# STUDY OF ACCURACY OF THE THICKNESS OF FINISHED PRODUCTS SUBJECT PROCESSING DRAWING

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***Abstract:*** *In this paper is analyzed the accuracy of thickness of various products used in the processing type cupping of small cylindrical pieces, because of their influence on the thickness variation coefficient of thinning and the value of cupping forceThis explains the different values of the cupping force recorded experimental in comparison with those resulting from the simulation with FEM or by using the relations in literature.*

***Keywords:*** *The average values of the limits of the class; the absolute frequency of the class; the relative frequency of the class, the frequency histogram to the thickness of blank tape*

## INTRODUCING

Processing cupping of cylindrical parts (fig. 1) in steel and brass bands (fig. 2) are a result of different values of cupping force, which have been determined by simulation with FEM, experimental and using the relations in literature.

Figure 1: Small cylindrical parts made by cupping

with and without willful thinning of sheet thickness

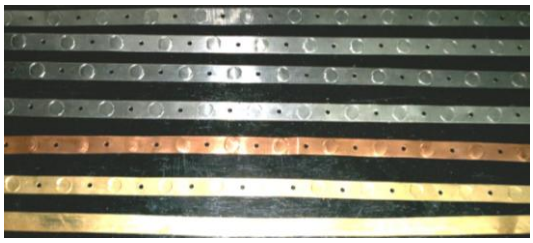


Figure 2: The semi-manufactured goods band type steel and brass

These are presented in table 1 the values resulting from drawing forces experimental tests, from the calculation of the relations of literature and of simulation with FEM for steel bands and in table 2-those obtained from brass band[1].

Table 1. Cupping forces values resulted from experimental tests, from the calculation of the relations of literature and simulation with FEM for steel bands

| The nr. of experiment | CuZn30-O | | |
|---|---|---|---|
| | Experimental | Calculation | Simulation |
| 1. | 339,48 | 258,34 | 149,04 |
| 2. | 248,22 | 209,8 | 183,61 |
| 3. | 483,07 | 357,5 | 245,84 |
| 4. | 212,31 | 180,7 | 149,04 |
| 5. | 276,67 | 242,5 | 193,35 |
| 6. | 454,6 | 324,2 | 203,03 |
| 7. | 205,28 | 155,3 | 139,02 |
| 8. | 253,19 | 201,9 | 178,72 |
| 9. | 125,21 | 141,7 | 168,89 |

Table 2. Cupping forces values resulted from experimental tests, from the calculation of the relations of literature and of simulation with FEM for brass band

| The nr. of experiment | The cupping force [daN] | | | | | |
|---|---|---|---|---|---|---|
| | A3k | | | A5 | | |
| | Experimental | Calculation | Simulation | Experimental | Calculation | Simulation |
| 1. | 225,56 | 191,2 | 168,89 | 361,32 | 292,6 | 173,8 |
| 2. | 351,71 | 303,9 | 245,84 | 317,29 | 285,6 | 236,4 |
| 3. | 774,87 | 485,7 | 296,47 | 498,64 | 413,8 | 273,7 |
| 4. | 258,08 | 218,5 | 178,72 | 208,88 | 185,0 | 168,9 |
| 5. | 381,12 | 327,8 | 245,84 | 377,74 | 311,4 | 236,4 |
| 6. | 556,02 | 366,2 | 245,84 | 302,29 | 281,7 | 245,8 |
| 7. | 239,75 | 215,7 | 168,89 | 199,69 | 162,6 | 159 |
| 8. | 397,66 | 320,5 | 236,43 | 351,8 | 304,1 | 222,2 |
| 9. | 180,59 | 202,3 | 217,44 | 155,06 | 171,8 | 188,5 |

The study included nine experiences, of which the first six have supposed to consider of thinning processing by drawing with different values of the coefficient of cupping and thinning, and the other three correspond to drawing without thinning and different values of the coefficient of drawing.

The drawing forces values obtained experimentally are certainly influenced by variations in thickness, which in turn influences the coefficient of thinning. The values obtained by drawing simulation with FEM or by calculating the relationship of literature are not affected by these variations in the thickness of semi-manufactured goods. Therefore a study was made for the determination the accuracy of the blank tape thickness with width B = 20mm and thickness g = 0.4 mm.

**STUDY OF THE ACCURACY OF THE THICKNESS OF HALF-FINISHED BAND**

For the study of the accuracy of the blank thickness were built frequency histograms of the thickness of the bands [2] for three materials subject to deformation.In table 3 were recorded by the thickness values in the form of an ascending string and frequency. The measurements were made using a indicating micrometer accuracy 0,002 mm.

The sequence amplitude values are calculated with relation ([3], [4]):

$$R = x_{max} - x_{min} = 0{,}054. \quad (1)$$

The amplitude R is divided into a number of classes k (ranges) of equal size, which is determined with the help of his relationship Sturges:

$$k = 1 + 3{,}322 \cdot \log n, \quad (2)$$

where n - number of measurements, equal to 31. Get k = 5,9543.

The amplitude of the class will be:

$$a = R / k = 0{,}009. \quad (3)$$

He has compiled frequency table 4, where it was passed: $x_{ci}$ - mean values of class boundaries; $f_i$ - absolute frequency of the class; $p_i$ - the relative frequency of the class

Table 3. The blank tape thickness values A5 in [mm]

| | | | | | | |
|---|---|---|---|---|---|---|
| The thickness, $x_i$ | 0.401 | 0.402 | 0.405 | 0.409 | 0.41 | 0.412 |
| The frequency, $m_i$ | 1 | 1 | 1 | 1 | 1 | 1 |
| The thickness, $x_i$ | 0.415 | 0.417 | 0.419 | 0.423 | 0.425 | 0.426 |
| The frequency, $m_i$ | 2 | 1 | 2 | 1 | 3 | 3 |
| The thickness, $x_i$ | 0.428 | 0.43 | 0.435 | 0.436 | 0.44 | 0.455 |
| The frequency, $m_i$ | 3 | 4 | 1 | 2 | 2 | 1 |

Table 4. Frequency table of values for the thickness of the band A5

| Class number | Class range | | $x_{ci}$ | $f_i$ | $p_i = f_i / n$ | $\Sigma p_i$ |
|---|---|---|---|---|---|---|
| | on | to | | | | |
| 1. | 0.401 | 0.410 | 0.4055 | 4 | 0.1290 | 0.1290 |
| 2. | 0.410 | 0.419 | 0.4145 | 5 | 0.1612 | 0.2903 |
| 3. | 0.419 | 0.428 | 0.4235 | 9 | 0.2903 | 0.5806 |
| 4. | 0.428 | 0.437 | 0.4325 | 10 | 0.3225 | 0.9032 |
| 5. | 0.437 | 0.446 | 0.4415 | 2 | 0.0645 | 0.9032 |
| 6. | 0.446 | 0.455 | 0.4505 | 1 | 0.0322 | 1 |

Using the data in table 4 was obtained the frequency histogram (Figure 3).

Statistical parameters were determined:

- the average value $\overline{X}$, which characterizes the central tendency of concentration of values,

$$\overline{x} = C + \frac{\sum_{i=1}^{k}(x_{ci} - C)\cdot f_i}{n} \quad (4)$$

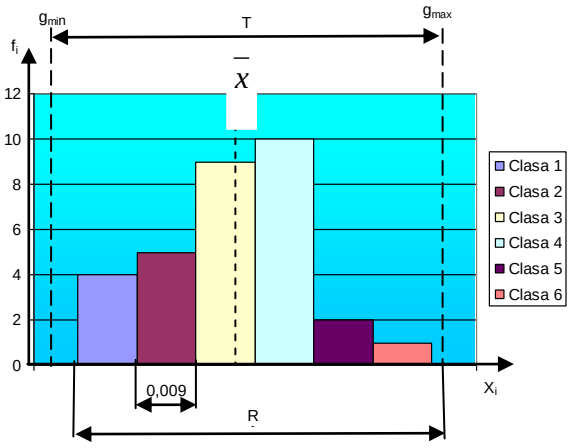
where: C-thickness value with maximum frequency. Was obtained $\overline{X}$ = 0.4246.

- the dispersion σ, estimated with the index S were calculated using Bessel's relationship, which shows a tendency to increase the thickness of the scattering from the central value $\overline{X}$,

$$S^2 = \frac{1}{n-1}\cdot\sum_{i=1}^{k}\left(x_i - \overline{x}\right)^2 \cdot m_i, \quad (5)$$

$$S = \sqrt{S^2}$$

Was obtained S = 0,012.



$g_{min}$ = 0,35, $g_{max}$ = 0,45, n = 31, $\overline{X}$ = 0,4246, S = 0,012

Figure 3. Frequency histogram of band tape thickness A5

The thickness of the band of the A5 is 0.4 ± 0,05 mm [5]. Analyzing the frequency histogram thickness can be drawn the following conclusions:

1) appearance of its peak position histogram leading to her engagement at the kind of asymmetrical shape positive[3];
2) measured values characterized by the highest frequencies are close to the average value, which shows a tendency of grouping around the mean of these values;
3) position limits in relation to histogram field tolerance (T) indicates that the settling process of rolling sheet, from which it was cut, was achieved by the maximum amount of thickness. The amplitude of the histogram is included in the field of tolerance and is easily moved to the right. This shows that it is necessary to a slight increase in the accuracy of the production process of the blank tape, which would lead to the situation R ⊂ T.

For the band A3K the measured thickness values sequence is presented in table 5. Quantities deduction R = 0,101 , k = 6,49 = 0,015 allowed the construction of table 6 frequency values of the thickness, which allows to obtain the frequency histogram in Figure 4. Have been calculated: $\overline{X}$ = 0,4382; S = 0,028.

Table 5. The blank tape thickness values A3K în [mm]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| The thickness, xi | 0.404 | 0.405 | 0.406 | 0.409 | 0.41 | 0.417 | 0.418 | 0.419 |
| The frequency, mi | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| The thickness, xi | 0.420 | 0.421 | 0.424 | 0.425 | 0.429 | 0.438 | 0.440 | 0.441 |
| The frequency, mi | 3 | 1 | 3 | 2 | 4 | 2 | 2 | 3 |
| The thickness, xi | 0.445 | 0.448 | 0.451 | 0.453 | 0.456 | 0.458 | 0.463 | 0.468 |
| The frequency, mi | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| The thickness, xi | 0.477 | 0.486 | 0.492 | 0.499 | 0.505 | | | |
| The frequency, mi | 1 | 1 | 1 | 1 | 1 | | | |

Table 6. Frequency table of values for the thickness of the band A3K

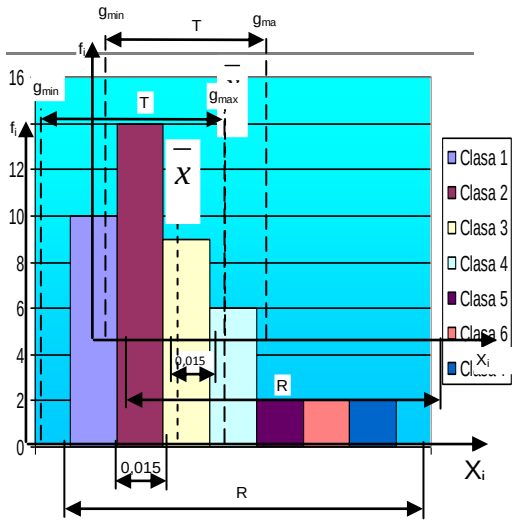
| Class number | Class range | | $x_{ci}$ | $f_i$ | $p_i$ | $\Sigma p_i$ |
|---|---|---|---|---|---|---|
| | on | to | | | | |
| 1 | 0.404 | 0.419 | 0.4115 | 10 | 0.2222 | 0.2222 |
| 2 | 0.419 | 0.434 | 0.4265 | 14 | 0.3111 | 0.5333 |
| 3 | 0.434 | 0.449 | 0.4415 | 9 | 0.2000 | 0.7333 |
| 4 | 0.449 | 0.464 | 0.4565 | 6 | 0.1333 | 0.8667 |
| 5 | 0.464 | 0.479 | 0.4715 | 2 | 0.0444 | 0.9111 |
| 6 | 0.479 | 0.494 | 0.4865 | 2 | 0.0444 | 0.9556 |
| 7 | 0.494 | 0.509 | 0.5015 | 2 | 0.0444 | 1.0000 |

Using the data in table 6 were obtained a frequency histogram (Figure 4).The thickness of the tread of the A3K is 0.4 ± 0,05 mm [5]. Analyzing the frequency histogram thickness can be drawn the following conclusions:

1) after the appearance of the histogram peak position is much closer to form "the chasm left" [3];
2) measured values characterized by the highest frequencies are close to the mean value;
3) position limits in relation to histogram field of tolerance shows that adjusting the rolling process of the sheet, from which it was cut, was achieved by the maximum amount of thickness. The amplitude of the histogram is included in the field of tolerance about half. This shows that it is necessary to increase the accuracy of the production process of the blank tape, leading to the R ⊂ T. S confirm a value relatively large scatter of measured values.

Figure 4.Frequency histogram of band tape thickness A3K

For the band CuZn30-O the sequence value thickness measured is shown in table 7. Determination of quantities R = 0,056, k = 6, = 0,009 allowed construction of frequency table thickness values (table 8), which allows to obtain the frequency histogram in Figure 5. Have been calculated: $\overline{X}$ = 0,4195; S = 0,0146 .




$g_{min}$ = 0,35, $g_{max}$ = 0,45, n = 45, $\overline{X}$ = 0,4382, S = 0,028

Table 7. The blank tape thickness values CuZn30-O în [mm]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| The thickness, xi | 0.395 | 0.398 | 0.401 | 0.402 | 0.405 | 0.408 | 0.409 | 0.411 |
| The frequency, mi | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 2 |
| The thickness, xi | 0.413 | 0.415 | 0.416 | 0.418 | 0.42 | 0.421 | 0.425 | 0.427 |
| The frequency, mi | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 |
| The thickness, xi | 0.428 | 0.431 | 0.433 | 0.435 | 0.439 | 0.445 | 0.448 | 0.451 |
| The frequency, mi | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Table 8. Frequency table of values for the thickness of the band CuZn30-O

| Class number | Class range | | $x_{ci}$ | $f_i$ | $p_i$ | $\Sigma p_i$ |
|---|---|---|---|---|---|---|
| | on | to | | | | |
| 1 | 0.395 | 0.404 | 0.3995 | 5 | 0.1563 | 0.1563 |
| 2 | 0.404 | 0.413 | 0.4085 | 6 | 0.1875 | 0.3438 |
| 3 | 0.413 | 0.422 | 0.4175 | 9 | 0.2813 | 0.6250 |
| 4 | 0.422 | 0.431 | 0.4265 | 5 | 0.1563 | 0.7813 |
| 5 | 0.431 | 0.44 | 0.4355 | 4 | 0.1250 | 0.9063 |
| 6 | 0.44 | 0.449 | 0.4445 | 2 | 0.0625 | 0.9688 |
| 7 | 0.449 | 0.458 | 0.4535 | 1 | 0.0313 | 1 |

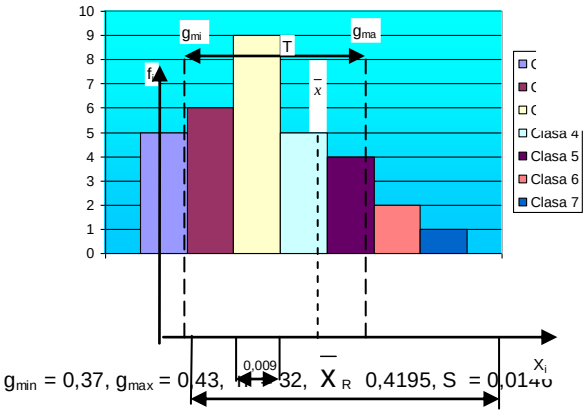



Figure 5.Frequency histogram of band tape thicknessCuZn30-O

The thickness of the band tape is a CuZn30 0.4 ± 0.03 mm [6]. Analyzing the frequency histogram thickness can be drawn the following conclusions:

1) after the appearance and position of histogram peak, it has an asymmetrical shape positive [3];
2) measured values characterized by the highest frequencies are close to the average value;
3) the histogram position in relation to the limits of the tolerance field shows that adjusting the rolling process of the sheet, from which it was cut, was achieved by the maximum amount of thickness. The amplitude of the histogram is included in the field of tolerance, at the rate of about 60%. This shows that it is necessary to increase the accuracy of the production process of the blank tape, leading to the R ⊂ T. S value justifies the scattering of measured values.

**CONCLUSIONS**

The final conclusion of this analysis is that variations in band thickness from 0,05 to 0,1 mm have influence on the coefficient of thinning. As a result, between the deep drawing forces values obtained experimental and those obtained by simulation and calculation differences appear.

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