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EVALUATION OF DATA OF FLATNESS MEASUREMENT

SÁNDOR FEGYVERNEKI
University of Miskolc, Hungary
Department of Applied Mathematics
matfs@uni-miskolc.hu

FERENC NAGY
University of Miskolc, Hungary
Department of Applied Mathematics
matnf@uni-miskolc.hu

PÉTER RAISZ
University of Miskolc, Hungary
Department of Applied Mathematics
matrp@uni-miskolc.hu

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Abstract. The main point of the milling technology in this paper we are dealing with is that a horizontal rod - of the same breadth as the ingot – 'sits up' onto the highest point of the ingot, and at a given distance (depth) d the surface is milled down. The task to be solved is the determination of this distance d in such a way that the depth of the milling should be at least 8 mm even at the lowest point of the surface.

Keywords: aluminium alloys, depth of the milling

1. Introduction

From aluminium alloys so-called rolling ingots are made to be rolled. The profiles and lengths of the ingots are varied. One of the worst defects arising in the course of rolling is the surface blistering caused by the accumulation of unwanted elements. According to the standpoint of the majority of experts, this accumulation may occour to a higher extent on the surface of the ingots, thus the outer surface is to be removed. If this removal is not of the sufficient extent, then the chance of arising surface blistering is higher, while if the extent of the removal is exorbitant, then it cuts the output down substantially. The two ends and the sides are sawed off (by circular or endless saw), while on the sides of the largest surface the unwanted zone is removed by milling [3].

The main point of the milling technology is that a horizontal rod - of the same breadth as the ingot – 'sits up' onto the highest point of the ingot, and at a given distance (depth) *d* the surface is milled down.

The task to be solved is the determination of this distance *d* in such a way that the depth of the milling should be at least 8 mm even at the lowest point of the surface. The task is easier to understand when looking at the picture of the ingots waiting for measurement.

2. Measurement, Processing Data

Figure 1. Flatness measurement

The surface to be treated can be observed much better in Figures 2 and 3.

Figure 2. The face of an ingot

A zoomed part of this ingot is in Figure 3.

Measurements were performed on the surface of the ingots by a laser device. The accuracy of the measurements was 0.01 mm. There were two-two sequences of measurements for each of the 10 faces of 5 aluminum ingots, in 5 x 10 point per faces. The first sequence of measurements gave in five-five points transversely the vertical deviations with respect to the left-wing edge, while the second sequence lengthwise in ten-ten points the vertical deviations with respect to the first edge.

Figure 3. A zoomed part of the ingot **from Figure 2**

Table 1. Here are the data for one face of an ingot as an illustration

	Ingot **A** face *A*				
405 cm	-3.43	-0.64	-3.61	-1.86	-1.33
360 cm	-1.85	-1.3	-5.11	-1.83	-1.32
315 cm	-1.65	-1.21	-4.27	-3.02	-1.73
270 cm	-1.48	-1.24	-4.05	-2.84	-1.4
225 cm	-0.72	-0.34	-2.77	-1.73	-0.55
180 cm	0.07	0.25	-1.35	-0.82	0.22
135 cm	0.89	0.99	-0.01	0.34	1.03
90 cm	-3.3	1.36	0.71	1.01	1.62
45 cm	1.45	1.15	0.86	0.88	1.33
0 cm	0	0	0	0	0
	x0	**x1**	**x2**	**x3**	**x4**

The problem was to decide with a satisfactory safety, whether the present technology – the sensor of the milling machine is a rod laid on the peaks of the face – is able to ensure the required minimal milling depth (at least 8 mm).

Processing the data the following steps were performed:

1. The vertical deviations with respect to the first left-hand point were calculated.
2. The maximum of each row was determined.
3. The minimum of each face was calculated.
4. For each row the difference of the row-maximum and the face-minimum were calculated.

Thus the results for the previous face **A** of ingot *A* are the following:

Table 2. The calculated results for the previous face **A** of ingot *A*

Ingot A face *A*

					Row-max	absmin	difference
-3.43	-2.38	-4.4	-4.26	-2.66	-2.38	-7.78	5.4
-1.85	-3.94	-7.78	-4.69	-1.26	-1.26	-7.78	6.52
-1.65	-3.76	-6.95	-6.28	-2.23	-1.65	-7.78	6.13
-1.48	-4.18	-7.04	-6.57	-2.44	-1.48	-7.78	6.3
-0.72	-2.91	-5.71	-5.21	-1.39	-0.72	-7.78	7.06
0.07	-2.44	-4.19	-4.57	-0.82	0.07	-7.78	7.85
0.89	-1.28	-2.08	-2.89	0.91	0.91	-7.78	8.69
-3.3	-1.02	-1.94	-2.37	1.51	1.51	-7.78	9.29
1.45	-1.58	-1.8	-2.39	0.94	1.45	-7.78	9.23
0	-2.58	-2.67	-2.87	-0.79	0	-7.78	7.78

It is to be mentioned that in the above model the row-max was chosen from the 5 measured data, while the face minimum was chosen from the 50 measured data. Thus the actual deviation is somewhat greater, but a more precise estimation could be reached only by a much more time-consuming and more expensive sequence of measurements. Both the experience and the photos of the ingots support the supposition of the independence of these data. Therefore we considered them as the elements of a sample (VAR1) [2].

VAR1

5.400	6.520	6.130	6.300	7.060	7.850	8.690	9.290	9.230
7.780	7.090	6.420	7.970	6.440	6.170	5.860	5.680	5.150
6.010	7.460	5.160	4.640	4.600	4.430	4.240	4.030	3.800
3.870	4.290	5.210	4.000	4.710	4.910	5.350	5.580	6.080
6.330	6.320	6.080	4.960	4.400	5.210	4.690	4.820	4.560
4.000	4.530	4.140	4.580	5.450	4.510	4.470	4.800	5.260
5.730	6.320	6.870	7.080	6.950	6.240	3.740	4.940	4.970
5.050	5.310	4.760	3.690	3.780	4.480	5.270	5.100	4.950
5.200	5.400	5.790	6.360	6.840	7.040	6.890	6.210	3.250
3.640	4.090	4.250	4.550	5.090	5.260	5.310	5.830	5.380
3.260	2.620	2.850	3.230	4.190	3.370	3.730	4.240	4.410
4.990								

3. Statistical Results

Since at the beginning of the machining the measuring rod sits onto the maximum point of the first edge and even from the lowest point 8 mm milling is required, thus VAR1 can be treated as 100 ingot-faces.

Some of the descriptive statistics of sample VAR1 by Statistica for windows 9 [2]:

Sample size	100	
Mean	5.310100	
Confidence interval (95%)	5.046214	5.573986
Median	5.155000	
Minimum	2.620000	
Maximum	9.290000	
Range	6.670000	
Lower quartile	4.420000	
Upper quartile	6.190000	
Quartile range	1.770000	
Variance	1.768700	
Standard deviation	1.329925	
Skewness	0.681855	
Kurtosis	0.575884	

On the basis of these statistics and considering the histogram, we performed tests for distribution fitting for normal (Gaussian), lognormal, gamma, extreme value and Weibull distributions [1].

Using χ^2-test for the distribution fitting for lognormal distribution, the value of the χ^2-statistic is 2.246493, with degree of freedom 8. For the other plausible distributions the χ^2-statistics are greater.

Considering the density histogram, the above statistics and the χ^2-test, we can consider the sample VAR1 as of lognormal distribution [2].

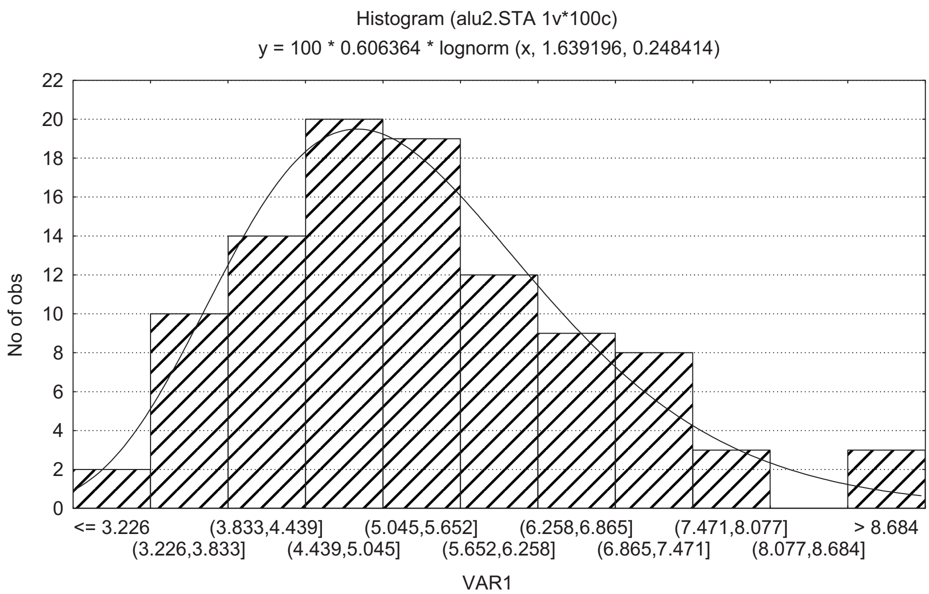

Figure 4. The frequency histogram was made using Statistica for Windows

The practical consequence of this statement can be demonstrated by some examples [2]:

If the distance of the measuring rod and the face-minimum is supposed to be 9 mm, then it will be right in 98.76 % of the cases.

If the distance of the measuring rod and the face-minimum is supposed to be 8 mm, then it will be right in 96.18 % of the cases.

If the distance of the measuring rod and the face-minimum is supposed to be 7 mm, then it will be right in 89.15 % of the cases.

Approaching the situation from the point of view of reliability, we get the following values.

To get a 99% reliability, the distance of the measuring rod and the face -minimum should be supposed to be 9.180 mm,

To get a 98% reliability, the distance of the measuring rod and the face -minimum should be supposed to be 8.580 mm,

To get a 95% reliability, the distance of the measuring rod and the face -minimum should be supposed to be 7.751 mm,

To get a 90% reliability, the distance of the measuring rod and the face -minimum should be supposed to be 7.082 mm,

Subsequently seven sequences of measurements were performed – under various conditions – and the measured data fully supported the abovementioned inferences [1].

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REFERENCES

[1] FEGYVERNEKI, S.: *Robust estimators and probability integral transformation*, Math. Comput. Modelling, 38, (2003), pp. 803-814.

[2] JOHNSON, J. L.: *Probability and Statistics for Computer Science*, Wiley New York, 2008.

[3] FEGYVERNEKI, S., RAISZ, P.: *Sampling from delivered scrap, Report* (in English) - ALCOA-KÖFÉM Kft. Öntöde Üzletág, (2008), pp.1-29.