Increase of reliability of contact networks of electric transport, due to increase of strength of the joint unit of pipes of different diameters

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Abstract. The feature of the stress state of the supports of the contact networks is the presence of a joint of pipes of different diameters, the ultimate state of which is determined, as a rule, the strength of the weld. The proposed unit allows to increase the reliability and strength of the connection and also exclude the presence of a weld bead on the outer surface of the pipe of smaller diameter in the place of its attachment to the upper end of the support ring.
Key words: Reliability, transport, contact network, pipe connection

One of the main elements of the contact network are the supports that provide the given position of the contact suspension in the plan and profile above the roadway, due to which the transmission of electricity to the rolling stock and the reliability of the current collection are realized. Because of their lack of redundancy, they directly affect the continuity of the technological process of transportation, and in case of destruction they create a threat to violations of traffic safety and people's lives.

The analysis of damage to the supports of the contact networks of urban electric transport made it possible to identify two characteristic problems: metal supports - damages in the junction of pipes of different sections; Reinforced concrete supports - corrosion of concrete and reinforcement.

To connect the links of the two link steel pillars to each other, a smaller diameter pipe is welded with six wedges. In a pipe with a larger diameter, holes are made under the places of the wedges. Then the lower link is pushed with force to the upper, after which welded joints connect a pipe of larger diameter with wedges. The pipe joint is closed from above by a flange, which is welded with a discontinuous suture.
Fig. 1. Steel standard bearings:
a - type of OS; б - type OS-2B; в - type OSC; г - type of OSG;
1 - body of support; 2 - flange; 3 - wedge; 4 - overlay, δ = 8; 5 - base; 6 - the door;
7 - pipe Ø 45x4; 8 - overlay δ = 10

The connection of pipes of different diameters is carried out through the end face (Fig. 2, a).

Fig. 2. Types of connection of tubular rods of different diameters
a) butt by means of a face piece, б) connection through a profile with ribs,
в) pipe in the pipe with cross mortise cutters, г) joint through intermediate plates, д) connection
with gradual transition to a smaller diameter (cold rolling), е) with a conical liner, ж) welded combined
connection with a flange, з) combined bolted compound.

For the supports of contact nets, the essential question is the weldability of the slice with the main
rods. The peculiarity of the stressed state of supports with such connections is the presence of a joint
of pipes of different diameters, the limiting state of which is determined, as a rule, by the strength of
the welded seam. Even with the maximum allowable weld joints, the strength condition is not met.
Which leads either to an increase in the cross section, or the introduction of additional elements in the
form of plates, edges to increase the strength of the nodal section. With this increase in the cross
section, the cross section naturally leads to over-consumption of steel, given the massive construction
of the supports. And the introduction of additional elements in the unit on one side increases the laboriousness, on the other, worsens the aesthetic qualities of the supports (Figure 3).

Fig. 3. The actual state of the supports and their assemblies

The pipe connection assembly of different diameters includes the ends of pipes of larger and smaller diameters on which the respective connecting parts are connected, connected by tightening bolts, the connecting piece of the larger diameter pipe \( D_0 \) is an end plug with holes for passage of the coupling bolts connected to the end of a larger diameter pipe. The connecting part of a pipe of smaller diameter \( d_0 \) is made in the form of a support ring whose internal diameter corresponds to the diameter \( d_0 \), the base of the support ring has a cylindrical belt with an outer diameter \( D_0 \) which, to the height \( L \) from its upper boundary to the upper end of the support ring, decreases to a diameter \( d \), the base outside is planted on the end of a pipe with a smaller diameter, hot-fit flush with its end, which is welded to the base of the support ring by a welded seam with edge cutting; holes for a spanner with holes coaxial to the holes in the end plug are formed along the contour of the outer surface of the base of the support ring. The support ring and the end plug are interconnected by tightening bolts inserted from the inside of the end plug into its holes, the heads of which are welded to it, and for connecting pipes of larger and smaller diameters \( D_0 \) and \( d_0 \), respectively 325 and 219 mm, their walls are respectively 10 and 9 mm, and the height \( L \) of the support ring and the outer diameter of its upper end \( d \), respectively 200 and 225 mm, the outer diameter of the support ring \( D(x) \) is determined, depending on the current coordinate \( x \), measured from the upper boundary of the cylindrical base belt of reference ring, from the table.

| \( x \), mm | 0   | 5   | 10  | 15  | 20  | 25  | 30  | 35  | 40  | 50  | 100 | 200 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| \( D(x) \), mm | 325,0 | 289,8 | 271,3 | 259,8 | 252,1 | 246,5 | 242,4 | 239,2 | 236,7 | 233,2 | 228,7 | 225,0 |
The proposed construction makes it possible to increase the reliability of the connection and its strength by increasing the moment of resistance of a pipe of smaller diameter, with a bearing ring mounted on it, in the area of its attachment to a pipe of larger diameter, providing a smooth transition from diameter $D_0$ to diameter $d_0$, as well as exclusion on the outer surface of a pipe of smaller diameter in the place of its attachment by the upper end of the support ring.

The shape of the outer surface of the support ring that surrounds the end of the smaller diameter pipe is selected so that in all sections of the connection the bending stresses do not exceed the allowable value $\sigma_{\text{max}}$ and should be as uniform as possible while providing a smooth transition from diameter $D_0$ to diameter $d$. Based on these conditions, the most complete use of the support ring material is carried out and the local stress concentration associated with the abrupt change in the cross-section of the base of the support ring at the place of its rigid embedding in the end plug of a larger diameter pipe is eliminated.

The calculation of the pipe joint for bending of pipes according to the ANSYS program showed that the flexural stresses at the welding site of a pipe with a diameter $d_0 = 219$ mm to the flange, with the same loading scheme as for the proposed sample of the junction unit, is 359.4 MPa, which is 32.8 %, which is greater than the value obtained in the calculation for the proposed connection variant.

Conclusions: The proposed connection option allows to increase the reliability of the connection and its strength, and also to exclude the weld on the outer surface of a pipe of smaller diameter at the place of its attachment with the upper end of the support ring.
References

[1] Afanasyev A S 1988 *Contact networks of tram and trolleybus: A textbook for SPTU* Moscow: Transport 264 p

[2] Kuznetsov I L, Sabitov L S, Isaev A V 2012 *Structures with joints of steel pipes of different diameters* Kazan: KGASU 123 p

[3] Sabitov L.S. Development and investigation of joints of pipes of different diameters, *Izvestiya KazGASU*. 2008. № 1 (9). Pp. 102-105.

[4] Sabitov L S, Kuznetsov I L, Gatiyatov I Z 2014 Experimental studies of joints of pipes of different diameters in the supports of contact networks of electric transport *Bulletin of Civil Engineers* No 6 (47) pp 90-95

[5] Kuznetsov I L, Sabitov L S *Node of connecting pipes of different diameters* Patent for the invention of the Russian Federation No 2365805

[6] Kuznetsov I L, Sabitov L S *Method for manufacturing a junction of pipes of different diameters* Patent for the invention of the Russian Federation No 2382266