Laboratory work № 3

THE EFFECT OF RADIAL INTERFERENCE ON THE DURABILITY OF THE STRIP WITH HOLES FILLED WITH BUSHINGS, BOLTS AND RIVETS

Purpose of work - and investigation of the effect of installation of bushings, bolts and rivets with countersunk and round manufactured heads on the fatigue life of aluminum alloy plates.

The content of the work

1. Familiarization with the typical design variants of the airframe elements of modern airplanes and helicopters with bushings, bolts and rivets.
2. Acquaintance with typical variants of making samples of plates with free holes and plates with filled holes.
3. Determination of the effect of installation the bushings, bolts and rivets with countersunk heads on the fatigue life of aluminum alloy plates.

Prediction of cyclic durability of plates with free holes and plates with filled holes

The service life and reliability of the airframe of an aircraft in specific operating conditions are determined by the durability of its structural elements. Special place among them is occupied by structural elements with holes: connections, hatches, cutouts, holes for laying routes of the functional systems of the aircraft, as well as drainage and mounting holes.

Long-term practice of aircraft operation shows that most of the dangerous destruction of structures occurs due to the occurrence of fatigue cracks in elements with holes. To increase the durability of airframe elements with holes and joints, rational choice of their geometrical parameters, ensuring a minimum level of stress concentration in the zones of probable fatigue failure, performs local plastic deformation of parts in the area of the holes, conduct surface treatment of the parts to be connected, and also install fasteners and bushings with radial interference (Fig. 3.1, 3.2).

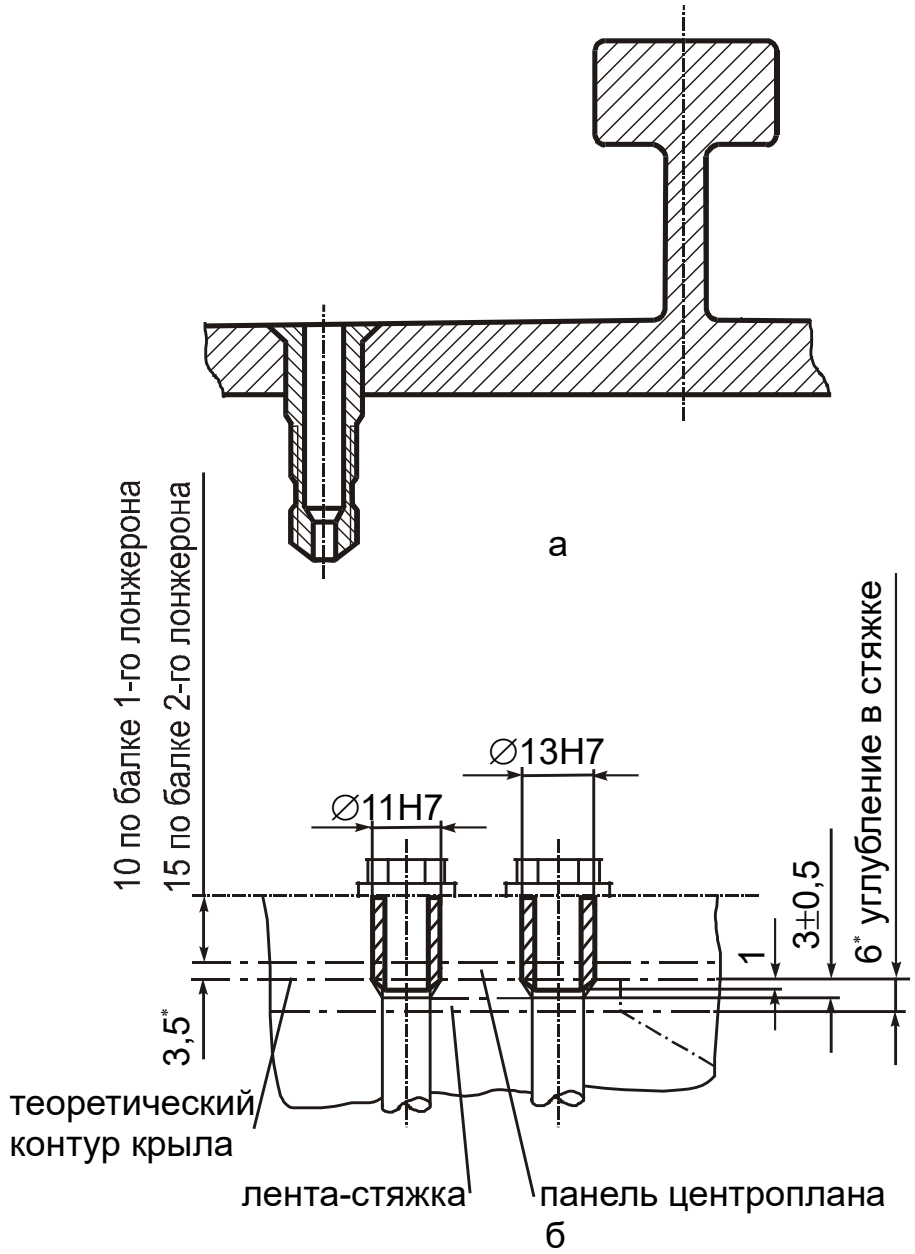


Fig. 3.1. Bushings installation variants in the design of aircraft ANTONOV: a - on the bottom surface of the center section inside the wing box of a heavy transport aircraft; b - on the bottom surface of the passenger aircraft wing

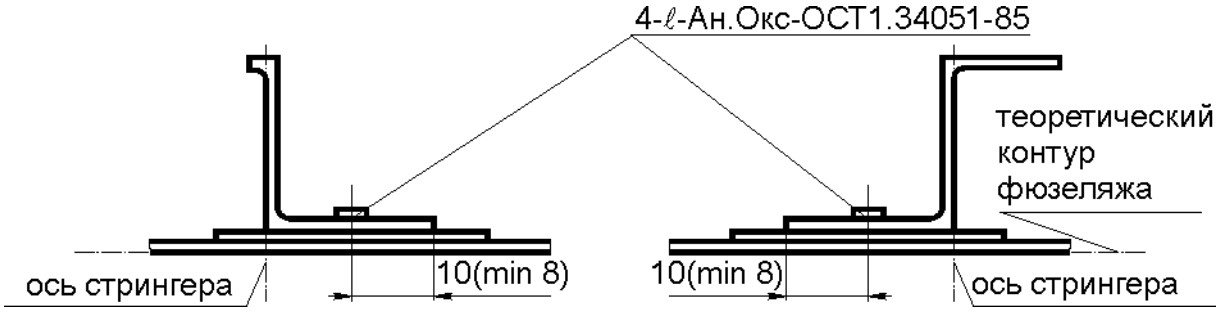


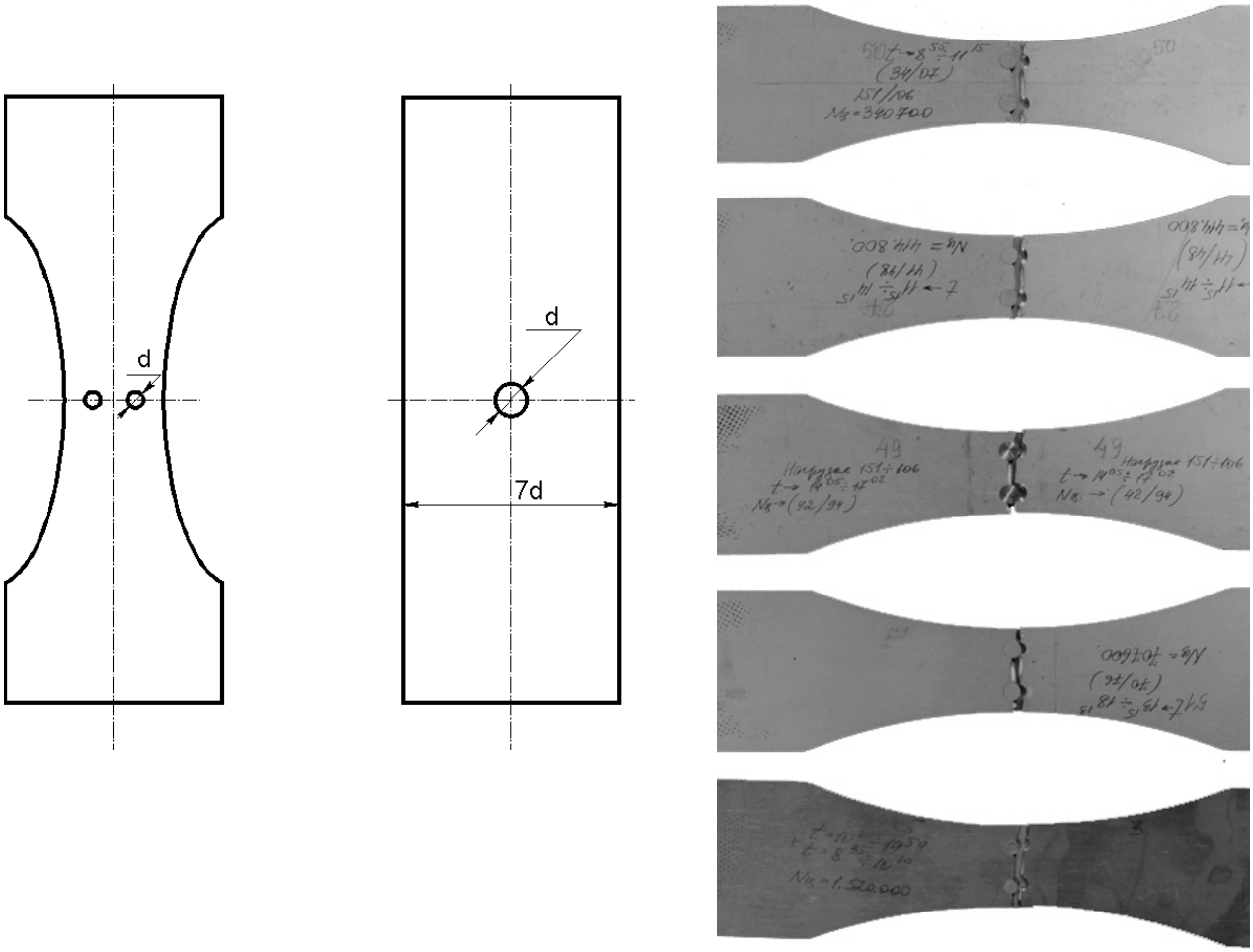
Fig. 3.2. Typical elements of the fuselage prefabricated panels passenger aircraft

It is possible to calculate the durability of structural elements with free and filled unloaded standard holes by using fatigue tests of structural elements with the specified irregularities of experimental dependencies, presented in the form

$$N\sigma_0^m = A,$$

where m – exponent, A – constant, σ_0 – stress of equivalent pulsing cycle in gross section, MPa.

Knowing σ_0 and coefficients m and A, it is possible to calculate the cyclic durability of plates with free and filled unloaded holes (Fig. 3.3).



а б

Fig. 3.3. Variants of sample plates with free and filled sleeves with no holes (a) and the nature of the destruction of the samples (b)

Values m and A presented in tables. 3.1 – 3.3.

Table 3.1

The parameters of the S-N curve of the constructive zones of the airframe with free holes and holes with bushings

Sample type	Plate material	Bushing Material	B/d	Joint Interference, %	m	A
Plate with a hole	Д16чТ	--	4	--	3,1705	$2{,}4465\cdot10^{11}$
Plate with a hole	В95пчТ1	--	4	--	1,9402	$3{,}1789\cdot10^{8}$
Plate with a bushing	Д16чТ	30ХГСА	12	1±0,2	4,5131	$9{,}7673\cdot10^{14}$
Plate with a bushing	В95пчТ1	30ХГСА	12	1±0,2	2,9151	$8{,}5266\cdot10^{10}$

Table 3.2

S-N curve parameters of the airframe zones with bolts

Sample type	Plate material	Fastener Type	d_0, mm	Radial Interference s	Tightening moment, Н·м	m	A
Plate with a bolt	Д16АТ	Bolt OCT1 31103-80	6	--	--	3,57	$1{,}9471\cdot10^{12}$
			6	--	30	2,5879	$8{,}3498\cdot10^{10}$
			6	1,5	30	2,663	$1{,}3812\cdot10^{11}$
			6	1,5	--	3,9087	$8{,}5902\cdot10^{13}$

Table 3.3

Parameters of the S-N curve of airframe zones with free holes and with rivets

Sample type	Plate material	Fastener Type	B/d and d_0, mm	Radial Interference, %	m	A
Plate with a hole	Д16АТ	--	7,54	--	3,6581	$6{,}758\cdot10^{12}$
Plate with a rivets		Countersunk OCT1 34052-85	7,54	1 … 4	4,833	$1{,}794\cdot10^{16}$
Plate with a rivets		Round OCT1 34040-79	7,54	1 … 4	4,415	$5{,}853\cdot10^{15}$

Individual tasks to perform laboratory work are presented in Table. 3.4.

Таблица 3.4

Individual tasks for laboratory work

№	σ_0, MPa,		№	σ_0, MPa,		№	σ_0, MPa,		№	σ_0, MPa,	
1	184	130	8	177	123	15	170	116	22	163	109
2	183	129	9	176	122	16	169	115	23	162	108
3	182	128	10	175	121	17	168	114	24	161	107
4	181	127	11	174	120	18	167	113	25	160	106
5	180	126	12	173	119	19	166	112	26	159	105
6	179	125	13	172	118	20	165	111	27	158	104
7	178	124	14	171	117	21	164	110	28	157	103