Structure Design of Hydraulic Replacement System for Damaged Tower

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Abstract. In this paper, hydraulic replacement system of the damaged tower material is researched. The hydraulic replacement device is set out along main material; using the reinforcing plate and connecting bolt holes of double column battens angle steel tower to design the hydraulic replacement system for damaged tower, this paper mainly studies the problem of connection mode between hydraulic replacement system and tower, length adjust device and angle adjust device.

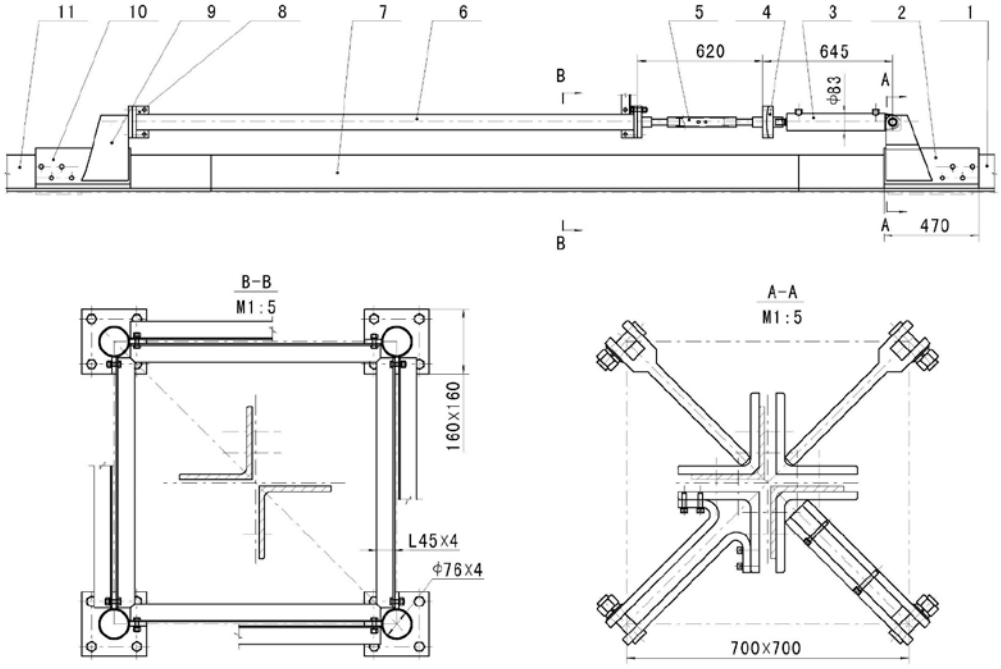
Introduction

Many types of overhead transmission line tower, is mainly divided into angle steel tower and steel tube tower, especially in the high voltage transmission lines, most are angle steel towers. But because of the section properties, the angle steel is easily deformed by external shocks. So the research of rapid repair technology of angle steel tower damaged tower material has important significance.

Structure design

Considering economy, hydraulic replacement system of the damaged tower material is suitable for material deformation is less than 300mm, is better than pole-tower in saving time. In this paper, the hydraulic replacement system of tower material relies on the Nanyang - Jingmen AC line Strain tower designed by the Northeast Electric Power Design Institute, tower material uses double column battens angle steel, namely two angle steels back to back, with a leg that a cross affixed plate bolted to steels. When damage occurs above 8th segment of angle steel tower, the 20t lift hydraulic replacement system can be used to replace damaged tower material, as shown in Figure 1.

Hydraulic replacement system of the damaged tower is supported by tower main material (bottom) (1) connected by bottom connecting plate (2). The top lift produced by cylinder (3) transmits through angle adjust device (4), length adjust device (5), structure segment (6), flange (8), bearing plate (9) and connecting plate (top) (10) to tower main material (top) (11), which can uninstall the damaged tower material loads and then to replacement the damaged tower material.



1—tower main material (bottom);2—connecting plate (bottom);3—cylinder; 4—angle adjust device;5—length adjust device;6—structure segment; 7—damaged tower material;8—flange;9—bearing plate;10—connecting plate(top); 11—tower main material (top).

Fig.1 Construction of hydraulic replacement system of the damaged tower material

Cylinder design

Hydraulic replacement system of the damaged tower material consists of four sets of hydraulic jacking system, top lift of each hydraulic jacking system F' is 5t, the pressure level is 16MPa, and top lift should be met:

$$\mathrm{F} = \frac{\pi}{4} D^2 P_n = \frac{\pi}{4} D^2 \times 16 \geq \mathrm{F}' = 50000 \tag{1}$$

So inside diameter of cylinder d is:

$$\mathrm{d} \geq \sqrt{\frac{\mathrm{F}'}{4\pi}} = \sqrt{\frac{50000}{4\pi}} = 50000 = 63.09\mathrm{mm} \tag{2}$$

Inside diameter of cylinder d is 66mm. Thickness of cylinder should be met:

$$\delta \geq \frac{P_{\max} D}{2.3[\sigma] - 3P_{\max}} = \frac{1.5\times16\times63}{2.3\times148-3\times1.5\times16} = 5.63\mathrm{mm} \tag{3}$$

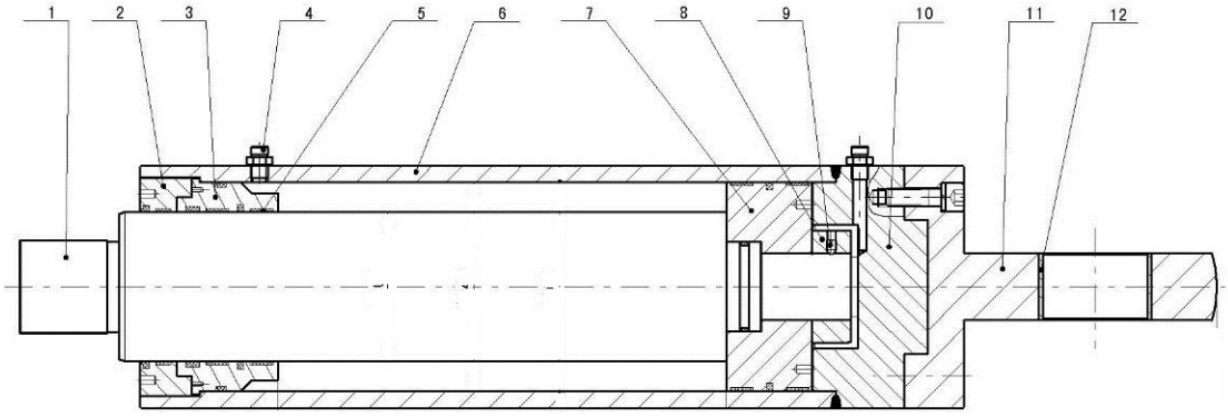
$P_{\max}$ - the maximum allowable pressure, $P_{\max} \leq 1.5P_n$.

σ_s- the yield strength of cylinder material (MPa).

Set the cylinder thickness as 6.5mm, so the outside diameter of cylinder D is 79mm, and the rated pressureof cylinder P as follows:

$$\mathrm{P} = 0.35 \frac{\sigma_s (\mathrm{D}^2 - d^2)}{\mathrm{D}^2} = 0.35 \times \frac{370\times(79^2-66^2)}{79^2} = 39.11MPa \geq 16MPa \tag{4}$$

Cylinder of replacement system as shown.



1—piston rod;2—cylinder lid;3—bearing gland;4—oil inlet and outlet;5—seal and support pieces;6—cylinder barrel;7—piston;8—piston gland;9—set screw;10—bottom of cylinder;11—hinged bearing under cylinder;12—wear sleeve.

Fig.2 Assembly diagram of cylinder

Design of connection between cylinder and tower material

Damaged tower main material uses double column battens angle steel, its section shape as shown in Figure 3.

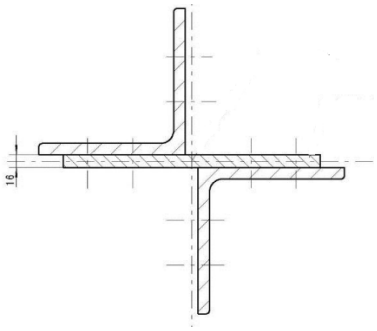


Fig.3 Double column battens angle steel

Hydraulic replacement system of the damaged tower material contains four sets of hydraulic jacking system, so needs four support points connected with double column battens angle steel, connecting four L200 × 20 angle steels on the L180 × 16 double column battens angle steel, there are four support plates connected on the angle bisector of each L200 × 20 angle, and three different types of support plate structure are shown in Figure 4.

When the support plates bolt on the L200 × 20 angle steels, M20-6.8 bolt is selected, which its $[\tau]$ is 132MPa, minor diameter d_1 is 17.29mm. There are four support plates in all, and each support plate is connected with four bolts. So shear stress of the M20 bolt is:

$$\tau = \frac{F}{m \times n \times \frac{\pi}{4} d_1^2} = \frac{20 \times 9.8 \times 10^3}{16 \times 2 \times \frac{\pi}{4} \times 17.29^2} = 26.1\text{MPa} \leq \frac{[\tau]}{n} = \frac{132}{s} = 26.4\text{MPa} \quad (5)$$

m- the number of bolts,

n- number of boltplanes in shear

s- safety factor

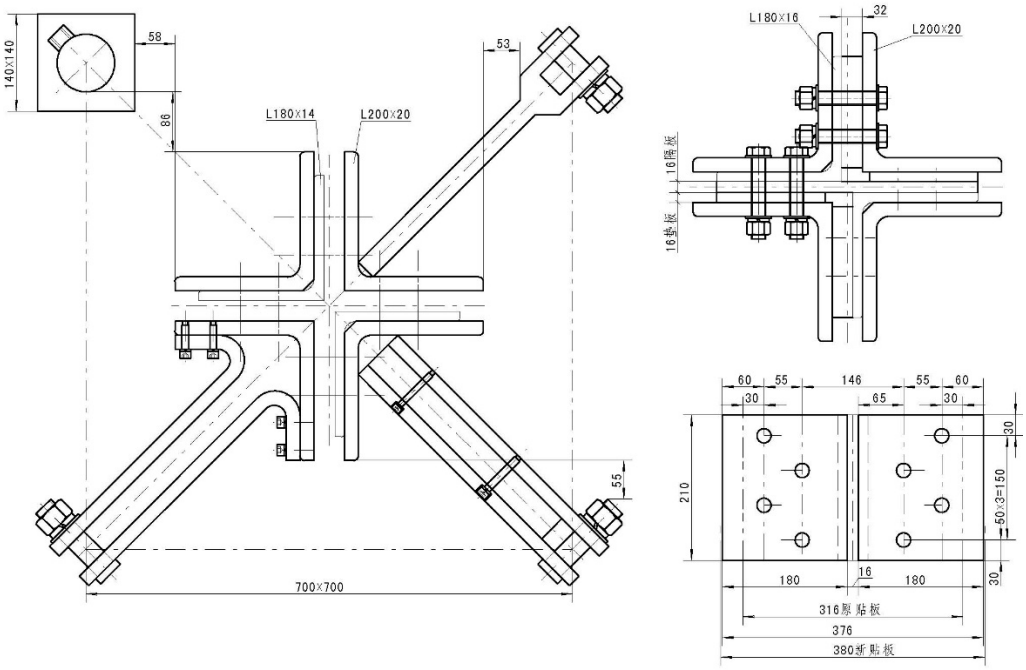


Fig.4 The connection mode of cylinder and double column battens angle steel

Safe position of hydraulic replacement system on a tower is shown in figures 5. Among them, the left figure roughly shows that the replacement status of the longest segment, the middle figure shows the connection of cylinder on both ends of the tower, right figure approximately shows that the situation of cylinder installation.

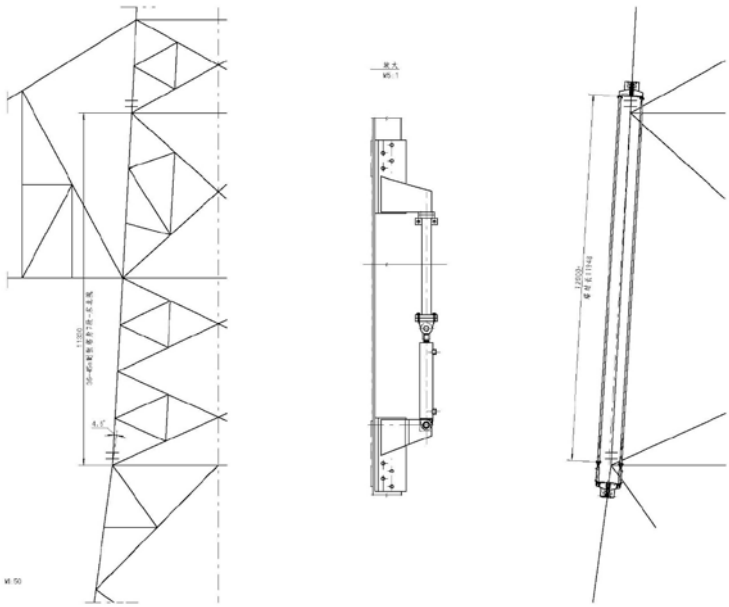


Fig.5 The installation position of cylinder on the tower

As can be seen from the figure 5, there is a huge length difference between cylinder and the replacing tower material, so piston rod and top supporting of tower material need to be connected by mid structure segment, which the mid segment use standard segment design. While the length regulator and the angle regulator are installed for expanding the applicable scope of hydraulic replacement system of the damaged tower material.

Conclusions

In this paper, hydraulic replacement system of the damaged tower material is designed by the design of hydraulic cylinder, connection between cylinder and tower material, and other designs; replacement system can economically and effectively replace damaged tower material whose

deformation is less than 300mm; the length regulator and angle regulator make the hydraulic replacement system be more compatible with more damaged tower material, and which meets actual work requirements.

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