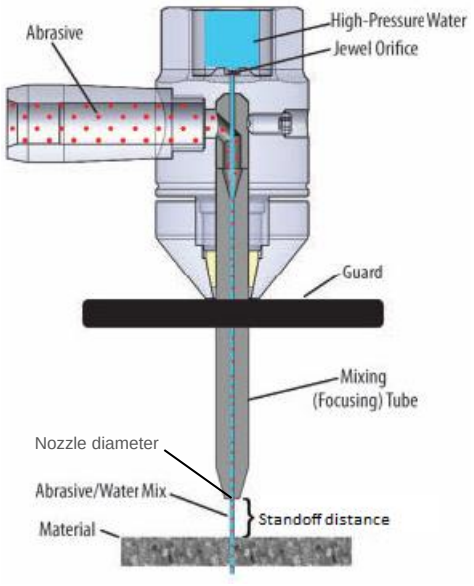
Deadline: March 24th, 2020, 23:59

Assignment Type: Individual

Total Points: 15

Water jet cutting is a technology for cutting a wide variety of materials using a very high-pressure jet of water. Cutting soft materials is possible using pure water jet. Adding abrasives to the water allows for cutting harder materials such as steel and concrete. Figure 1 depicts an abrasive water jet (AWJ) cutter in practice and a stylized sketch of it.

(a) An AWJ cutter



(b) AWJ mechanism

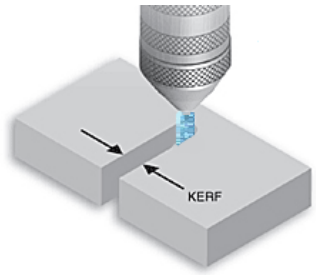
Figure 1: Abrasive water jet cutters in practice

One of the most important benefits of water jet cutting is that during the cutting process no heat is produced. Hence, the structure of the material is retained. In addition, only a very small amount of the material is wasted using this technology. Moreover, the water and the abrasives used for cutting the material can be recycled and reused.

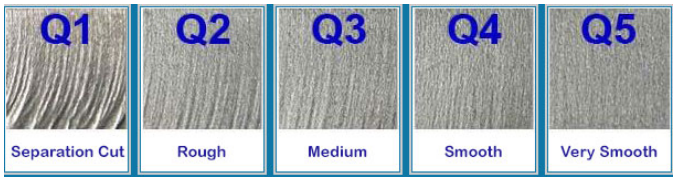
AIRMINIBUS uses AWJ cutting to cut metal pieces used in aircraft. Out of two types of metal sheets, namely *MTL1* and *MTL2* three part types *A*, *B* and *C* are produced which in total results in 6 different part numbers. The main difference between the two metal sheets is the thickness. The nominal thickness of MTL1 and MTL2 are 0.9 mm and 1.25 mm, respectively.

There are sensors connected to the machine which record the cutting parameters for every piece that is cut by the machine. These parameters include the standoff distance and the average traverse speed.

After performing the cut, the quality of the cut is checked at 5 critical points of the part. The average kerf width as well as the surface roughness are recorded for each part produced. The average kerf width is the average width of the material removed from the metal sheet (2a) and the surface roughness, Ra, determines how smooth the resulting surface is after the cut. Ra is the arithmetic average of the absolute values of the profile height deviations from the mean line and usually is measured in $\mu\mathrm{m}$. Figure 2b illustrates surfaces ranging from high Ra values (Q1) to very smooth surfaces with low Ra values (Q5).



(a) Kerf shaped after cutting a workpiece



(b) Surfaces with different Ra values

Figure 2: Quality measures of a cut

Based on the characteristics of the part being produced and the material used different nozzles and hence different nozzle diameters are used. The nozzle diameter used for the production of each part is also recorded during the operation of the machine.

In order to increase the accuracy of the machine and achieving the cutting parameters, maintenance is performed on a periodic basis.

The company has provided the data recorded by the machine for a period of 90 days of production. The data is stored in the file "waterjet_data.csv". Each of the 236549 rows of the dataset corresponds to single piece produced by the machine. The description of the columns of the dataset is as follows:

- **prod_day:** The day of production starting from 0, the first day of the 90-day period until 89, the last day of production.
- **part_type:** The type of product (A, B or C).
- **material:** The material used for the piece.
- **part_number:** The code used for the part.
- **thickness:** The average thickness of the metal sheet used, measured in mm.
- **nozzle_diameter:** The diameter of the nozzle used for production the piece, measured in mm.
- **standoff_distance:** The standoff distance measured in mm.

- **traverse_speed:** The average traverse speed of the machine during the production of the piece, measured in $\mathrm{mm/min}$.
- **kerf:** The average kerf width caused by the cut, measured in mm.
- **Ra:** Ra value of the resulting cut surface measured in $\mu\mathrm{m}$.

Task 1 **(15 Points in Total)**

The AIRMINIBUS company wants to improve its understanding of the AWJ machining process. Support this effort by conducting a descriptive analytics study. The study has to identify the main drivers of the quality measures in the AWJ cutting process performed in the company. Support your answer by suitable visualizations of the provided data and quantitative statistical measures.

If applicable, provide and explain ideas for future improvements of the process.