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CALCULATION OF TECHNOLOGICAL DIMENSIONS

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The designation of TP represents a multialternative task, the correct solution of which requires realization of a number of calculations. In the beginning of designation kinds of processing of blank surfaces and methods of achievement of their accuracy appropriate to the requirements of the drawing, type of manufacturing and equipment, existing in the machine shop, previously are defined or established.

At low accuracy of initial blanks TP begins with rough machining of surfaces having greatest stocks. Stocks are removed in first turn from those surfaces on which the defects are probable. This is done for the purpose of the prompt elimination of a spoilage.

The further manufacturing route is designed with a principle of machining at first rough, and then more accurate surfaces. The most accurate (precise) surfaces are machined in the last turn.

At drawing up of a TP route it is required previously to define quantity of machining of each surface. For this purpose it is better to take a surface with the most accurate (precise) size and to write a sequence of machining. Thus minimal allowances $2Z_{min}$ are consecutive "covered" on the final (design) size, which allows us to receive the intermediate technological dimensions.

In our task, for example, the most accurate outside size of a sleeve is $\varnothing 30h7$ (Fig. 1). It should be machined with 7 grade of tolerance, before – with 9 grade of tolerance, and earlier – with 11 grade of tolerance. Initial workpiece is a rod with 14 grade of tolerance in condition of delivering.

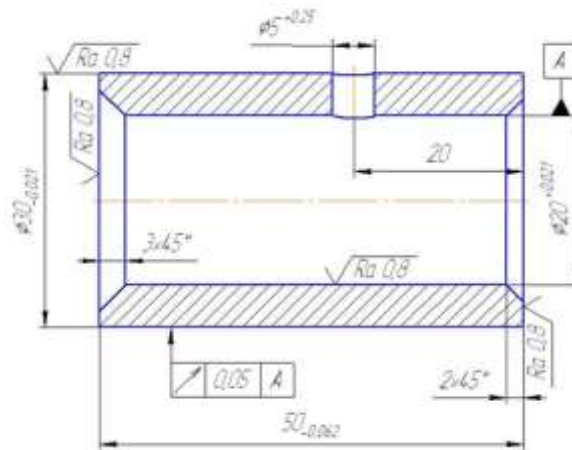


Fig. 1. Sketch of a part "sleeve"

We begin to write down the technological sizes from the end (design size is written first in a **right** position) and we go from the right hand to the left. In our example it is necessary to carry out heat treatment (quenching). The route of sleeve processing is written:

$$35h14 \rightarrow 31.13h11 \rightarrow 30.48h9 \rightarrow \text{Heat treatment} \rightarrow 30h7.$$

$$2Z_{min} = 1.8 \text{ mm} \quad 2Z_{min} = 0.4 \text{ mm} \quad 2Z_{min} = 0.32 \text{ mm}$$

Allowance is a layer (thickness of a layer) of a material, removed in machining. Its minimal thickness Z_{min} depends on many factors, but basics are:

1. Roughness of a machined surface received at the previous manufacturing (index ***i-1***) – Rz_{i-1} ;

2. Thickness of a defective layer of a machined surface received at the previous manufacturing – $h_{def\ i-1}$;

3. Warping of a machined surface received at the previous manufacturing – ρ_{i-1} ;

4. Error of locating and clamping of a workpiece received at **considered** manufacturing (index i) – ε_i .

If allowance is less minimal, the traces and defects from the previous machining will be on has machined surface, which is not allowable. Allowance is removed per one or several processing step, if the thickness is too large.

Minimal allowance for considered machining (on considered processing step) is defined from the tables or calculated by the formulas. If for calculation of minimal stock taking into account the seldom probability of occurrence in the same direction of warp of a surface received at the previous manufacturing (ρ_{i-1}) and error of locating and clamping received at considered manufacturing (ε_i) for rotation surfaces an equation is following:

$$2z_{i\min} = 2 \cdot \left(R_{z,i-1} + h_{def,i-1} + \sqrt{(\rho_{i-1}^2 + \varepsilon_i^2)} \right), \quad (1)$$

where $2z_{i\min}$ – is a minimal allowance of rotation surfaces for considered manufacturing.

It is better to calculate minimal allowance taking into account the probability of occurrence in the same direction of warp of a surface received at the previous manufacturing (ρ_{i-1}) and error of locating and clamping received at considered manufacturing (ε_i) for rotation surfaces:

$$2z_{i\min} = 2 \cdot \left(R_{z,i-1} + h_{def,i-1} + \rho_{i-1} + \varepsilon_i \right). \quad (2)$$

In this case we avoid of an invalid (a penalized) workpieces due to very small allowance. Calculation of minimal allowances and technological sizes will be more suitable to do by filling a table. Following equations are used for calculation of minimal and maximal calculated technological size at the previous manufacturing ($d_{\min\ i-1\ calc}$ and $d_{\max\ i-1\ calc}$)

$$d_{\min\ i-1\ calc} = d_{\max\ i\ accepted} + 2z_{\min\ i}; \quad (3)$$

$$d_{\max\ i-1\ calc} = d_{\min\ i-1\ calc} + Td_{i-1}, \quad (4)$$

where Td_{i-1} is tolerance of a surface machining at the **previous** manufacturing.

After these calculations it is necessary to round accepted basic technological size $d_{i-1 \text{ accept}}$ of “shafts” in the greatest value.

For “holes” following equations are used:

$$D_{\max i-1 \text{ calc}} = D_{\min i \text{ accepted}} - 2z_{\min i}; \quad (5)$$

$$D_{\min i-1 \text{ calc}} = D_{\max i-1 \text{ calc}} - TD_{i-1}. \quad (6)$$

where TD_{i-1} is tolerance of a surface machining at the previous manufacturing.

After these calculations it is necessary to round accepted basic technological size $D_{i-1 \text{ accept}}$ of “holes” in the least value.

In order to avoid writing of equations and all calculation we suggest to use a table and carry out all calculations with the special order.

First of all it is necessary to write a sequence of a surface processing (for our example it is $\text{Ø}30\text{h}7$, Fig. 1), name of machining and grade of tolerance in a column No. 1 (Table 1).

Then it is necessary to write parameters of a surface machining for each processing step (fill in columns 2, 3, 4), to write an error of a workpiece clamping ε (fill in a column 5 on the next stroke).

Table 1
Calculation of minimal allowances and limit technological dimensions

Technological transitions	Components of allowance, μm				Calculated minimal allowance, $2z_{\min}$, μm	Accepted technological size d_{accept} , mm	Tolerance T, μm	Calculated limit sizes, mm	
	R_z	h_{def}	ρ	ε				d_{\min}	d_{\max}
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>
External surface $\text{Ø}30\text{h}7(-0.021)$									
Initial workpiece is a cold rolling rod (h14)	160	250	500	---		35h14	620	33.22	33.84
Turning:									
<i>rough</i> (h11)	40	40	30	100	2·1010	31.2h11	160	31.01	31.17
<i>semifinish</i> (h9)	10	10	10	100	2·210	30.6h9	62	30.46	30.52
Quenching	20	100	100	---	---	----	---	---	---

(HRC 42-46)									
Round grinding (h7)	6	6	5	10	2·230	30h7	21	29.979	30
Internal surface (hole) Ø20H7(+0.021)									
								<i>D_{max}</i>	<i>D_{min}</i>
Center hole drilling (H18)	40	40	51	---	Do not require of definition	8H18	2200	8.0	10.2
Drilling of a hole (H14)	60	60	1076	90	No premanufact. hole	16.4H14	430	16.828	16.398
Boring (H11)	40	40	51	90	2·1286	19.4H11	130	19.54	19.41
Heat treatment	20	100	100	---	---	----	---	---	---
Internal grinding (H7)	6	6	5	20	2·230	20H7	21	20	20.021
External surface (length of the sleeve) 50h9(-0.062)									
								<i>l_{min}</i>	<i>l_{max}</i>
Cut off a workpiece (quality of a right face end) (h16)	80	80	500			56h16	1900	54.06	55.96
Turning of a right face end (h14)	40	40	24	500	1160	52.9h14	740	52.16	52.90
Quality of a left face end (h16)	80	80	500	---	---	---	---	---	---
Turning of a left face end (h14)	40	40	24	100	760	51.4h14	740	50.578	51.318
Quality of a right face end (h14)	40	40	24	---	---	---	---	---	---
Flat grinding of a right face end (h11)	6	6	5	74	178	50.4h11	190	50.154	50.344
Quality of a left face end (h14)	40	40	24	---	---	---	---	---	---
Flat grinding of a left face end (h9)	6	6	5	50	154	50h9	62	49.938	50

Calculation of minimal allowance is carried out by sum of component parameters Rz, hdef and ρ from the previous manufacturing and error of clamping ε from the considered manufacturing (see Table 2, upper and lower strokes).

Table 2. Calculation of minimal allowances

Technological transitions	Components of allowance, μm				Calculated minimal allowance, 2z _{min} , μm	Accepted technological size, d _{accept} , mm	Tolerance T, μm	Calculated limit sizes, mm	
	Rz	h _{def}	ρ	ε				d _{min}	d _{max}
I	2	3	4	5	6	7	8	9	10
External surface Ø30h7(-0.021)									
Initial workpiece is cold rolling rod (h14)	160	250	500	---					
Turning:	2z _{min}								
.....rough (h11)	40	40	30	100	2-1010				
.....semifinish (h9)	10	10	10	100	2-210				
Quenching (HRC 42-46)	20	100	100	---	---	---	---	---	---

Calculation of minimal size d_{min} on the previous manufacturing is carried out by sum of maximal accepted size on the finish manufacturing d_{max acc} (d_{max acc} = 30.00 mm) and minimal allowance at this manufacturing 2·z_{min} (2·z_{min} = 0.46 mm) (Table 3, lower stroke).

Table 3. Calculation of technological sizes

Technological transitions	Components of allowance, μm				Calculated minimal allowance, 2z _{min} , μm	Accepted technological size, d _{accept} , mm	Tolerance T, μm	Calculated limit sizes, mm	
	Rz	h _{def}	ρ	ε				d _{min}	d _{max}
I	2	3	4	5	6	7	8	9	10
External surface Ø30h7(-0.021)									
Initial workpiece is a cold rolling rod (h14)	160	250	500	---		35h14	620	33.22	33.84
Turning:	d _{min}								
.....rough (h11)	40	40	30	100	2-1010	31.2h11	160	31.01	31.17
.....semifinish (h9)	10	10	10	100	2-210	30.6h9	62	30.46	30.522
Quenching (HRC 42-46)	20	100	100	---	---	---	---	---	---
Round grinding (h7)	6	6	5	10	2-230 μm = 0.46 mm	30h7	21	29.979	30.00 mm

Then calculation of d_{max} on the previous manufacturing is carried out by sum of minimal size d_{min} on the previous manufacturing and tolerance for this manufacturing T (column 8) (Table 3). In our example: d_{max} = 30.46 + 0.062 = 30.522 mm.

After this calculation it is necessary to round accepted basic technological size $d_{i-1 \text{ accept}}$ of “shafts” in the greatest value ($30.522 \approx 30.6$). In accordance to 9 grade of tolerance (from column 1) tolerance zone $h9$ is written for a “shaft” without looking on the letter (fundamental deviation) of the design size. Accepted technological dimension is $30.6h9$ (see column 7, stroke “semifinish ($h9$)”).

Then it is necessary to continue by the similar order. Diameter of initial workpiece is accepted to 35 mm as rods are manufactured only with the even digits or divisible to 5 digits ($33.84 \approx 35$ mm) (see column 7, stroke “Initial workpiece is a cold rolling rod ($h14$)”).

For calculation of longitudinal dimensions, it is necessary to take into account quality of surfaces on the **right** and **left** sides of a workpiece (face end **A** and **B**). In order to don't forget this quality it is better to write parameters of a machined surface **in a stroke under a stroke of calculation** (Table 4).

Table 4 Calculation of minimal allowances and limit technological dimensions for surfaces of manufacturing

Technological transitions	Components of allowance, μm				Calculated minimal allowance, $z_{\text{min}}, \mu\text{m}$	Accepted technological size, $d_{\text{accept}}, \text{mm}$	Tolerance, $T, \mu\text{m}$	Calculated limit sizes, mm	
	R_z	h_{de}	ρ	z				d_{min}	d_{max}
1	2	3	4	5	6	7	8	9	10
External surface (length of the sleeve) $50h9(-0.062)$									
Cut off a workpiece (quality of a right face end) ($h16$) and left face on previous cut off operation	80	80	500			$56h16$	1900	54.06	55.96
Turning of a right face end ($h14$)	40	40	24	500	1160	$52.9h14$	740	52.16	52.90
Quality of a left face end ($h16$)	80	80	500						
Turning of a left face end ($h14$)	40	40	24	100	760	$51.4h14$	740	50.578	51.318
Quality of a right face end ($h14$)	40	40	24						
Flat grinding of a right face end ($h11$)	6	6	5	74	178	$50.4h11$	190	50.154	50.344
Quality of a left face end ($h14$)	40	40	24						
Flat grinding of a left face end ($h9$)	6	6	5	50	154	$50h9$	62	49.938	50

Conclusion

This format of a table and special order of calculation facilitates process of technological dimensions definition, do it more obviously.

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ПОЛУЧЕНИЕ ГРАНУЛИРОВАННЫХ КОМПОЗИЦИЙ ИЗ ТЕХНОГЕННОГО СЫРЬЯ

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Использование промышленных отходов в виде вторичного сырья – одно из главных направлений экономического развития и экологического благополучия страны. Согласно данным государственного доклада «О состоянии и об охране окружающей среды Российской Федерации в 2016 году» и федеральному классификационному каталогу отходов, утвержденным приказом Росприроднадзора № 242 от 22.05.2017, было выявлено, что ежегодно в России образуется около 30 тонн золошлаковых отходов (ЗШО). В связи с этим проблема использования техногенных материалов в производстве является актуальной.

Приблизительно 90% серы сегодня – побочный продукт нефтепереработки цветной металлургии. С экологической точки зрения соединения серы занимают одно из первых мест в мире по отрицательному воздействию на окружающую среду. Также, сера в виде пыли, может способствовать возникновению различных хронических заболеваний легких. Техническая сера устойчива к агрессивным средам и обладает высокой прочностью, а такие свойства, как водостойкость и гидрофобность, делают её идеальным материалом для использования в строительной промышленности [1 – 7].

Золошлаковые отходы являются достаточно дешевым продуктом. Применение ЗШО при изготовлении различного вида строительных материалов в существенной степени улучшает их физико-химические свойства. Кроме того, золошлаковые материалы по минералогическому и химическому составу практически идентичны минеральному природному сырью. Использование ЗШО в качестве основного сырья для