STUDIES REGARDING THE CALCULATION OF SLIDING FIT DIMENSION CHAIN

S.l.dr.ing. Constanța **Rădulescu**
Prof.univ.dr.ing. Liviu Marius **Cîrțînă**
Faculty of Engineering"Constantin Brâncuși" University of Tg-Jiu,
radulescu@utgjiu.ro; cirtina@utgjiu.ro

Abstract: *This paper presents a case study regarding the determination of a dimension chain consisting in the case of a sliding fit of a guide column and a bushing guide of a die. It also presents the distribution of the chain elements tolerances values, their standard deviation and output probabilities values for the studied values. Data processing was made with a PQRS statistic program.*

Key words: dimension chain, tolerance, standard deviation

1.INTRODUCTION

The allocation of a part dimensional tolerances is a special matter because it influences both the good operation of the assembly and its execution cost. When we refer to the production cost of a part, we have to consider several determining factors, that is: the production process, material, thermal and chemical treatments, part size, part dimensional tolerances, etc.

When we refer only to the size of dimensional tolerances of a revolution part, they are rendered in tables in the specialized literature (the case of shafts and bores). Even if these values have been determined at industrial scale, they are not the optimal ones.

The specialized literatures presents charts where the value of the execution index cost increases along with the decreases of the part execution class (fig1). This is normal because we know that allocating restricted tolerances requires more complex processing operations, and implicitly leads to the increase of production costs.

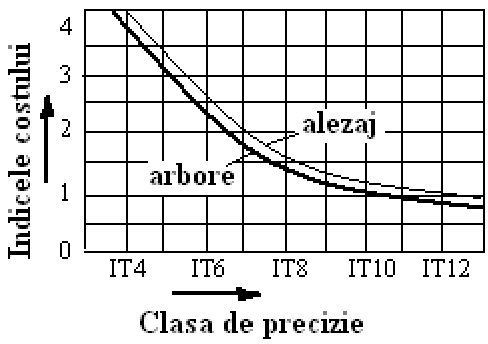

Fig.1. *Production cost index depending on the precision class.*

In order to see the importance of the part execution tolerance, the case of shafts can be discussed. In general, the specialized literature presents us simpler cases when the shaft and bore form a clearance fit. But we have to study the cases of tight fits and medium fits.

2.DETERMINING THE CALCULATION OF DIMENSION CHAINS FOR A SLIDING FIT

It is known that the tolerances of parts dimensions presented in the execution drawing have to coincide with the real tolerances determined as a result of measurements made. It is always desired that the measured dimension, and implicitly its deviations be within the ranges of the provided tolerance field, in this case we speak about permissible deviations or conformities. But there are cases when the measured dimension is not in the tolerance field and then we are speaking of non-permissible deviations or non-conformities, and therefore parts are rejected (fig.2).

If we consider a normal distribution of the measured dimensions of a sample for determining parts non-conformities we can be in one of the following cases:

- If measured values have values very close to the provided limit values (upper, lower) there

is a high probability of accepting these non-conformities parts P≥90%. In this case, these non-conformities have the name of AQL acceptable quality level;

- If measured values are far from the limiting values, there is a small possibility for accepting

these non-conformities parts, P<10%. In this case, these non-conformities have the name of LQ quality limit LQ.

Starting from this idea, we will study the case of the dimension chain formed in a fit. It is known that the dimension chain of a fit generally consists of three elements: increasing element (bore), reducing element (shaft) and closing element.

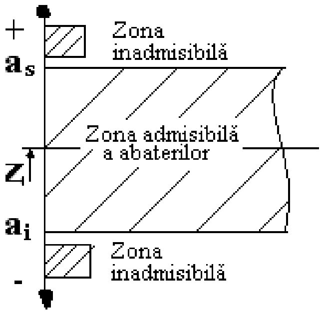

Fig.2. *Tolerance field areas*

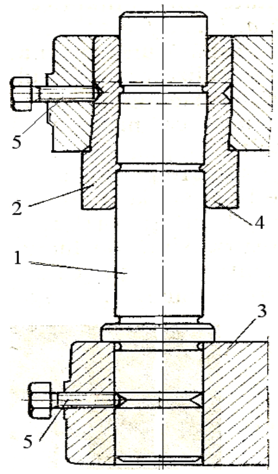

Fig.3. *The fit between a guide column and a bushing guide of a die*

This paper will study the case of a sliding fit of a guide system. The guide system consists of a guide bushing and a guide column of a die. The guide column has a cylindrical tail and a support collar. Along with the guide bushing it forms a sliding fit H7/h6. The fit dimension will be Ø50 H7/h6.

For the guide column:

Ø50 h6($^{0}_{-0,016}$), therefore: Li=49,984mm, Lm=49,992mm, Ls=50,000mm and T_d=0,016mm.

For the guide bushing:

Ø50 H7($^{+0,025}_{0}$), therefore: LI=50,000mm, LM=50,0125mm, LS=50,025mm and T_d=0,025mm

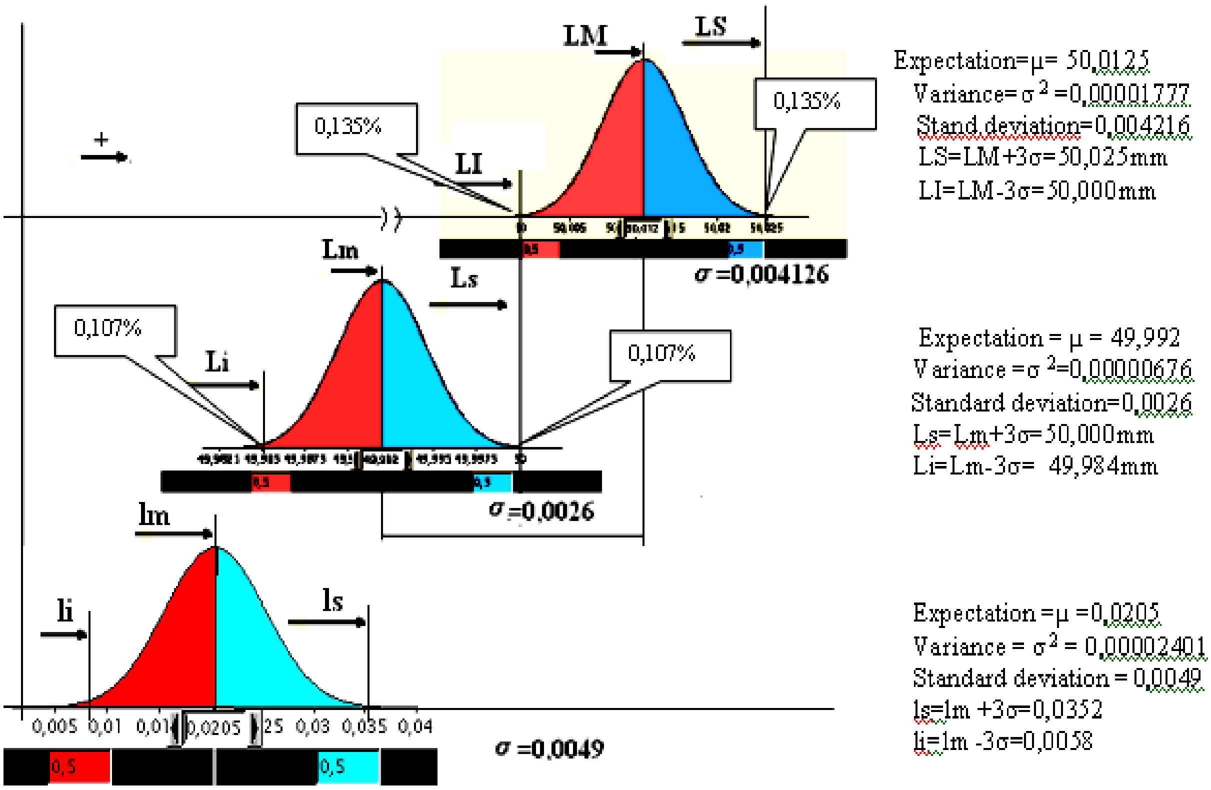

Fig.4. *Initial values distribution.*

In order to see the importance of the part execution tolerance, we can discuss the case of fits. In general, the specialized literature presents us simpler cases when the shaft and bore form a clearance bore. We have to study the cases of tight fits and intermediary fits when dimensions overlap.

It is known that the tolerances of a part dimensions, presented on the execution drawing have to coincide with the real tolerances determined as a result of the measurements made. We always want that the measured dimension be within the ranges of the tolerance field.

In this case, the dimension chain consists of three elements: increasing element and decreasing element (rated dimensions of the column and bushing) and closing elements. The upper and lower values of the closing element are the value of minimal and maximal clearance of the sliding fit discussed. In this case we will get:

$$J_{\min} = D_{\min} - d_{\max} = 50,000 - 50,000 = 0,000mm$$

$$J_{\min} = D_{\max} - d_{\min} = T_D - T_d = 0,025 + 0,0,016 = 0,041mm$$

Outputs probability for the minimal and maximal dimensions of the shaft and bore are determined as follows:

- For the bore:

- At the upper limit

$$u_s = \frac{X_S - X_M}{\sigma_1} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00135, which means that p=0,135%;

- At the lower limit:

$$u_i = \frac{X_I - X_M}{\sigma_1} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00135, which means that p=0,135%;

- For the shaft:
  - At the upper limit

$$u_s = \frac{X_s - X_m}{\sigma_2} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00107, which means that p=0,107%;

- At the lower limit:

$$u_i = \frac{X_i - X_i}{\sigma_2} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00107, which means that p=0,107%.

In this case, for the closing element between the shaft and bore, which have the rated dimension equal to 0, the standard medium deviation is calculated using the relation:

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2} = \sqrt{[illegible]^2 + [illegible]^2} = [illegible]$$

The reduction factor for normal distribution will be:

$$r_{DN} = \frac{[illegible]}{[illegible]} = [illegible]$$

If we consider the reduction factor and we consider the same value of the square average deviation for the two elements of the dimension chain, then the distribution curves with their related values are presented in figure 5.

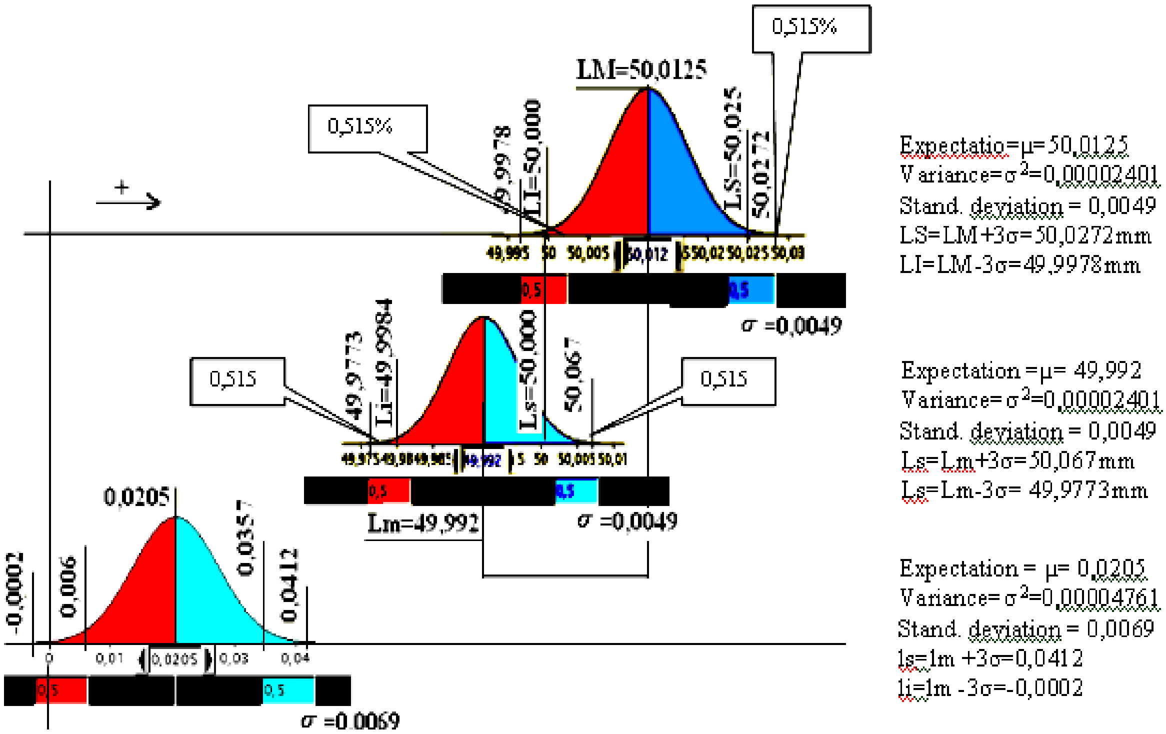

Fig.5. *Final values distribution.*

Outputs probability for the minimal and maximal dimensions of the shaft and bore are determined as follows:

- For the bore:
  - At the upper limit

$$u_S = \frac{X_S - X_M}{\sigma} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00539 which means that p=0,539%;

  - At the lower limit:

$$u_I = \frac{X_I - X_M}{\sigma} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00539, which means that p=0,539%;

- For the shaft:
  - At the upper limit

$$u_s = \frac{X_s - X_m}{\sigma} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values 0,00515, which means that p=0,515%;

  - At the lower limit:

$$u_i = \frac{X_i - X_i}{\sigma} = \frac{[illegible]}{[illegible]} = [illegible],$$

the specialized literature chooses the values of 0,00515, which means that p=0, 515%.

In this case, for the closing element between the shaft and the bore, which has the rated dimension 0, the standard medium deviation is calculated using the relation:

[illegible]

The deviations of this element are therefore determined:

$$ls = lm + 3\sigma = 0{,}0412mm$$

$$li = lm - 3\sigma = -0{,}0002mm$$

after determining all the elements and their related deviations, the related conclusions can be drawn.

3.CONCLUSIONS

As we can see in fig.3, values spreading, both for shafts and for bores, is made according to a normal distribution with the standard deviation for bores σ=0,004126 and for the shaft σ=0,0026. In this case, the closing element of the dimension chain has a normal distribution curve, with the standard deviation of σ=0,0049, and the value of the tolerance field middle point of the closing element is lm=0,0205mm.

All the three elements of the dimension chain are within the admitting limits. The output probabilities percentage is very small, which means that the siding fit is complied with, and the percentage of non-conformities is also very small.

In fig. 4, we notice that values spreading is made according to a normal distribution with the standard deviation σ=0,0049 both for bores and for shafts. In this case, the closing element of the dimension chain has a normal distribution chain, with a standard deviation σ=0,0069, and the value of the tolerance field middle point of the closing element is lm=0,0205mm. In this case all the three elements of the dimension chain regarding values spreading are not within the admitting limits. Outputs probability percentage is very low in this case as well, because the difference between the calculated limitations and the real limitations is very small to the order of thousands. Nonetheless, outputs probability for this case increases and there is the possibility that a sliding fit transform into tight fit.

REFERENCES.

1. Dumitraș, C. – Dies and matrices made of modulated elements, Technical Press, Bucharest, 1980.
2. Liviu-Marius Cirtina, Constanta Radulescu - Effects of Measuring Uncertainty over the Quality of the Products - WSEAS International Conference on MANUFACTURING ENGINEERING, QUALITY and PRODUCTION SYSTEMS, Transilvania University of Brasov, Romania, April 11-13, 2011
3. Liviu Marius CÎRȚÎNĂ, Constanţa RĂDULESCU- Researches regarding the determination and optimization of dimension chains in the case of the direct problem, Reliability and Durability Magazine, Supplement, no 1/ 2010, pag. 85, "Academica Brâncuşi" Press, Târgu Jiu, ISSN 1844 – 640X.
4. Gunter Kirschling, - Quality assurance and tolerance, Springer-Verlag Berlin Heidelberg 1991.
5. http://members.home.nl/sytse.knypstra/PQRS/