Parts and assemblies engineering

Lab-2

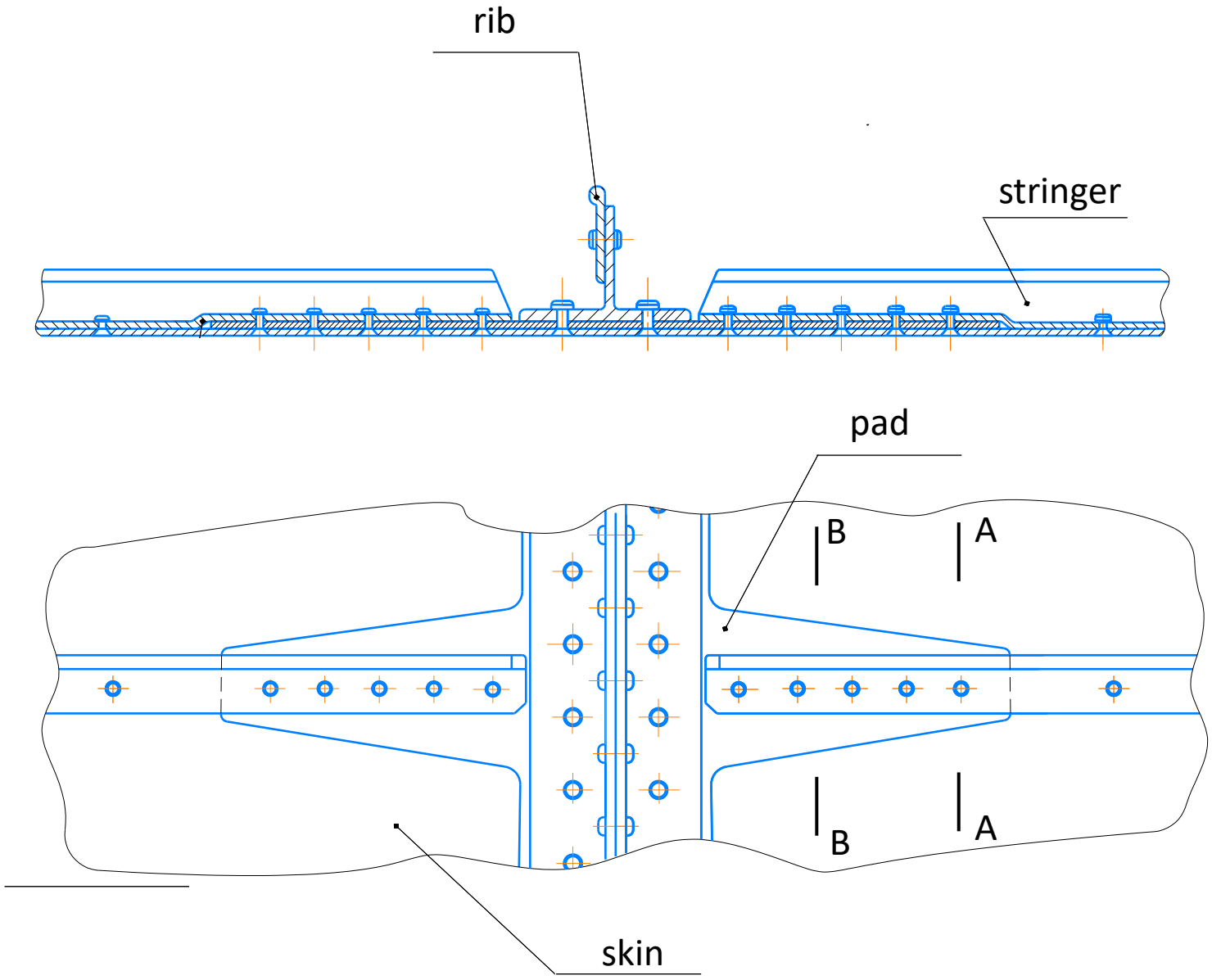
Denis Dukhnovskiy and Olga Rod

The task

Design the overlap joint (rivet) between two stringers and the rib

The goals of task:

- Determine the number of rivets
- Calculate the diameter of rivet
- And determine the overlap joint position between two stringers and rib with pad
- Determine the thickness and dimensions of pad



Task guide

1. Choose the task variant and obtain maximum tensile load for stringer:

$$P_{\max\_str} = A_{str} \cdot \sigma_{B\_str} \text{ or } P_{\max\_str} = P \cdot 1.3$$

Type of stringer	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
	H	B	S=S1	a	
710012	20	15	1.5	2	65

	Variants			
Variants	1	2	3	4
Type of stringers	710010	710003	710020	710012
P, N	1350	1000	1900	2400

2. Choose the materials of stringers, pad and skin

Task guide

Table – Variants of Task

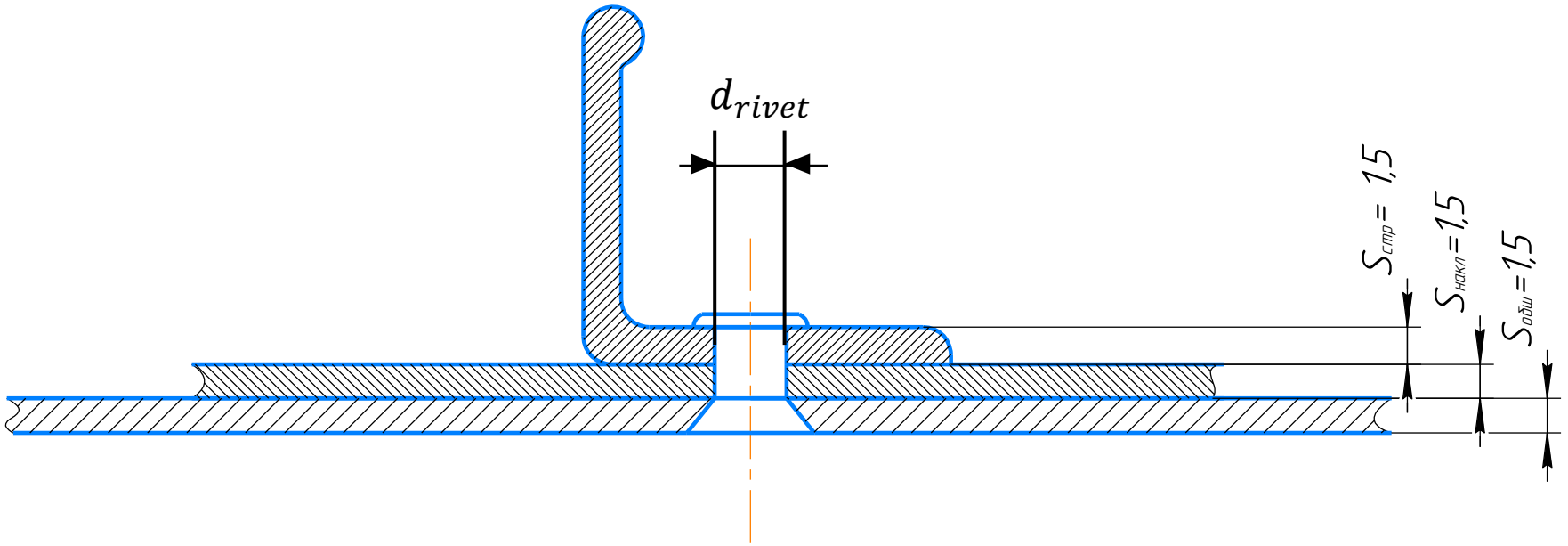
	Variants						
Variants	1	2	3	4	5	6	7
Type of stringers	710010	710003	710020	710012	420069	420075	710017
P, N	1350	1000	1900	2400	2700	3800	2300

Task guide

3. Preliminary diameter of rivet calculate by equation:

$$d_{\text{rivet}} = 2\sqrt{t_{total}}, \text{ where } t_{total} = t_{str} + t_{skin} + t_{pad}$$

t_{str}= S or S1 - thickness of stringer, t_{skin} - thickness of skin, t_{pad} - thickness of pad



For preliminary calculation thickness of skin and pad equal 1.5 mm

Task guide

4. Checking of tensile stress:

$$\sigma \leq [\sigma], \textit{ where } \sigma = \frac{P_{\max\_str}}{A_{str\_without\_rivet}}$$

$A_{str\_without\_rivet}$ - is the cross-section area of stringer without area of rivets;

$A_{str\_without\_rivet} = A_{str} - d_{\text{rivet}} \cdot t_{str}$;

The value of $[\sigma]$ is equal to $[\sigma] = 0.8 \cdot \sigma_{B,srt}$;

5. Calculate the coefficient of safety η :

$$\eta = \frac{[\sigma]}{\sigma}, \textit{ ideally } \eta = [1\ldots1.5]$$

Task guide

6. After assuming the material and diameter of the rivet we can calculate the requirable number of rivets :

$$n_{rivet} = \frac{P_{\max\_str}}{P_{\max\_riv}};$$

where n_{rivet} - determine with GOST 1 10642-72 data and the maximum number of rivets in a row along stringers axis a 5…6;

7. Check for bearing of stringer under rivet:

$$\sigma_{bearing} = \frac{P_{\max\_riv}}{d_{\text{rivet}} \cdot t_{str}} \leq 1.3 \ldots 1.5\sigma_{B,str};$$

8. And calculate the coefficient of safety η :

$$\eta = \frac{[\sigma]}{\sigma_{bearing}}, \textit{ ideally } \eta = [1\ldots1.5], [\sigma] = 1.3 \cdot \sigma_{B,srt};$$

Task guide

9. Checking the edge distance m for cutting failure:

$$2 \cdot d_{\text{rivet}} \leq m \leq 2 \cdot d_{\text{rivet}} + 2;$$

10. Calculate the actual shear stresses of the edge:

$$\tau_{act} = \frac{P_{\max\_riv}}{2 \cdot m \cdot t_{str}} < \tau_B;$$

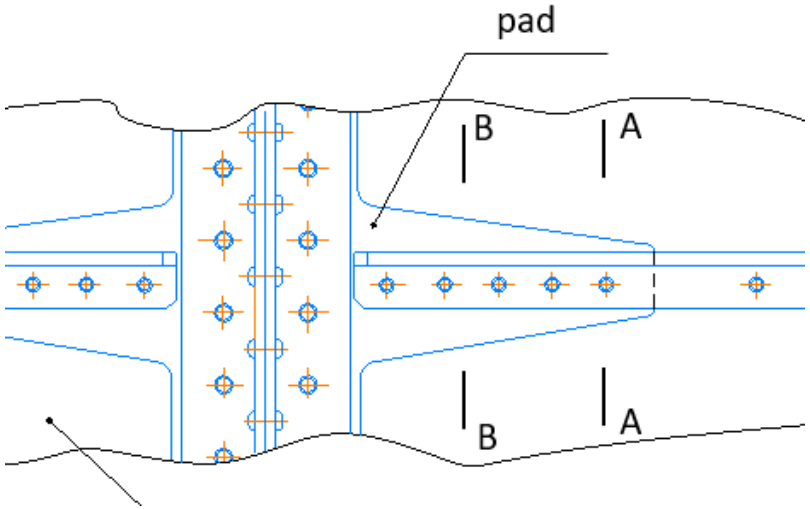
Where $\tau_B = (0.6 \ldots 065) \cdot \sigma_{B,str};$

Task guide

11. Analysis of pad:

Check the bearing in A-A section, assuming the thickness and material of the pad:

$$\sigma_{bearing,pad} = \frac{P_{\max\_riv}}{d_{\text{rivet}} \cdot t_{str}} \leq [\sigma]_{bear} = 1.3 \ldots 1.5\sigma_{B,pad};$$



One should use $\sigma_{B,riv}$ if $[\sigma]_{B,riv} \leq [\sigma]_{B,pad}$ in the upper expression;

Task guide

12. Tension failure in A-A and B-B sections:

The minimum width $b_{\min}$ of the pad in a section is obtained due to tension in section:

$$b_{\min\,A-A} = \frac{k \cdot P_{\max\_riv}}{t_{\text{pad}} \cdot \sigma_{B\_pad}} + n_{rivet\,A-A} \cdot d_{\text{rivet}}, where\ n_{rivet\,A-A} = 1$$

To evaluate the width b in the sections we should calculate the stress:

$$\sigma_{A-A} = \frac{P_{\text{str}}}{t_{\text{pad}} \cdot (b_{min} - n_{rivet\,A-A} \cdot d_{\text{rivet}})} \leq [\sigma]_{bear} = 1.3 \ldots 1.5 \cdot \sigma_{B,pad};$$

where: k≈1,15…1,2 stress concentration factor

$n_{rivet\,A-A}$ -number of rivets in the section A-A (equal to 1)

$\sigma_{B,pad}$ -strength of material of the pad

Task guide

13. Tension failure in A-A and B-B sections:

The minimum width $b_{\min}$ of the pad in a section is obtained due to tension in section:

$$b_{\min\,B-B} = \frac{k \cdot P_{\max\_riv}}{t_{\text{pad}} \cdot \sigma_{B\_pad}} + n_{rivet\,B-B} \cdot d_{\text{rivet}}, where\ n_{rivet\,B-B} = 1$$

To evaluate the width b in the sections we should calculate the stress:

$$\sigma_{B-B} = \frac{P_{\text{str}}}{t_{\text{pad}} \cdot (b_{min} - n_{rivet\,B-B} \cdot d_{\text{rivet}})} \leq [\sigma]_{bear} = 1.3 \ldots 1.5 \cdot \sigma_{B,pad};$$

where: k≈1,15…1,2 stress concentration factor

$n_{rivet\,B-B}$ -number of rivets in the section A-A (equal to 1)

$\sigma_{B,pad}$ -strength of material of the pad

Task guide

14. Calculate the length of the rivet:

For rivet joint the skin and stringers:

$$t_{stringer\_skin} = t_{str} + t_{skin}$$

Check the length with GOST 1 10642-72

For rivet joint the skin, stringers and pad:

$$t_{total} = t_{str} + t_{skin} + t_{pad}$$

Check the length with GOST 1 10642-72

15. Sketch the joint and prepare the report of lab

Task guide

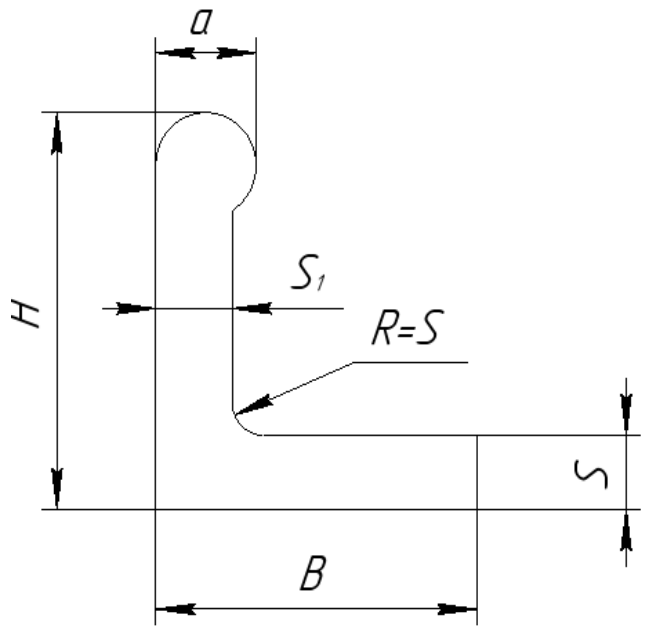


Table – Variants-1

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710010	H	B	S=S1	a	37
	20	13	1.0	3	

Task guide

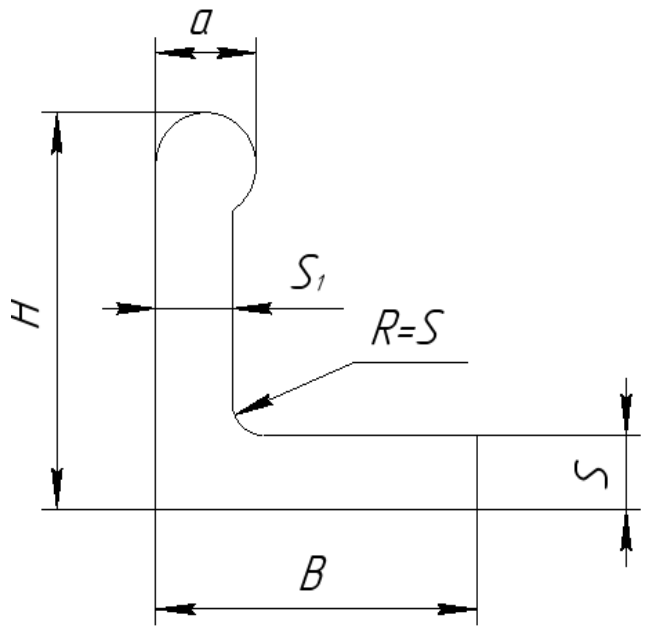


Table – Variants-2

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710003	H	B	S=S1	a	37
	15	18	1.0	3	

Task guide

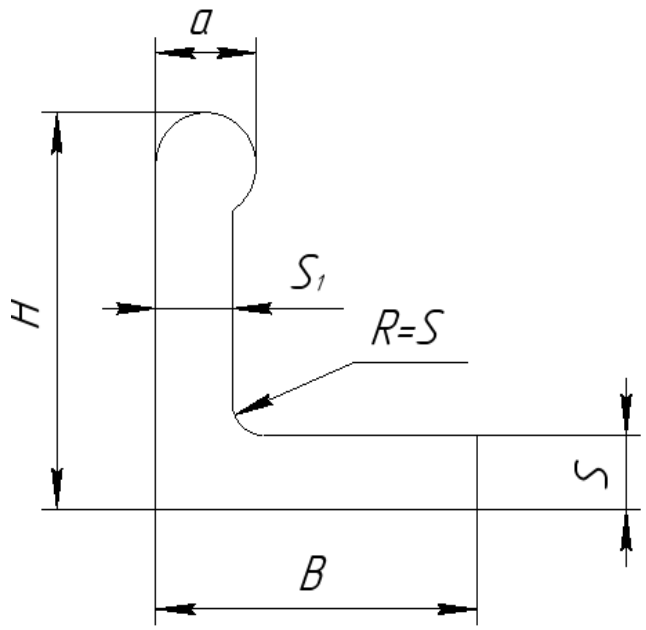


Table – Variants-3

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710020	H	B	S=S1	a	52
	23	13	1.5	4	

Task guide

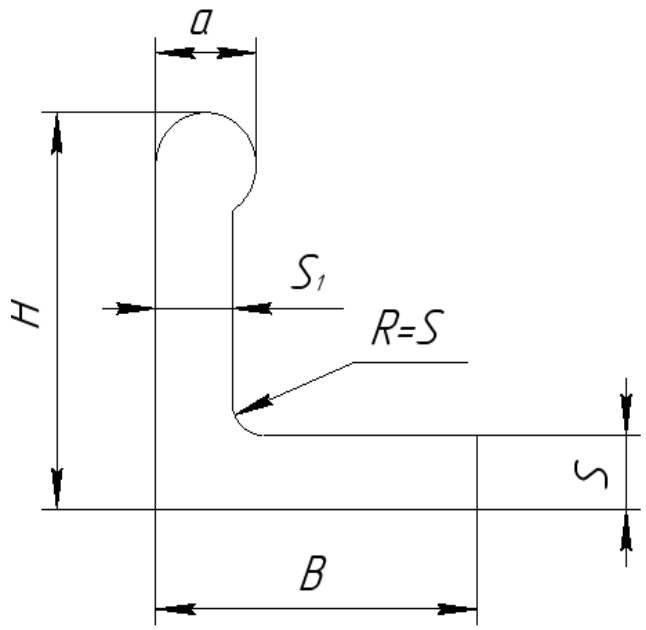


Table – Variants-4

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710012	H	B	S=S1	a	65
	20	15	1.5	2	

Task guide

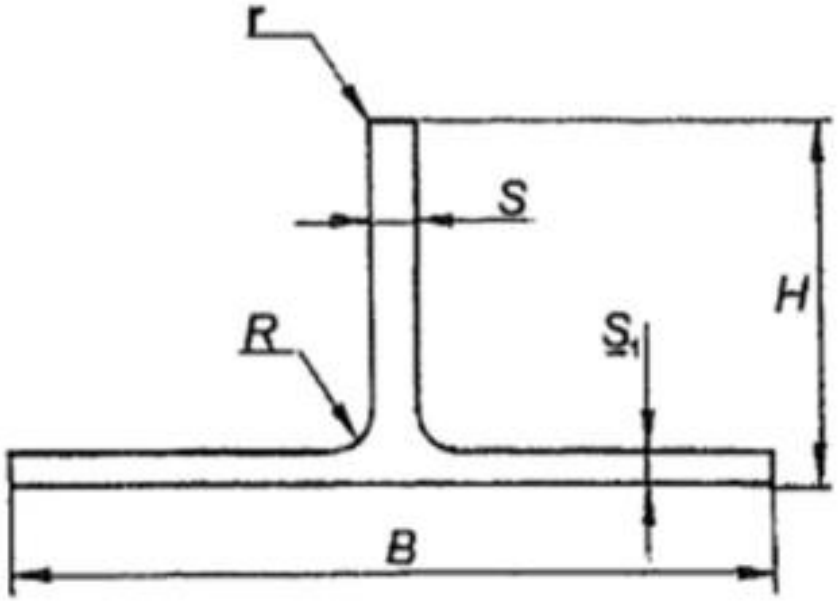


Table – Variants-5

Type	Dimensions, $[mm]$					Cross-section area, $[mm^2]$
420069	H	B	S	S1	R	82
	20	30	1.5	2.0	2.0	

Task guide

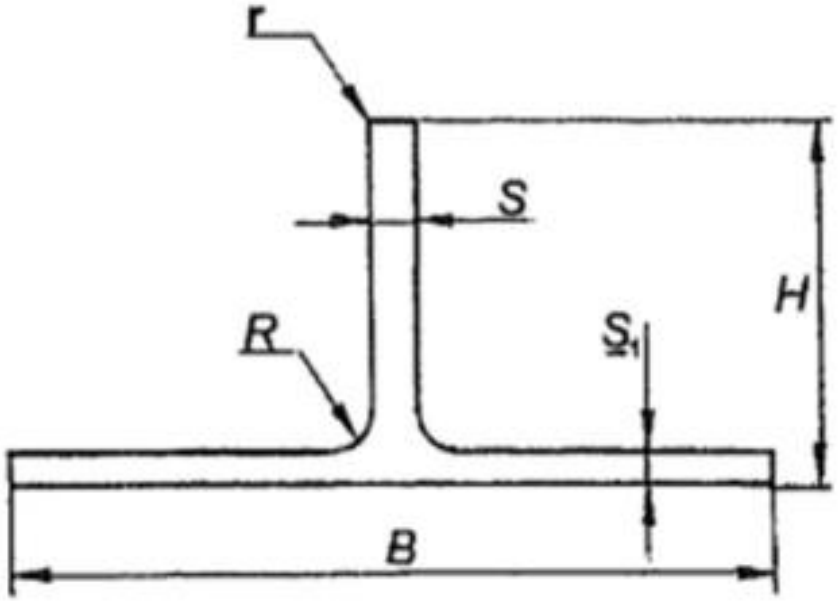


Table – Variants-6

Type	Dimensions, $[mm]$					Cross-section area, $[mm^2]$
420075	H	B	S	S1	R	105
	20	38	2.0	1.5	2.0	

Task guide

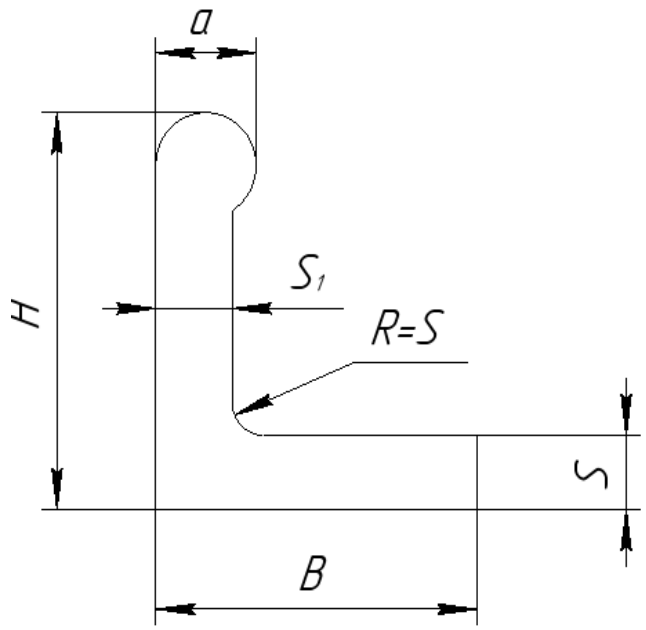


Table – Variants-7

Type	Dimensions, $[mm]$				Cross-section area, $[mm^2]$
710017	H	B	S=S1	a	98
	20	20	1.5	3.5	

Task guide

Table – Material Properties

Material	Ultimate tensile strength σ_B, MPa	Proof strength σ_{02}, MPa	Shear strength* τ_B, τ_{02} (% of tensile strength)	Modulus of elasticity E, GPa	Shear modulus G, GPa	Density, ρ g/cm^3
30ХГСА	1100	850	63	210	78	7,85
Д16Т	450	300	50	72	28	2,8
ВТ20	1000	910	50	110	44	4,5

* - ultimate shear strength and proof strength are approximated by taking the denoted percentage of tensile ultimate and proof strength respectively

Task guide

Link for section data, variants and PPT