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PRODUCTION MANUFACTURABILITY ASSESSMENT OF THE PRODUCT DESIGN

E. TIKHON, N. POPOK
Polotsk State University, Belarus

On the basis of technical and economic analysis of the relations properties between design and technological solutions, method for assessment production manufacturability by combining various manufacturability coefficients, taking into account the degree of their influence on the labor intensity production.

The influence of design characteristics on the labor intensity of technological preparation and products production. Example of the influence of production design (PD) characteristics on the types of labor intensity of PD production (table 1).

Table 1. – Influence of product design characteristics on labor intensity subspecies

№	Product design characteristics	Labor intensity specie (L_i)								
		L_2			L_3					
		L_{21}	L_{22}	L_{23}	L_{31}	L_{32}	L_{33}	L_{34}	L_{35}	L_{36}
1	Amount of purchased elements	+		+	+	+	+			
2	Amount of repeatable details	+		+	+					
3	Amount of repeatable connections		+	+				+		
4	Precision methods		+						+	
5	Amount of borrowed elements	+		+						
6	Amount of typical details	+								
7	Details precision					+				
8	Surface roughness of details					+				
9	Material hardness of details					+				
10	Mass of product elements						+			+
11	Amount of connection types								+	
+ – influence of characteristics on labor intensity subspecies										

On the basis of the data in table 1, a coefficients list of manufacturability PD manufacturing was determined [1] and their calculation formulas were developed [2]:

1. Purchased coefficient (C_P):

$$C_P = a_2 a_{21} \frac{\sum E_{P_i} b_{com_i}}{E} + a_2 a_{23} \frac{\sum E_{P_i} b_{com_i}}{E} + a_3 a_{31} \frac{\sum E_{P_i} b_{com_i}}{E} + a_3 a_{32} \frac{\sum E_{P_i} b_{com_i}}{E} + a_3 a_{33} \frac{\sum E_{P_i} b_{com_i}}{E}, \quad (1)$$

where E_{Pi} - the i-th purchased element; b_{comi} - coefficient reflecting the level of structure complexity of the i-th element; E - the total number of elements in the PD; a_2 - the influence degree L_2 on L; a_3 - the influence degree L_3 on L; a_{21} - the influence degree L_{21} on L_2; a_{23} - the influence degree L_{23} on L_2; a_{31} - the influence degree L_{31} on L_3; a_{32} - the influence degree L_{32} on L_3; a_{33} - the influence degree L_{33} on L_3.

2. Repeatable details coefficient:

$$C_{RD} = a_2 a_{21} \frac{\sum (D_{RD} - D_{RD.B} - 1) b_{com_i}}{D - D_P - D_B} + a_2 a_{23} \frac{\sum (D_{RD} - D_{RD.B} - 1) b_{com_i}}{D - D_P - D_B} + a_3 a_{31} \frac{\sum (D_{RD} - D_{RD.B} - 1) b_{com_i}}{D - D_P - D_B}, \quad (2)$$

where $D_{RD.B}$ - the number of repeated borrowed details, D_{RD} - the number of repeatable details of the i-th group.

3. Repeatable connections coefficient:

$$C_{RC} = a_2 a_{22} \frac{\sum (C_{RC} - 1) b_{com.c_i}}{C} + a_2 a_{23} \frac{\sum (C_{RC} - 1) b_{com.c_i}}{C} + a_3 a_{34} \frac{\sum (C_{RC} - 1) b_{com.c_i}}{C}, \quad (3)$$

where C_{RC} – the number of repeated connections of the i-th group; C - the total number of connections;

$b_{com.ci}$ - coefficient of the connection structure complexity level of the i-th group; a_{22} - the influence degree L_{22} on L_2; a34 - the influence degree L_{34} on L_3.

4. Coefficient of details material hardness:

$$C_H = a_2 a_{22} \frac{\sum n_{Hi} b_{Hi} b_{SHi}}{n}, \quad (4)$$

where n_{Hi} - the details number of the i-th material hardness value; n - the number of details in the product; b_{Hi} - the influence degree of the i-th value of the details material hardness on the labor intensity.

5. Borrowing coefficient (C_B):

$$C_B = a_2 a_{21} \frac{\sum E_{Bi} b_{com_i}}{E - E_P} + a_2 a_{23} \frac{\sum E_{Bi} b_{com_i}}{E - E_P}, \quad (5)$$

where E_{Bi} - the i-th borrowed element.

6. Typification coefficient:

$$C_{TYP} = a_2 a_{21} \frac{\sum D_{TYPi} b_{com_i} b_{TYPi}}{D - D_P - D_B - D_R}, \quad (6)$$

$\sum D_{TYP}$ - the details number of the i-th typical representative group;

b_{TYPi} - the influence degree of typical details to reduce the labor intensity of their manufacture; b_{comi} - coefficient of the details design complexity level of the i-th typical representative group.

7. Details precision coefficient:

$$C_{PR} = a_3 a_{32} (1 - \frac{n_S}{\sum A_i b_{PRS_i} b_{PRi}}), \quad (7)$$

where Ai - the value of the i-th precision quality of the details size in the product; b_{PRi} - coefficient taking into account the labor intensity of achieving precision Ai when the part is processed; n_S - the number of details surface areas in the product; b_{PRSi} - the area fraction of the i-th detail surface from the total surface area of all details in the product taken as a unit.

8. Coefficient of details surfaces roughness:

$$C_{RN} = a_3 a_{32} (1 - \frac{n}{\sum B_i b_{RN_i} b_{SRNi}}), \quad (8)$$

where Bi - the value of the i-th details surface roughness parameter in the product; n - the number of details surfaces in the product; b_{SRNi} - the area proportion of the i-th details surface from the total surface area of all details in the product taken as a unit; bRNi - the influence degree coefficient of Bi on labor intensity of processing the i-th surface.

9. Coefficient of precision methods efficiency:

for the closing links of dimensional chains.

$$C_{MDCH} = a_3 a_{35} \frac{CI \cdot b_{P.CI} + ICI \cdot b_{P.ICI} + GI \cdot b_{P.GI} + ADJ \cdot b_{P.ADJ} + FT \cdot b_{P.FT}}{CI + ICI + GI + ADJ + FT}, \quad (9)$$

where CI - the number of dimensional chains assembled by the complete interchangeability method; ICI - the number of dimensional chains assembled by the incomplete interchangeability method; GI - the number of dimensional chains assembled by the group interchangeability method; ADJ - the number of dimensional chains assembled by the adjustment method; FT - the number of dimensional chains assembled by the fitting method.

10. Connection coefficient:

$$C_C = a_3 a_{35} \frac{\sum n_i b_{C_i} b_{SC_i}}{n}, \quad (10)$$

n_i - the number of i-th type connections; n - the number of connections in the product; b_{Ci} - the influence degree of the i-th connection type on labor intensity (for cylindrical movable ones b_{Ci} will have a minimum value and for welded joints it will be maximum); b_{SCi} – the contact areas proportion of the i-th connection type from total contact area of all joints in the product taken as a unit; a_{35} - the influence degree of L_{35} on L_3.

11. Element mass coefficient:

$$C_M = a_3 a_{33} \frac{\sum n_i b_{M_i}}{n} + a_3 a_{36} \frac{\sum n_i b_{M_i}}{n}, \quad (11)$$

where n_{Mi} - the number of the i-th mass value elements; n - the number of elements in the product; b_M - the influence degree of the i-th element mass value on the labor intensity; a_{36} - the influence degree of L_{36} on L_3.

Conclusion. The given calculation formulas of manufacturability coefficients make it possible to determine an integral assessment of the manufacturability level at the manufacturing PD stage by summing their values.

The manufacturability coefficients of disposal preparation and design production preparation are determined by the same method.

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