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THE APPLICATION OF 'TARGET VALUE' THEORY TO ACHIEVE INDUSTRIAL EXCELLENCE OBJECTIVES

Abstract: *The "target value" theory is a concept promoted in the field of mechanical engineering that can bring important benefits for the correct calibration of product quality that is perceived much better if the 6σ deviation and $\overline{X}$ deviation are minimized for a parameter value given by its target value. Through this work we aim to perform an exhaustive analysis and concrete experiments of this concept with the goal of achieving the Industrial Excellency's targets. For the case studies concrete measures and specifications are suggested. The viewpoint approached in this paper brings an extra value in orienting the technological processes and equipments with a view to achieving the products' quality and competitiveness.*

Key words: *mechanism, quality, tolerances, Target Value, 6σ, Industrial Excellency.*

1. INTRODUCTION

The Industrial Excellency (*IE*) means the achievement of two targets: profit for the producer and total contentment for the beneficiary [1].

The profit is obtained by adjusting the product to the specific market's requirements, by increasing the quality and diversification, shortening the delivery time limits and reducing the prices.

The client's contentment will be expressed by appreciating the product, showing loyalty towards the producer.

"*Target Value*" *theory -TVT* reflects Taguchi concept that defines, analyses and measures the quality in an unexpected manner by calculating the losses for society produced by this parameter's variations (deviations) given a nominal value; the quality loss begins from the moment in which the product is delivered to the beneficiary and it is quantified by costs that are directly proportional to the deviation (deflection) size of the discussed parameter given the target value. This concept considers the parameter's nominal value as an ideal value or *target* value [1], [10].

This is one of the sensitive elements that may cause errors during the entire life of the analyzed product. This means that the *TVT* application in the mechanical engineering field without a special analysis and an explanation of used terms, may lead to serious interpretation errors and, implicitly, to designing errors [1], [2].

The *sensitive* elements of this concept will be apprehended in the paperwork that, by their interpretation inadequate to the field, may cause errors and mistakes in the designing, processing or control of surfaces generated by machine tools.

This paperwork proposes to analyze the implications of implementing this quality concept in the dimensional accuracy and ISO fittings field.

Concrete measures and specifications will be suggested which allow the *TVT*'s correct application in the mechanical engineering field.

2. SOME ASPECTS ABOUT *TVT*'S ADAPTATION TO THE SPECIFIC TERMINOLOGY OF MECHANICAL ENGINEERING

The errors sources, called *"sources of noise"* which come into the manufacturing process and during the entire economic life, will not disturb the projected quality of the product. The target value is often imposed by client's exigencies and the competition on the specific market.

TVT can be represented by the *L(y)* function represented as in Figure 1a and the equation of *TVT* may be written under the following form [1], [10]:

$$L(y) = K(y-m)^2 \qquad (1)$$

where: $L(y)$ is the loss produced by the value deviation of the parameter compared with the target value and, implicitly, it represents the cost of this loss; m the *target* value of the parameter; y is the achieved value of the analyzed parameter; K the sole constant value for each analyzed parameter and which reflects the economical loss encountered by the client due to the parameter (product)'s deviation from the target value m.

The specialized literature [1], [7] recommends the K:

$$K = A_0 / \Delta_0^{\ 2} \qquad (2)$$

where: Δ_0 is the half functional tolerance or the client's tolerance; the exceeding of this tolerance is apprehended by the client as a "*non-quality*" and "*non-comfort*" element given the product; A_0 is the client's loss generated by the exceeding of the functional tolerance.

We apprehend a second "sensitive" element of TVT concept; in the specialized literature [1], [10], Δ_0 (Figure 1) is presented as the functional tolerance. In accordance with the plotting of Figure 1 and the theory of tolerances regulation, Δ_0 is, actually, an allowable limit deviation or it may be deemed as half of functional tolerance of the parameter (size) under consideration.

This analysis will lead to diminishing the client's losses (A_0) by additional expenses A from the producer and by establishing a safety tolerance called as *production tolerance* Δ smaller than Δ_0; the size of Δ is established starting from the *TVT* equation (1).

The relation (1) becomes:

$$L(y) = A = K(y-m)^2 \tag{3}$$

It is deemed: $K = A_0 / \Delta_0{}^2; \Delta = y-m;$

The relation (3) becomes:

$$L_y = A = \frac{A_0}{\Delta_0^2}\Delta^2 \tag{4}$$

where: A is the producer's expense to find adequate technical-constructive and technologic solutions as the product's parameters be integrated as well as possible with the production tolerance Δ; A_0, Δ_0 have the same meaning as for the equation (2).

In accordance with the relation (4), the production tolerance will be:

$$\Delta = \Delta_0\sqrt{\frac{A}{A_0}} \tag{5}$$

In Figure 1b it was drawn the *TVT* graphic which is adapted to the specific concepts ISO fittings field taking care about precision parameters meet in mechanical engineering field.

This paper goes further and differentiates the *error concept* in: processing error - ε_p and measurement error - ε_m and includes them in the *TVT* equation.

The processing error ε_p will be defined as the algebraic difference between the achieved dimension d_r and the *target value* dimension d_t:

$$\varepsilon_p = d_r - d_t \tag{6}$$

Therefore, relation (1) becomes:

$$L(y) = K(d_r - d_t)^2 = K\,\varepsilon_p^2 \tag{7}$$

where: K has the same meaning as shown in relation (2); d_r is the achieved dimension; d_t is the theoretical or the *target* dimension; ε_P is the processing error of the deemed size. Relation (2) becomes:

$$K = A_0 / 1/2t_f{}^2 \tag{8}$$

where: A_0 has the same meaning as shown in relation (2); t_f is the functional tolerance.

On the basis of the relation (3), the relation (4) becomes:

$$L_y = A = \frac{A_0}{t_f^2}t_p{}^2 \tag{9}$$

where: A and A_0 have the same meaning as shown in relations (3) and (4); t_f is the functional tolerance; t_p is the production tolerance; the relation (5) becomes:

$$t_p = t_f\sqrt{\frac{A}{A_0}} \tag{10}$$

For determining the production tolerance t_p it may be also used the relation recommended by the specialized literature [6]:

$$t_p = t_f - 2\,\varepsilon_m \tag{11}$$

Measurement error is defined like an algebraic difference between the effective dimension d_{ef} and the achieved dimension d_r:

$$\varepsilon_m = d_{ef} - d_r \tag{12}$$

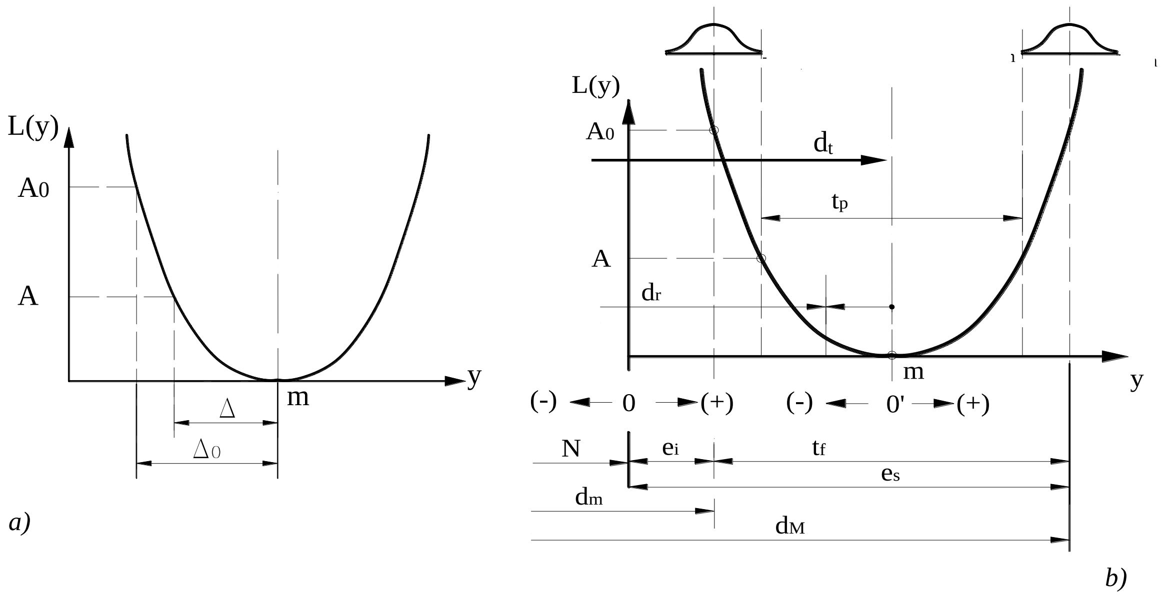

Figure 1 TVT adapted to the specific concepts of the dimensional accuracy and ISO fittings field; a) general presentation; b) adapted presentation.

The effective dimension d_{ef} is emphasized by measurement. Consequently, its value will depend on the error that accompanies the chosen control means. The specific error of each control is called measurement error ε_m that depending on the producer's exigencies; ε_m may determine the production tolerance t_p (Figure 1,b) and it is recommended to not exceed 5…10% of the functional tolerance t_f [6], [7]. In conformity with relation (12) the equality between d_{ef} and d_r is possible if the measurement errors ε_m aim to zero that is an ideal target, almost impossible in the real conditions.

3. CASE STUDY

The conformity of *TVT* quality model applied in mechanical engineering field and in compliance with those above-mentioned, in Figure 2 there are shown four possible cases for achieving a parameter.

Case 1. It has as characteristic the dispersion field of processing errors $6\sigma_1$ equal to the prescribed tolerance *t* and $\overline{X}_1$ equal to *Vmed*. In this case, the achieved parameter complies with the *t* tolerance and with the acceptable limit values *Vm* – minimum value and V_M- maximum value. Thus, a relatively large number of effective values *Vef* of the achieved parameter have different values from the target value *m*. In other words, the processing errors ε_p have a great value, not acceptable according to *TVT* theory.

The processing error will be:

$$\varepsilon_p = Vef - Vmed \tag{13}$$

where: ε is the processing error; *Vef* – the effective value of the parameter, achieved during the manufacturing process and made evident by measurement; *Vmed* – the prescribed medium value (the target value).

The quality loss of the product will depend on the square error ε_p, according to the relation (7):

$$y = f(x) = K\,(Vef - Vmed)^2 = K\varepsilon_p^{\,2} \tag{14}$$

Case 2. It has as characteristic $6\sigma_2$ less than *t* and $\overline{X}_2$ equal to *Vmed*. In this case, the achieved parameter has effective values *Vef* around the target value *m* with a much more share. Thus, the quality loss according to the relation (7) and (14) is much smaller and complies much better with the *TVT* requirements.

Case 3. It has as characteristic $6\sigma_3$ less than t, but $\overline{X}_3$ is different from Vmed. In this case, the achieved parameter has effective values Vef estranged from the target value with a very large share. Consequently, the quality loss according to the relation (14) is big and it complies neither with the t tolerance nor the TVT

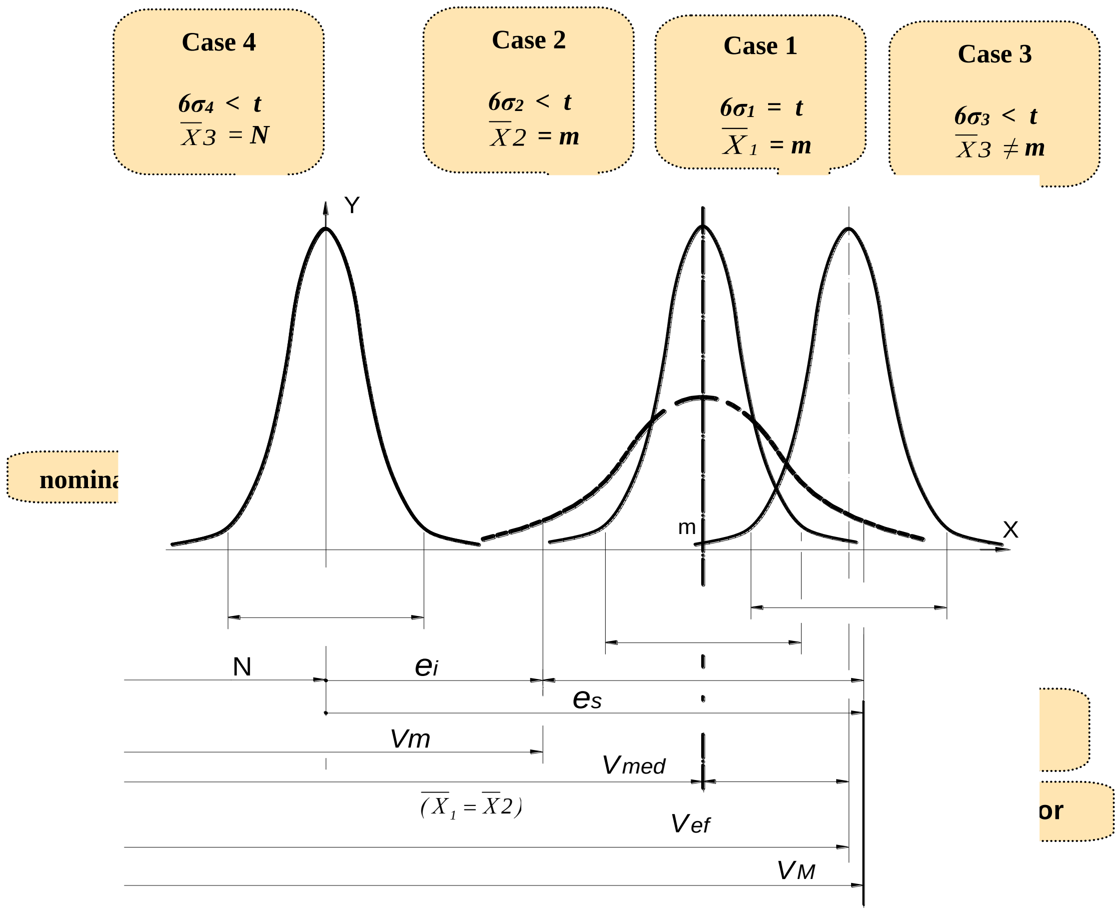

Figure 2 Case study; the conformity of TVTs quality model to the mechanical engineering industry. Four possible cases for achieving a parameter.

requirements.

Case 4. It has as characteristic $6\sigma_4$ less than *t*, but $\overline{X}_4$ is equal to the nominal *N*. In this case, the achieved parameter has effective values *Vef* come out of the *t* and, consequently, it will be generated a factory reject. This error may percolate through the designing process and, afterwards, through the processing process, by confounding the nominal *N* with the target value *m*.

In this case, the quality loss according to the relation (2) is big and does not comply with TVT's requirements. This error can be done in designing, processing or control process when the nominal is considered target value in strictly conformity with TVT concept.

Case 4 is the *sensitive* element of *TVT* that considers the *nominal* value as *target value* for an analyzed parameter. In the mechanical engineering field, this aspect may cause designing interpretation and control errors of fittings or errors in establishing the dimensional accuracy. These possible confusions may lead to *non-quality*.

In order to prevent this fact, this paperwork proposes to make a precise differentiation between the N- *nominal value* and *target value* concepts and at the same time, between the *deviation (E* or *e)* and *error(ε)* concepts; in the mechanical field these are distinct and non-confoundable values.

At the same time, on the above-mentioned basis (Figure 2), it may be drawn the conclusion that the *deviation (e, E)* concept and that of *error (ε)* are distinct and non-confoundable.

The misunderstanding of the four concepts: *nominal* (*N*); *target* value (*m* or d_t /D_t); *deviation* (*e/E*); *error* (*ε*) may cause confusions and errors during the technical and economical life of the mechanisms or precise units. This possible confusion represents an important sensitive element of TVT's theory.

5. CONCLUSIONS

The "sensitive" elements of this concept was apprehended in the paper that, by their interpretation inadequate to the field, may cause errors and mistakes in the designing, processing or control of surfaces generated by machine tools. In the mechanical engineering field, in general, and in the dimensional tolerances and ISO fittings field, in particular, this interpretation may lead to errors both in designing and in processing or control. At the same time, in the specialized literature [1], [8], [10] there is a confusion regarding the deviation and error concepts. Often the nominal value is incorrectly considered as the target value; this paper call the attention for this mistake and promotes the idea that the correct choice of the analyzed parameter's target really determines the quality of the product.

These possible confusions represent *"sensitive"* elements that may lead to *"non-quality".*

With a view to preventing this fact, this paperwork proposes, on the basis of some eloquent schemes (Figure 1b; Figure 2) to make a precise differentiation between the *"nominal"* and *"target value"* (ideal value) concepts and, at the same time, between the *"deviation"* and *"error"* concepts.

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