TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 68, Issue IV, November, 2025

OPTIMIZING CNC MACHINING TECHNOLOGIES VIA DIMENSIONAL STRUCTURAL EFFECTS

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Abstract: *This paper explores the structural optimization of CNC machining processes, considering that in complex dimensional structures, the structural effect manifests as increased machining allowance tolerances, which reduces the degree of technological assurance of accuracy. This structural effect increases the required machining accuracy. The phenomenon of error compensation and its impact on reducing tolerances in both formed technological dimensions and machining allowances is evaluated. The paper proposes a tool for evaluating technological dimensional structures, based on the relationship between acceptable tolerances in formed technological dimensions and machining allowances.*

Key words: *optimality, dimensional structure, dimensional chain, tolerance, technological assurance, machining allowance*

1. INTRODUCTION

Optimizing CNC machining technologies involves assigning tolerances to all technological dimensions based on the precision requirements of the design dimensions.

Technological tolerances directly influence machining costs, following the relationship $C = C_F + C_V(\omega)$, where C_F is a fixed cost independent of tolerance, and $C_V(\omega)$ is a variable cost that decreases as tolerance increases [1]. In the technological design and comparative analysis of process variants, fixed costs do not influence the allocation of optimal tolerances [2].

The relationship between design tolerances and technological tolerances is well recognized. To establish and analyze this relationship, the tolerance diagram method is frequently used [3,4]. Allocating design tolerances requires a parallel assignment of appropriate technological tolerances, ensuring both cost-effective manufacturing and correct functional performance [5]. Therefore, in technological design, dimensional tolerances serve as both constructive and technological variables.

The allocation of design and technological tolerances must ensure the functionality of both the part's design structure and the technological process structure [6].

The most reliable method for ensuring linear dimensional accuracy is to derive the design dimension solely from its corresponding technological dimension (Fig. 1).

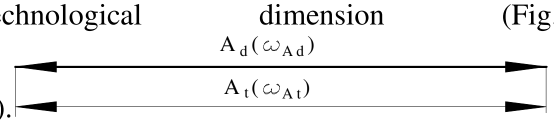

Fig. 1. The design dimension is assured only by the own technological dimension, $\omega_{Ad} = \omega_{A_t}$

The machining process reaches optimality when the technological dimensional structure closely mirrors the design dimensional structure [7]. In CNC machining, the recommendation for structural similarity is extended to the blank (cast, molded, etc.) and the technological system, due to the morphological transformation capabilities of the machine tools [8].

Dimensional chains derived from similar structures (Fig. 2) indicate that each design

Received: 13.06.25; **Similarities**: 23.10.25: **Reviewed**:04.11/28.10.25: **Accepted**:13.11.25.

dimension (e.g., $A_d, B_d, ...$) is formed by its corresponding technological dimension ($A_t, B_t, ...$), its initial blank dimension ($A^0, B^0, ...$), and any individual adjustments ($A_{adj}, B_{adj}, ...$).

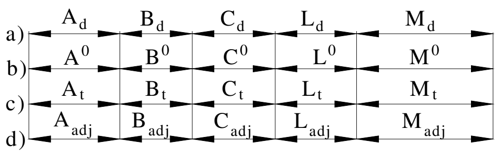

Fig. 2. The similarity for technological optimality of various dimensional chains: (a) of the part (design), (b) of blank, (c) technological, and (d) of technological adjustment.

1. STRUCTURAL EFFECTS IN COMPLEX TECHNOLOGICAL DIMENSIONAL CHAINS

When defining the dimensional structure of a machining operation in terms of technological tolerance allocation, the assurance of precision must be considered by adapting the characteristics of equipment, machining methods, and adjustment procedures [9]. The statistical data on machining accuracy included in the guidance refer to elementary dimensional structures (Fig. 3).

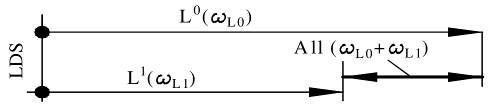

Fig. 3. Formation of a link between "technological dimension's tolerance" and "machining allowance tolerance".

Experimental statistical analysis is performed on processed artifacts [10], where technological dimensions $L_t(\omega_{L_t})$ are primarily formed from the locating datum surface *LDS* by transforming the blank dimensions $L^0(\omega_{L0})$. From the elementary dimensional chain in Figure 3, it can be concluded that precision improvements $\omega_{L0} \rightarrow \omega_{L_t}$ are limited by the increase in machining allowance $All = All_{vin} + \omega_{All}$ considered during technological design and, consequently, by the increased tolerance of the machining allowance $\omega_{All} = \omega_{L0} + \omega_{L1}$. The machining allowance value, and consequently its tolerance, determines the degree of technological precision assurance.

This establishes the link between machining accuracy ω_L^{stat} and machining allowance tolerance ω_{All}^{stat} - one of the key conditions for ensuring technological accuracy. The link between the statistical values of the technological tolerance ω_L^{stat} and the machining allowance tolerance ω_{All}^{stat} is represented in Figure 4. This link represents the interval of the technological functionality and objectively characterizes the elementary dimensional structure in a physical and technical way.

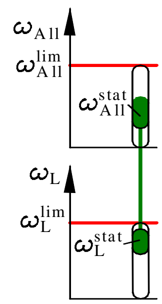

Fig. 4. The technological functionality interval: "ω_L^{stat} - ω_{All}^{stat}"

However, this does not reflect the specifics of complex technological dimensional structures, nor does it consider the position of a formed technological dimension within a chain composed of interacting and interdependent elements.

A complex technological dimensional structure is considered functionally optimal if each technological dimension is formed with precision and machining allowance tolerance within the limits of the physically and technically defined functional interval of the elementary dimensional structures.

In modern CNC machining, technological dimensions are integrated into complex dimensional structures. The formation of technological dimensions within such systems occurs under mutual constraints with systemic effects [11], and their complexity is expressed through three distinct structurally driven phenomena:

1. increasing the precision requirements imposed to technological dimensions;

2. increasing the tolerances of machining allowances (worsening the technological assurance of machining accuracy);
3. error compensation, which results in the reduction of both the tolerances of machining allowances (improving the technological assurance of machining accuracy) and the reduction of the tolerances of technological dimensions.

2.1. Increasing accuracy requirements imposed on technological dimensions.

When forming a technological dimensional structure similar to the design structure, it often happens that a design dimension B_d is composed of its own technological dimension B_t and one or more already existing (historical) dimensions C_t (Fig. 5).

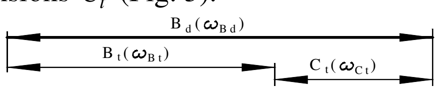

Fig. 5. Formation of the design dimension through its own technological dimension and through a already existing (historical) one.

As a result, both B_t and C_t must be formed with increased precision, such that:

$$\omega_{B_t} + \omega_{C_t} = \omega_{B_d} \tag{1}$$

Reducing the permissible limit of the technological dimension tolerance ($\omega_L^{lim\,1} < \omega_L^{lim}$), also necessitates reducing the machining allowance tolerance limit ($\omega_{All}^{lim\,1} < \omega_{All}^{lim}$) with the placement of the machining allowance tolerance in the inadmissible area (Fig. 6).

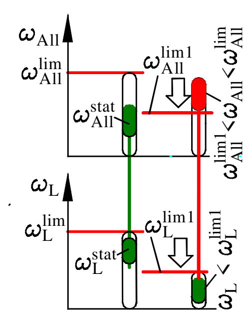

Fig. 6. The structural effect of technological non-assurance of accuracy.

2.2. Increasing machining allowance tolerances.

In complex technological dimensional structures, the tolerance of a machining allowance depends on the position of the formed technological dimension within the dimensional chain. The tolerance of the machining allowances increases with the increase in the order number of the element in the chain and includes all the tolerances of the target dimensions and the semi-finished product, starting from the locating datum surface [8].

According to the maximum and minimum method, the machining allowance tolerance can be expressed by:

$$\omega_{All\,n} = \sum_{i=1}^{n} (\omega_{L_i}^{0} + \omega_{L_i}^{t}) \tag{2}$$

An inadmissible increase in machining allowance tolerance—exceeding the technological assurance limit - triggers a structural effect that increases the technological dimension's tolerance, resulting in reduced accuracy (Fig. 7).

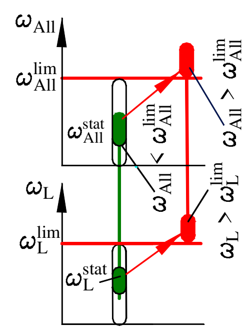

Fig. 7. Correlated structural effects of inadmissible increase in machining allowance tolerance and technological quota tolerance

These effects can be mitigated by dividing the complex technological dimensional structure into smaller segments with fewer elements [8]. The formation of technological dimensions from such structures can be achieved in variants.

The first variant involves forming technological dimensions from the locating datum surface *LDS* in opposite directions (Fig. 8a) with k elements in one direction and r elements in the ather direction from a total of n elements:

$$\begin{aligned} \omega_{All\,r}^{max}(right) &= \sum_{i=1}^{r} (\omega_{L_i}^{0} + \omega_{Lt\,i}) \\ \omega_{All\,l}^{max}(left) &= \sum_{i=1}^{k} (\omega_{L_i}^{0} + \omega_{Lt\,i}) \end{aligned} \tag{3}$$

The maximum values of the allowance tolerances in both directions must differ as little as possible, so that the degree of technological assurance is identical.

The second variant provides for the formation of technological elevations from the locating datum surface LDS and subsequently in the same direction from the technological adjustement base TAB (Fig. 8b). The first group consists of k elements, the next group - of r elements. The tolerances of the maximum addition on the groups are:

$$\omega^{max}_{All_l}(LDS) = \sum_{i=1}^{k}(\omega^0_{L_i} + \omega_{Lt\,i}) \qquad (4)$$

$$\omega^{max}_{All_r}(TAB) = \sum_{i=1}^{r}(\omega^0_{L_i} + \omega_{Lt\,i})$$

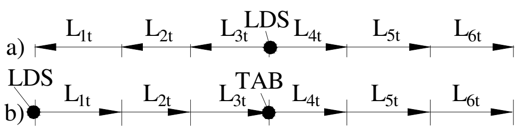

Fig. 8. Reducing effect of increasing machining allowance's tolerances by dividing the dimensional chain into parts.

2.3. Reducing machining allowance tolerances and technological dimension tolerances through error compensation

Errors caused by elastic deformation ε^y, cutting edge wear ε^w, and mounting inaccuracies ε^{mnt} during sequential machining are mutually compensated [12] (Fig. 9) by the value:

$$\omega^c = min\{\varepsilon^y_i + \varepsilon^w_i + \varepsilon^{adj}_i; \varepsilon^y_{i-1} + \varepsilon^w_{i-1} + \varepsilon^{mnt}_{i-1}\} \qquad (5)$$

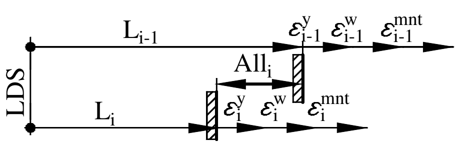

Fig. 9. Compensable errors when evaluating machining allowance tolerances

As a result, the machining allowance tolerance takes the value:

$$\omega_{All} = \omega_{L_{i-1}} + \omega_{L_i} - 2\cdot\omega^c \qquad (6)$$

Error compensation improves the accuracy of the closing element in the technological dimensional chain (Fig. 10):

$$\omega_\Delta = \omega_{L_i} + \omega_{L_k} - 2\cdot\omega^c, \qquad (7)$$

where $\omega^c = min\{\omega^c_i; \omega^c_k\}$.

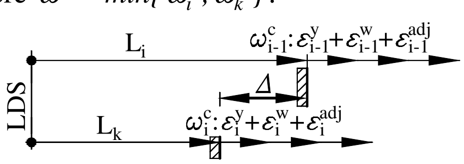

Fig. 10. Compensable errors when evaluating the dimension's tolerance – closing element Δ in chain.

Error compensation also is manifested for the technological dimensions in the chain, except for the first (fig. 11).

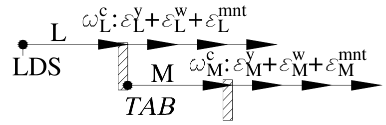

Fig. 11. Compensable errors in the formation of technological dimensions in the chain

Note. In all cases, the normals to the machined surfaces must be aligned.

It can be stated that the machining accuracy evaluated by the maximum - minimum method for the closing element in the dimensional chains or for the technological dimension formed in the chain is estimated as lower than the real one. Similarly, the tolerance of the machining allowances is estimated as higher than the real one.

Considering error compensation modifies the assessment of the structural effects described earlier. The increase in the accuracy requirements of technological dimensions is mitigated (Fig. 5). The tolerances ω_{B_t} and ω_{C_t} of technological dimensions B_t and C_t may be increased. The relation (1) can be rewritten in the form:

$$\omega_{B_t} + \omega_{C_t} - 2\cdot\omega^c_{B/C} = \omega_{B_d}, \qquad (8)$$

The increase in machining allowance tolerances is mitigated by the error compensation effect according to equation (2) rewritten in the form:

$$\omega_{All\,n} = \sum_{i=1}^{n}(\omega^0_{L_i} + \omega^t_{L_i} - 2\cdot\omega^c_{L^0_i/L^t_i}). \qquad (9)$$

Here $\omega^c_{L^0_i/L^t_i}$ represents the compensated errors when evaluating the machining allowance tolerance.

The desired technological dimensional structure are accepted under the following conditions (Fig. 12): a) increasing the machining allowances' tolerance without exceeding the technological assurance limit through the effects of error's compensation; b) increasing the technological dimensions' tolerances without loss of accuracy through the effects of error's compensation.

The final result depends on the specifics of the dimensional structures.

3. STRUCTURAL EFFECTS IN VARIOUS DIMENSIONAL TECHNOLOGICAL STRUCTURES

To evaluate the extent to which structural effects influence the allocation of technological tolerances, a series of similar design and technological dimensional structures was analyzed, involving the machining of front surfaces S1, S2, S3 and S4, positioned relative to surface 0 at 200, 150, 100, and 50 mm, respectively.

The analyses were performed using the maximum and minimum and maximum and minimum with error compensation methods. The effect of error compensation was evaluated by the relationship $\omega^c = u \cdot \omega_{Xt}$ in relationship (7) and by $\omega^c = u \cdot \omega^t_{Li}$ in relationship (8). Here u represents the weight of compensable errors in the tolerance field of the dimension with the smaller value from the pair of dimensions participating in the manifestation of the compensation phenomenon. The value $u = 0,4$ was accepted. It should be noted that the analysis is of a comparative nature, so the exact value of the factor u is not of principle.

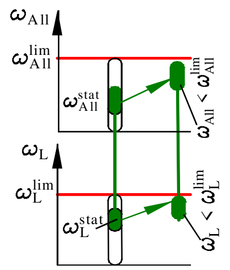

Fig. 12. Acceptable (due to structural and error's compensation effects) tolerances of formed technological dimensions and of machining allowances.

3.1. Similars *fan-shaped* dimensional structures

3.1. Similars *fan-shaped* dimensional structures (Fig. 13). From the dimensional relation graphs (Fig. 13a, b) , it is evident that the structural similarity leads to accuracy formation as described in Figure 1:

$$\omega_{A_t^i} \le \omega_{A_c^i}\ ,\ \omega_{B_t^i} \le \omega_{B_c^i}\ ,$$
$$\omega_{C_t^i} \le \omega_{C_c^i}\ ,\ \omega_{E_t^i} \le \omega_{E_c^i} \qquad (10)$$

This situation of technological accuracy's forming is valid for all cases analyzed below with similar constructive and technological dimensional structures.

The machining allowance tolerances ω_{All} for surfaces 1, 2, 3 and 4 are determined from the relationships:

$$\omega_{All_1} = (\omega_{A_t} + \omega_{A_t^0}) - 2 \cdot \omega^c_{1/1^0}\ ,$$
$$\omega_{All_2} = (\omega_{B_t} + \omega_{B_t^0}) - 2 \cdot \omega^c_{2/2^0}\ ,$$
$$\omega_{All_3} = (\omega_{C_t} + \omega_{C_t^0}) - 2 \cdot \omega^c_{3/3^0}\ , \qquad (11)$$
$$\omega_{All_4} = (\omega_{E_t} + \omega_{E_t^0}) - 2 \cdot \omega^c_{4/4^0}\ .$$

Calculation results are given in the table 1.

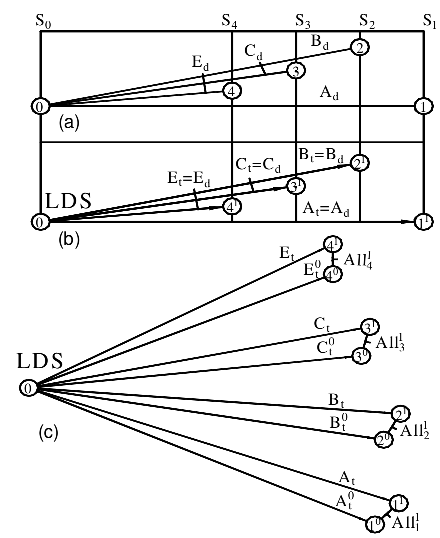

Fig. 13. Dimensional relationship graphs for *fan-shaped* structure.

Table 1

Machining allowance tolerances ω_{All} on surfaces and theirs statistical ω^{stat}_{All} and structural ω^{str}_{All} components

Allowance tolerances, mm	Machining surfaces			
	S_1	S_2	S_3	$S4$
Maximum and minimum method				
ω^{stat}_{All}	3.55	3.17	2.73	2.10
ω^{str}_{All}	**0**	**0**	**0**	**0**
ω_{All}	3.55	3.17	2.73	2.10
Maximum and minimum with errors compensation method				
ω^{stat}_{All}	2.11	1.91	1.65	1.32
ω^{str}_{All}	**0**	**0**	**0**	**0**
ω_{All}	2.11	1.91	1.65	1.32

It is noted that there are no cases where technological tolerances exceed the optimal statistical reference value, because each technological dimension A_t, B_t, C_t, E_t is independently formed from the locating datum surface *LDS* with statistical accuracy. For machining allowances tolerances, the errors compensation effect is manifested according to the scheme in Figure 9.

The structural effects for this type of structure are illustrated in Figure 14, with the machining strategy being considered functional.

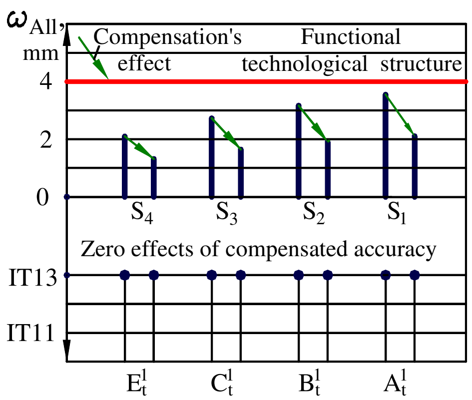

Fig. 14. Structural effects in *fan-shaped* dimensional structures.

Here and further on the limit value of the allowance tolerance is 4 mm - a conventional one and used for comparison purposes.

3.2. Similars *displaced fan-shaped* dimensional structures (Fig. 15).

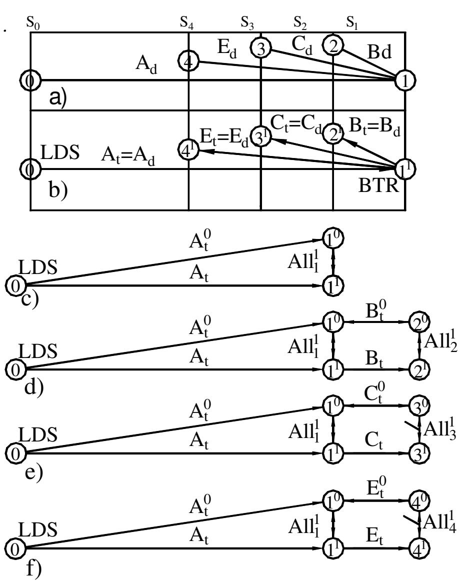

Fig. 15. Dimensional relationship graphs for *displaced fan-shaped* structure.

The conditions for ensuring dimensional accuracy are optimal and align with relations (9).

Figures 15d-f show that the dimensional chains for machining allowances on surfaces 2, 3, and 4 include the machining allowance of surface 1 as a component.

The machining allowance tolerances for surfaces 1, 2, 3 and 4 can be determined as follows:

$$
\begin{aligned}
\omega_{All_1} &= (\omega_{A_t} + \omega_{A_t^0}) - 2\cdot\omega^c_{1^1/1^0}, \\
\omega_{All_2} &= (\omega_{B_t} + \omega_{B_t^0}) - 2\cdot\omega^c_{2/2^0} + \\
&\quad + (\omega_{A_t} + \omega_{A_t^0}) - 2\cdot\omega^c_{1/1^0}, \\
\omega_{All_3} &= (\omega_{C_t} + \omega_{C^0}) - 2\cdot\omega^c_{3/3^0} + \\
&\quad + (\omega_{A_t} + \omega_{A^0}) - 2\cdot\omega^c_{1/1^0} \\
\omega_{All_4^i} &= (\omega_{E_t} + \omega_{E_t^0}) - 2\cdot\omega^c_{4/4^0} +, \\
&\quad + (\omega_{A_t} + \omega_{A_t^0}) - 2\cdot\omega^c_{1/1^0}
\end{aligned}
\qquad (12)
$$

Calculation results are given in the table 2.

Table 2

Machining allowance tolerances ω_{All} on surfaces and theirs statistical ω^{stat}_{All} and structural ω^{stat}_{All} components

Allowance tolerances, mm	Machining surfaces			
	S_1	S_2	S_3	$S4$
Maximum and minimum method				
ω^{stat}_{All}	3.55	2.10	2.73	3.17
ω^{str}_{All}	**0**	**3.55**	**3.55**	**3.55**
ω_{All}	3.55	5.65	6.28	6.72
Maximum and minimum with errors compensation method				
ω^{stat}_{All}	2.11	1.32	1.65	1.91
ω^{str}_{All}	**0**	**2.11**	**2.11**	**2.11**
ω_{All}	2.11	3.43	3.76	4.02

Each technological dimension B_t, C_t, E_t is formed as the second element in chains that include the technological dimension A_t . For B_t, C_t, E_t dimensions, the errors compensation effect is manifested according to the mechanism given in Figure 11. For machining allowances, the errors compensation effect manifests itself according to Figure 9.

From table 2 it can be seen that the increase in the tolerance of machining allowances caused by the structural effect occurs for surfaces 2, 3, 4 in the value of the tolerance of the technological dimension A_t . Graphically, the specifics of these dimensional structures are presented in Figure 16.

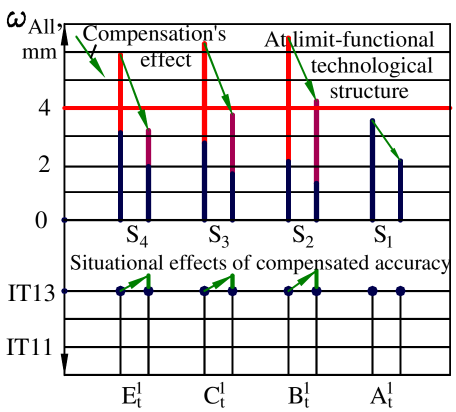

Fig. 16. Structural effects in *displaced fan-shaped* dimensional structures.

The structural effects of increased machining allowance tolerances are not critical, as each chain contains only two elements. Error compensation effects result in decreased machining allowance tolerances (improving technological assurance) and increased technological dimension tolerances (reducing accuracy requirements).

The machining strategy shown in Figure 15 is marginally acceptable.

3.3. Similar *fan-shaped – chain* dimensional structures (Fig. 17).

The technological dimensions A_t and E_t arranged in a fan pattern from the locating datum surface *LDS*, are formed with statistical accuracy and without error compensation effects. For technological dimensions C_t and B_t , positioned in the chain after E_t , as well as for all machining allowances, error compensation effects occur according to the mechanisms shown in Figures 11 and 9, respectively.

Figure 17c shows that the machining allowance tolerances for surfaces 1, 2, 3, and 4 can be calculated using the following relationships:

$$\omega_{All_1} = (\omega_{A_t} + \omega_{A_t^0}) - 2 \cdot \omega^c_{1/1^0}$$

$$\omega_{All_2} = \sum_{X=B,C,E} (\omega_{X_t} + \omega_{X_t^0}) - \sum_{x=2,3,4} 2 \cdot \omega^c_{x/x^0}$$

$$\omega_{All_3} = \sum_{X=C,E} (\omega_{X_t} + \omega_{X_t^0}) - \sum_{x=3,4} 2 \cdot \omega^c_{x/x^0} \quad (13)$$

$$\omega_{All_4} = (\omega_{E_t} + \omega_{E_t^0}) - 2 \cdot \omega^c_{4/4^0}$$

Calculation results are given in the table 3.

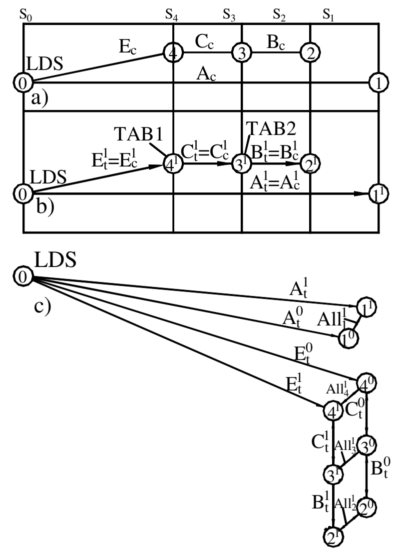

Fig. 17. Dimensional relationship graphs for *fan-shaped – chain* type structure.

Table 3

Machining allowance tolerances ω_{All} on surfaces and theirs statistical ω_{All}^{stat} and structural ω_{All}^{stat} components

Allowance tolerances, mm	Machining surfaces S_1	S_2	S_3	$S4$
Maximum and minimum method				
ω_{All}^{stat}	3.55	2.1	2.1	3.55
ω_{All}^{str}	**0**	**4.20**	**2.1**	**0**
ω_{All}	3.55	6.3	4.2	3.55
Maximum and minimum with errors compensation method				
ω_{All}^{stat}	2.11	1.32	1.32	1.32
ω_{All}^{str}	**0**	**2.64**	**1.32**	**0**
ω_{All}	2.11	3.96	2.64	1.32

The structural increase in machining allowance tolerances for surfaces 2 and 3 equals the sum of the tolerances of all technological dimensions between the locating datum surface *LDS* and the target surface (Fig. 17, tab. 3). Graphically, the specifics of these dimensional structures are presented in Figure 18.

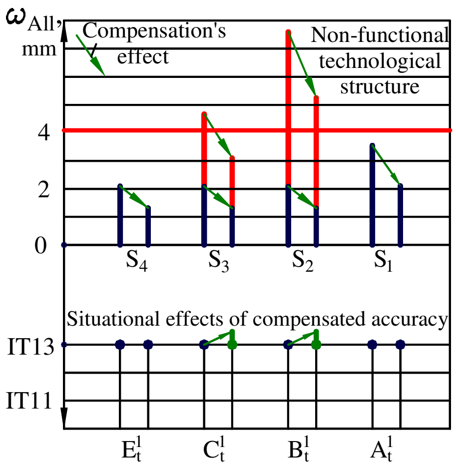

Fig. 18. Structural effects in *fan-shaped – chain* dimensional structures

The structural increase in machining allowance tolerances for surfaces 2 and 3 equals the sum of the tolerances of all technological dimensions between the locating datum surface *LDS* and the target surface (Fig. 16, tab. 3). Graphically, the specifics of these dimensional structures are presented in Figure 17.

The machining strategy illustrated in Figure 17 is unacceptable due to an insufficient degree of technological accuracy assurance.

3.4. Similar *chain* dimensional structures

(Fig. 19). The technological dimensions placed in a chain form from the locating datum surface LDS constitute complex structures of different lengths: 2, 3 and 4. The error compensation effects are manifested for technological dimensions B_t, C_t, E_t and for all machining allowances according to the mechanisms presented in figures 11 and 9.

Machining allowance tolerances for surfaces 2, 3 and 4 include as component elements all the pairs machining allowance tolerances of the previously machined surfaces according the following relationships:

$$\omega_{All_1} = (\omega_{A_t} + \omega_{A_t^0}) - 2\cdot\omega^c_{1/1^0}$$
$$\omega_{All2} = \sum_{X=A,B}(\omega_{X_t} + \omega_{X_t^0}) - \sum_{x=1,2} 2\cdot\omega^c_{x/x^0}$$
$$\omega_{All_3} = \sum_{X=A,B,C}(\omega_{X_t} + \omega_{X_t^0}) - \sum_{x=1,2,3} 2\cdot\omega^c_{x/x^0} \qquad (14)$$
$$\omega_{All_4} = \sum_{X=A,B,C,E}(\omega_{X_t} + \omega_{X_t^0}) - \sum_{x=1,2,3,4} 2\cdot\omega^c_{x/x^0}$$

Calculation results are given in the table 4.

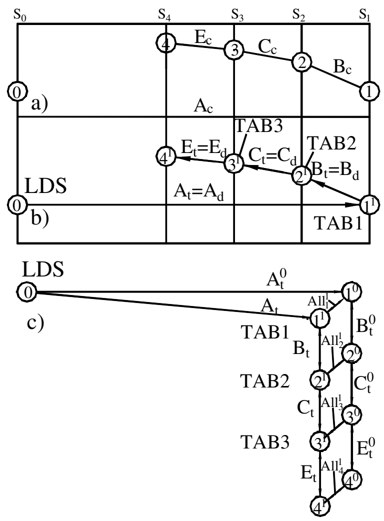

Fig. 19. Dimensional relationship graphs *chain* structure.

Table 4

Machining allowance tolerances ω_{All} on surfaces and theirs statistical ω^{stat}_{All} and structural ω^{stat}_{All} components

Allowance tolerances, mm	Machining surfaces			
	S_1	S_2	S_3	$S4$
Maximum and minimum method				
ω^{stat}_{All}	**3.55**	2.10	2.73	3.17
ω^{str}_{All}	**0**	**3.55**	**3.55**	**3.55**
ω_{All}	3.55	5.65	6.28	6.72
Maximum and minimum with errors compensation method				
ω^{stat}_{All}	**2.11**	1.32	1.65	1.91
ω^{str}_{All}	**0**	**2.11**	**2.11**	**2.11**
ω_{All}	2.11	3.43	3.76	4.02

Graphically, the specifics of these dimensional structures are presented in Figure

20. This technological dimensional structure is unacceptable.

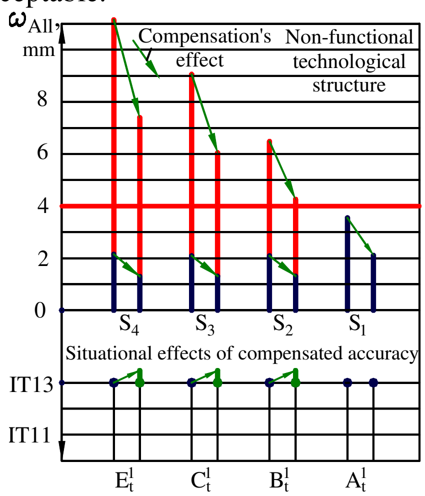

Fig. 20. Structural effects in *chain*" dimensional structures

4. CONCLUSIONS

Geometrically, the similarity between the design and technological dimensional relationship graphs reflects structural optimality - a design dimension is formed through its own technological dimension.

The properties of a dimensional structure composed of optimal elements may still be suboptimal due to systemic structural effects.

In complex technological dimensional structures, the following effects are observed:

- ✓ the structural effect of increasing the tolerances of the machining allowances (the effect of decreasing the degree of technological assurance of precision);
- ✓ the structural effect of increasing the necessary machining accuracy if the design dimension is formed not only by its own technological dimension;
- ✓ the effect of errors compensation with the decrease of the necessary machining accuracy;
- ✓ the effect of errors compensation with the decrease of the machining allowances' tolerances.

The machining allowance tolerance is determined by the position of the technological dimension within the chain, accumulating the tolerances of all target dimensions - along with error compensation effects - including the one in which it participates, cumulating with error compensation effects the tolerances of all target technological dimensions, including the dimension in which it participates.

A desired technological dimensional structure is acceptable under the following conditions:

- ➢machining allowance tolerances increase without exceeding the technological assurance limit, due to error compensation effects;
- ➢technological dimension tolerances increase without compromising accuracy, also due to error compensation effects.

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Optimizarea tehnologiilor de prelucrare CNC prin efecte structurale dimensionale

Lucrarea discută metodologia de optimizare structurală a proceselor tehnologice CNC de prelucrare mecanică, ținând cont de faptul că în structurile dimensionale complexe se manifestă efectul structural de creştere a toleranţelor adaosurilor de prelucrare, ceea ce reduce gradul de asigurare tehnologică a preciziei. Acest efect structural provoacă creşterea preciziei de prelucrare necesare. Este evaluat fenomenul de compensare a erorilor și efectele acestuia de micșorare a toleranțelor atât a cotelor tehnologice formate cât și a adaosurilor de prelucrare. Este propus un instrument de evaluare a structurilor dimensionale tehnologice bazat pe legătura dintre toleranțele acceptabile ale cotelor tehnologice formate și ale adaosurilor de prelucrare.

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