The Reconstruction of Active Guyed Television Towers Without Broadcasting Stop

V.N.Gordeyev [1], Yu.Dzhur [2], A.Lyubin[3], P.Pavlyk[4], L.Solovyov[5]

V.N.Gordeyev : 3, Malyshko street, ap. 186, Kiev, Ukraine 253192
Tel/fax : (38044) 543-26-33. E-mail: vadims @ carrier.kiev.ua

The development of the television and various means of communication together with construction of guyed television towers make the problem of ensuring their reliability and accident free operation rather important.

Active growth of cities and industrial areas and the fact that guyed television towers have turned out to be in the center of living area have raised the problem of excluding the possibility of accidents entirely that has been suggested as an urgent task of their operation.

The reliability of the guyed television towers that means stability of their operation indices within the project limits during the definite period of time is taken as the principal determinant for their evaluation and operation forecast. That is especially important for the guyed television towers erected 25-50 years ago that require new antenna equipment to be installed.

Nowadays in Ukraine there are more than 200 guyed television towers that have been operated for 25-50 years, including towers 50-200 m high and some unique ones 350 m high.

Inspection of television and communication towers that have been operated for such a long period of time has proved considerable loss of their carrying ability and consequently reduction of their operation reliability.

The biggest reduction has been observed, as a rule, in the guy system, as a matler of fact, in all its elements. In particular the following drawbacks have been revealed:

- entire or partial destruction of the cables;
- fissure formation in mechanical devices and items the guy system includes;
- damage of corrosion protection drawbacks.

The main reasons caused such steelworks drawbacks are aggressiveness and humidity of environment, irregular renovation of the corrosion protection on the guys and steelworks items that all have led to considerable corrosive wear.

As for mechanical devices and items their wear is connected with the qualities of material accepted when designing their construction forms, the qualities that have been revealed during long operation.

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[1] Dr., Prof., Member of IASS, Vice Director, Institute «UkrNIIprojektstalkonstruktsiya», Kiev, Ukraine.
[2] Eng., General director, Trust «Krivorozhstalkonstruktsiya», Krivoy Rog, Ukraine.
[3] Dr., Head of department, Institute «Dneprprojektstalkonstruktsiya», Dnepropetrovsk, Ukraine.
[4] Eng., Deputy General Director Trust «Krivorozhstalkonstruktsiya», Krivoy Rog, Ukraine.
[5] Eng., Director, Dnepropetrovsk Television Broadcasting Center, Dnepropetrovsk, Ukraine.

In particular the masts erected in the 40-50 year were equipped with screw guy devices and mechanical items with welded elements that have worked out their wear resources of reliability for a long time operation. Revealed in them fissures and other drawbacks testify this fact.

The analysis of the anchors located below mark 0.000 and inspection of foundations while digging out have shown entire absence of corrosion protection and corrosion drawbacks, besides, ground waters have risen above the upper edge of some foundations.

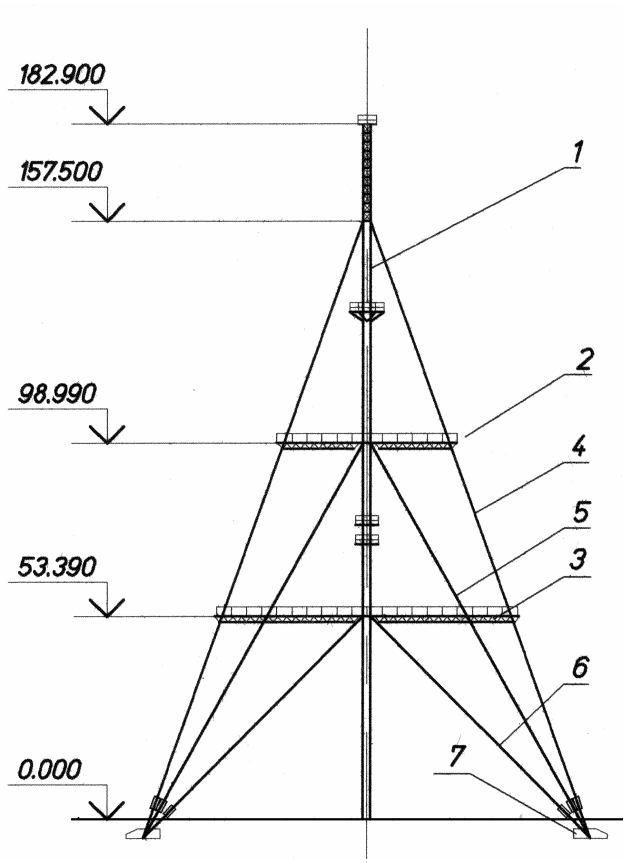

Fig. 1. 1 - Central mast shaft;
2,3 - Bars of upper and lower levels;
4,5,6 - Guys of the I, II and III levels,
7 - Foundation.

The analysis of actual conditions in the guy system and the method how to replace the guys are the subject of the present report. All the data are based on the reconstruction performed on a mast 182.9 m high in an Ukrainian city (fig 1).

The tower was erected in 1960. It is a construction with the central mast that is a steel tube 1600 mm in diameter. The mast is fastened by three levels of guys made of steel cables that are at angle 120^0 in the lay-out. All three guys of one direction are fixed to one foundation. The guys are fastened to the central mast at marks 53.900 m, 98.900 m and 157.500 m. The bottom level guys are made of a single cable 50.5 mm diameters. The first and the second level guys are of two cables 55 mm in diameter each. The bars are set in compliance with the guys. The bars are fastened to the central mast and to the cables by special joint hinges. The bottom of the central mast is rested on the carrying ring welded to the fixed foundation frame.

The undertaken inspections have shown that the mast operation under conditions of medium aggressive environment have caused considerable corrosion drawbacks of the cable especially in the joints of the guys with the bars.

In such joints according to the project with the purpose to get rid of squeezing the cables and focusing great concentrated transverse loads on the cable wire the circular bandages (tight steel bars wrapped by solid wind of wire) have been arranged. Such a solution of the problem has caused a seat of corrosion that in its turn predetermined especially strong corrosion destruction in these places. While opening the joints and inspecting the cables the corrosion destruction of the wire strands (up to 100% destruction of separate strands) has been confirmed.

Dismantlement of the joints that fasten the cables to the bars and inspection of bolts have shown their great corrosive wear up to 30-40% of their transverse sections. While opening corrosion blistering of the cables and breakage of the wire strands have been revealed. The cable in these places was being stratified when bending or knocking.

Visually the degree of the cable wear has been estimated as 30-40% loss of transverse section and correspondingly it has reduced the project reliability of the cable.

However, undertaken testing of the cables samples taken from damaged places have shown rather a greater loss of tensile strength that exceedes admissible limits taking into account obvious drawbacks. The samples of the cables cut out of the removed guys from the areas of intensive corrosion destruction have been tested.

Visual inspection of the sample and taken measurements have allowed to reveal partial destruction of four from seven strands within 800 mm. length.

The general wind of the cables and the wind of wire in strands have been broken. All wires including visually undamaged has got corrosion drawbacks up to 50% of diameter.

Basing on the measurements the total section of undamaged wires was estimated as 40-60% of the total section of the cable.

The samples have been tested by loading that hydrosystem of two hydrocylinders has produced.

The control of the loading was carried out in two ways:

- by a pressure-gauge for measuring the pressure of the liquid in the hydrosystem;
- by a mechanical dynamometer of tension.

The trial loading was applied gradually (50 kN each grade).

As a criterion to prove the loss by a cable its carrying ability was taken breakage of a strand. It was testified by a sound 'clap' when pressure in the hydrosystem fell down at the same time the sample got longer.

As the tests showed the entire work out of the cables under 600 kN force that is 40% of the project loading when the cable was broken off.

When exerting the load continuously accured breaking-off of the wire and then strands were fixed accompanying by sharp 'claps'.

All this allows to suggest corrosion drawbacks inside separate wires and strands that can not be seen. Besides, the character of destruction accompanied by separate sharp 'claps' during the tests raises the question of possible qualitative changes of the wire material (corrosion, fragility, loss of fatigue reliability etc.). this aspect requires special studying. However, even now the considerable fall of reliability and endurance in the guy system in due time is obvious and connected as with visual outside drawbacks so with inside breaking off.

So it can be stated that guy system has got less reliability and endurance margin in comparison with the entire construction. That is why generally admissible operation term for guys is 20-25 years meanwhile for steel antenna masts the terms may be 40-60 years that causes a necessity of their periodical replacement.

So guy system requires repeated reconstruction. This process causes as organization and technological problems as the question of uninterrupted broadcasting and communication.

The main request brought by television companies is stability of the position of the antenna equipment during the guys replacement to provide broadcasting without stop.

That is why the only way to solve the problem is the impose the reliability of maintaining the constant position of the mast where antennas are located.

Only this way allows not to disturb the antenna orientation and exclude broadcasting stop. It predetermines the general method how to perform what has been designed and developed on account of the following main positions:

- Necessity to improve the reliability of maintaining the position of the masts during reconstruction in order to provide broadcasting and radio transmission without stop;

- High safety and security in the centre of living area;
- Impossibility as a rule to use modern high-effective lifting-and-conveying machines for erection caused by little space of the construction site.

Spatial position of the masts during guys replacement can be only ensured by stable joints of cables to the masts. It allows to improve maintaining the position of the mast.

Taking into consideration repeated operations for the guys replacement (setting temporary guys, transferring tensions from the existing guys on the temporary ones, setting and fixing new guys, removing tensions from the temporary guys and transferring them on the new ones etc.) stability of the joints can be ensured by permanent tensions within the system of guys in each stage of reconstruction.

So the main criterion of improving the position of the mast is constant tensions in the guys during reconstruction regardless their correlation with the project ones.

To fulfill the reconstruction in accordance with the accepted technological chart aimed to improve maintaining position of the mast the complex of technological means has been developed in order to provide high degree of reliability while transferring the tensions from the existing guys to the temporary ones and then from the temporary to the newly set guys.

Traditional polyspast system can not be used for transferring tensions measured in kT under great loads. The manually switched on winch declined the cable by several cm, meanwhile, for example, declination of the third level guys by 12 mm increased or reduced the tensions by 10kN. On the second level tension of 10kN was produced by 8-9 m declination.

In accordance with this and taking into account domestic and foreign experience of guyed television tower erection and reconstruction a hydraulic gear was used in order to provide the greatest reliability, ease, and accuracy when transferring the tension.

Besides, all the equipment used to replacing the guys had got double protection that excluded a possibility to make a mistake during reconstruction.

The automatic system with proper software installed had been developed to control the tension in the guys. The system permitted to conduct the control and adjust the tensions simultaneously in one the guys of three levels.

To produce and test the guys the special test rig was designed and manufactured, it was equipment with the force reproducing hydraulic device, force measurement system, erective and other riggings to prepare the cables, pour in bushes, and transport the ready guys. The rig is 180 m long, it produces force 1000 kN.

The guys replacement started with the upper level. The sequence of actions was as follows:

1. Erection of auxiliary steelworks for fixing the temporary guys to the joint section of the mast.
2. Dismantlement of joint hinges of the bars from the side where the guys adjoins and then fixing the bars to the mast.
3. Control measurements to determine the actual tensions in the existing guys.
4. Setting the temporary guys and producing in them tensions equal to those in the existing guys. The tensions in the temporary guys are to be measured by pressure of liquid in the hydraulic system, in the regular by the applied dynamometer.
5. Dropping the tension in the existing guys to zero and their removal cable by cable.
6. Setting the new guys and devices producing in them tension equal to those in the temporary guys.
7. Drop the tensions in the temporary guys to zero and their removal.

8. Fastening the joint hinges of the bars to the guys in accordance with the project.

During reconstruction the position of the mast was under permanent supervision by geodetic instruments. In case if the vertical axis reclining from its initial position it was improved immediately. Having replaced one level guys all the assembly equipment was dismantled and then set again on another level guys.

In the final stage of the replacement the tensions were adjusted and brought up to the project figures and the mast position was improved. This work was carried out by special device used to adjusting and controlling tensions in the guys after replacing all the guys when the tensions were brought up to the project tensions the position of the mast was under control.

Control of the tensions in the guys and their correction according to the project and in connection with the position of the mast were carried out automatically with transferring of specific commands to an operator of the hydrosystem .

The experience had shown good validity of the equipment for the whole period of reconstruction under low temperature, besides, it has taken little time to replace the equipment from one level to another.

The reconstruction has been performed in the winter under unfavorable weather conditions. It has taken 80 days including prior to work period, manufacturing and testing the guys, removal of the existing guys and setting the new ones.

The described method for replacement of the guys with application of specially elaborated rigging having hydraulic gear has ensured high accuracy in operation, smooth forces relieving from the existing guys and efficient control over forces.