THE TECHNOLOGY OF FABRICATION OF THE POWER PIPES FOR HYDROTECHNICAL WORKS

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Abstract: *Hydrotechnical works are different form other engineering works because they are subjected to the action of the water, which is manifested by mechanical, physical – chemical and biological action. The quality and economic efficency of hydrotechnical works is established in the design stage, when the technologity of the works's execution given by the design is essential. This paper presents the stages of determining the optimal dimensions of the pipes, the technology of assembling the pipe from the hydroelectrical plant Râul Alb from Caraș - Severin County and the building of different devices for the increase of assembly productivity by welding the pipe's sections.*

Keywords: power pipes, dimensioning, execution, hydrotechnical works.

Introduction

Hydraulic energy resources are indispendsable in order to ensure energy consumption, which is in a state of continual growth. Conventional hydraulic energy is the energy produced by the running of rivers; it is also called hydro energy.This energy is obtained by transforming the potential energy of water from the barrier lakes into kinetic energy of the water duet o the flowing of water, which revolves the turbine and the drum of a generator which produces electrical energy.

Hydro energy is regenerable, due to the cycle of water in nature, with the help of solar energy. Hyrdo generated energy each year goes up to 2,1 million GWh, which represents between 16% and 18% from the consumption of electrical energy at world level. The yearly hydro production in Romania is of around 18 TWh, meaning 35% from the total consumption, but the potential of production is of 38 TWh/yearly.

Hydrotechnical works are different from the other engineering constructions by the fact that they are subjected to the actions of water, which are of a mechanical, physical-chemical and biological nature.

The dimensions and the shapes of hydrotechnical works are in tight correlation to the natural conditions of emplacement: topographical, geological and hydrological conditions. Generally, these conditions are unique for each work, each hydrotechnical work having original characteristics. Even the designing and the undertaking of these works are not done according to a template, but by taking into consideration the specific local conditions of each emplacement.

The determining of the optimal dimensions of the power pipes

Based on the calculus relations given in the speciality's literature, MathCAD was used to design a program for establishing the optimal dimensions of the power pipes, which are the main element of an hydrelectrical emplacement.

In the first stage, we determined the available hydraulic power of the hydroelectrical emplacement for flow capacity between 2 and 140 cubic metres/second and rough falls of between 50 and 300 metres, which are valued up to 400 MW. If the water runs through the pipe with a speed of 5 metres/second and 2,5 metres/second in a laminar regime, if the angle of the power pipe in respect to the orisontal is of 32 degrees and if on the route there are two elbow bends and two butterfly throttles, the percent loss of hydraulic power is the one shown in figure 1. In this figure the following were noted: 1 – gross fall of 50 metres; 2 – gross fall of 100 metrs; 3 – gross fall of 150 metres; 4 – gross fall of 200 metres; 6 – gross fall of 300 metres.

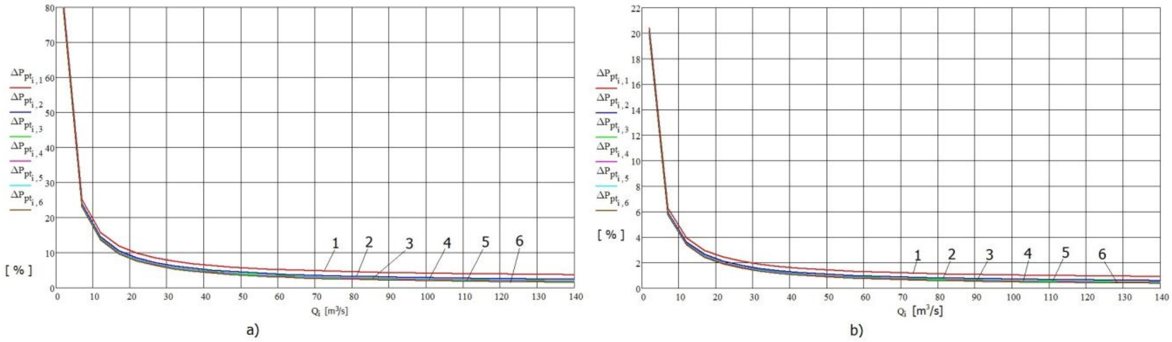

Fig. 1: The variation of percent loss of hydraulic power; flowing speed of 5 and 2,5 metres/second.

We can observe that for flow capacities installed under 10 cubic metres/second, the loss of hydraulic power in the pipe is very high, over 20%, and they go up to 80% for a flow capacity of 2 cubic metres/second, no matter how high is the fall of the hydroelectrical emplacement. This means that for flow capacities of under 20 cubic metres/second, the flowing speed must be reduced by increasing the diameter of the pipe. If the flowing speed is reduced to half (2,5 m/s), an increase of the inner diameter of the pipe from 0,7 to 1,0 metres, the hydraulic loss will be reduced to under 20% event o a 2 cubic metres/second flow, which will make the hydroelectrical emplacement efficient.

In the following stage, we analysed the inner diameter of the pipe from an economical point of view, on the criterion of the minimal cost of the building investment, and the results are shown in figure 2.a. By comparing the inner diametres, determined by the economical crieterion and the criterion of the flowing speed of 5 metres/second in laminar regime (figure 2.a) it has resulted that, in respect to the minimal cost of investment, we recommand the reduction of the inner diameter of the pipe with up to 15% in the case of a capacity flow of 140 cubic metres/second and a fall of 300 metres.

We can see that according to the economical criterion, the reduction of the flowing speed of the water through the pipe is recommended for installed flows of under 10 cubic metres/second, and for capacity flows higher than 10 cubic metres/second the flowing speed must be increased up to a maximum value of 5 … 6 metres/second. Also, we can observe that from an economical point of view the reduction of the pipe's diameter is recommended at the increase of the fall, of inner pressure, which can be practically done by building the pipe in stages, with a big diameter at the superior side.

In order to determine the thickness of the pipe's wall, we began from the condition of stability of the shell rings at atmospheric pressure, given by the relations foreseen in the technical prescription PT C4/2-2003 – Guide for designing, building, assembling and repairing of stable metallic recipients under pressure. In the first stage, we determined the limits of the ratio between length and diameter (figure 2.b), for a distance between the sections ' prop stays of 12 metres. We can observe that only for flows lower than 7 cubic metres/second we must apply a different calculus relation or the distace between prop stays must be reduced to 6 metres.

In the following, we are showing the variation margins of the thickness of the pipe' s wall(figure 2.c), for the criterion of stability at external pressure and for the crieterion of verification of inner pressure for the welding coordinates applied to the steel for under pressure recipients ' foils R510 and R360 STAS 2883/2-9, for diametres determined by the economical crieterion and by the crietrion of flowing speed of 5 metres/second, in a laminar regime. In figure 2.c we have noted: 1 – the margin of the wall's thickness by the crietrion of stability to external pressure; 2 – the margin of the wall's thickness by inner presure for R510 steel and the optimal diameter for the crietrion of flowing speed of 5 metres/second in a laminar regime; 4 – the variation of the wall's thickness by inner pressure for R360 steel and the optimal diameter by economical criterion.

Based on the determining of the values of the inner diameter and of the thickness of the pipe's wall, we determined the geometerical characteristics of its transversal section (area, resistance mode). Using these, we verified the pipe in respect to the solicitations of its own weight and of the weight of the water inside the pipe and of the axial force resulted by the friction between the water and the pipe's wall, and the safety coefficients for R510 steel are shown in figure 2.d. The following were noted in figure 2.d: 1 – for the diameter given by the flowing speed of 5 metres/second in laminar regime; 2- for the diameter determined according to the economical crietrion; 3 – for the diameter given by the flowing speed of 5 metres/second in laminar regime at the increase of the distance between prop stays at 24 metres; 4 – for the diamter determined according to the economical criterion at the increase of the distance between prop stays at 24 metres.

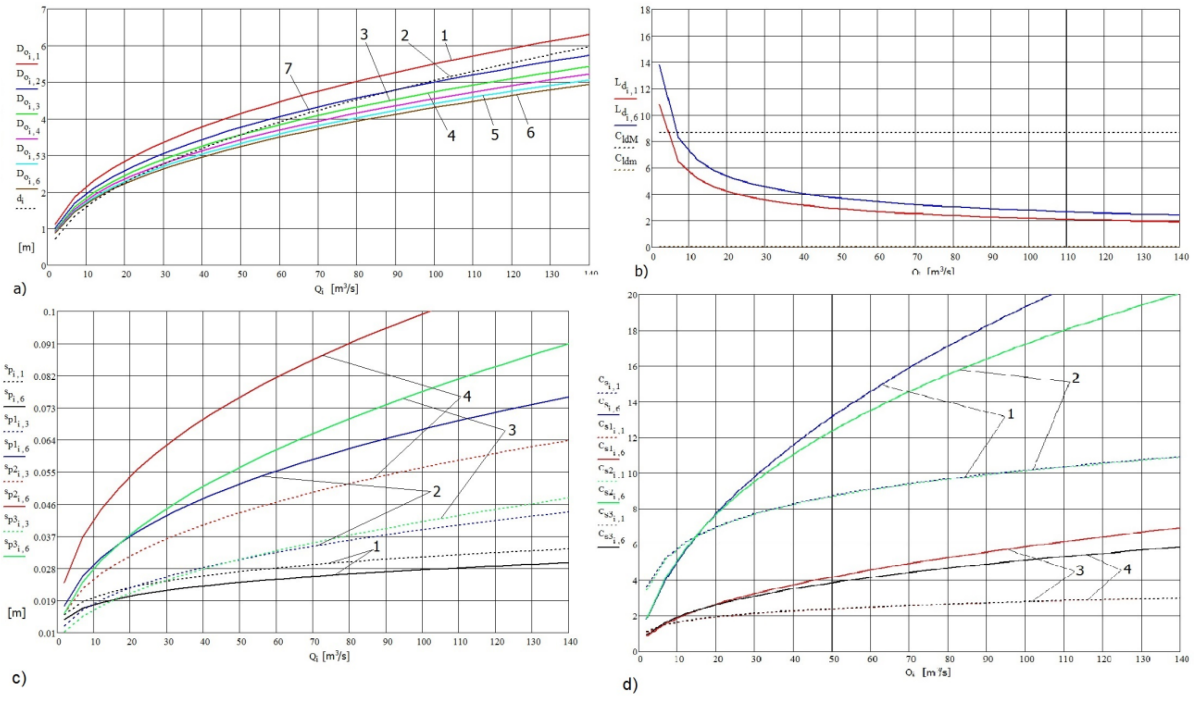

Fig. 2. Determining the diameter and thickness of the pipes's walls.

The technology of assembling the pipe at the hydroelectrical plant Râul Alb

The Râul Alb hydroelectrical plant uses the volume of water which is accumulated in the Poiana Rusca lake, and is part of the Hydroenergetic Emplacement Bistra-Poiana Mărului – Ruieni – Poiana Rusca. The project was first approved by decree no. 294 from 1981. But the construction in earnest of the plant began in 2005.The Poiana Rusca barrier has a height of 75 metres, 30 million cubic metres of water and a surface of 112,2 ha. The water goes into the plant coming from the Poiana Rusca lake through a subterrean gallery of 4273 metres, with a diameter of 3,1 metres and through a power pipe with a length of over 385 metres, with an inner diameter of 2,5 metres.

Due to the great length of the pipe and the terrain conditions which imposed that the pipe should be made with 2 inclining angles (21 and 40 degrees), the pipe was assembled on three levels.

The pipe on the first level was assembled in the first stage and it has 29 sections. The assemblying order is the same with the transportation order, from low to high, meaning from section 29 to section 1.The first section that was assembled was section 29 with half of the elbow bend of section 28, in accordance with figure 3, where the following were noted: 1 – anchor block; 2 – fixed section support; 3 – mobile section support; 4 – assemblied pipe section; 5 – exterior working platform; 6 – interior working platform, 7 – pipe section to be assemblied; 8 – transportation carriage; 9 – cable deviation roller; 10 – electric hoisting gear of 12,5 tf; 11 – link between hoisting gear and section; 12 – 60 ton crane; 13 – cable with hooks; 14 – railway for exterior platform; 15 – railway for the trolley that transports sections; 16 – collecting channel.

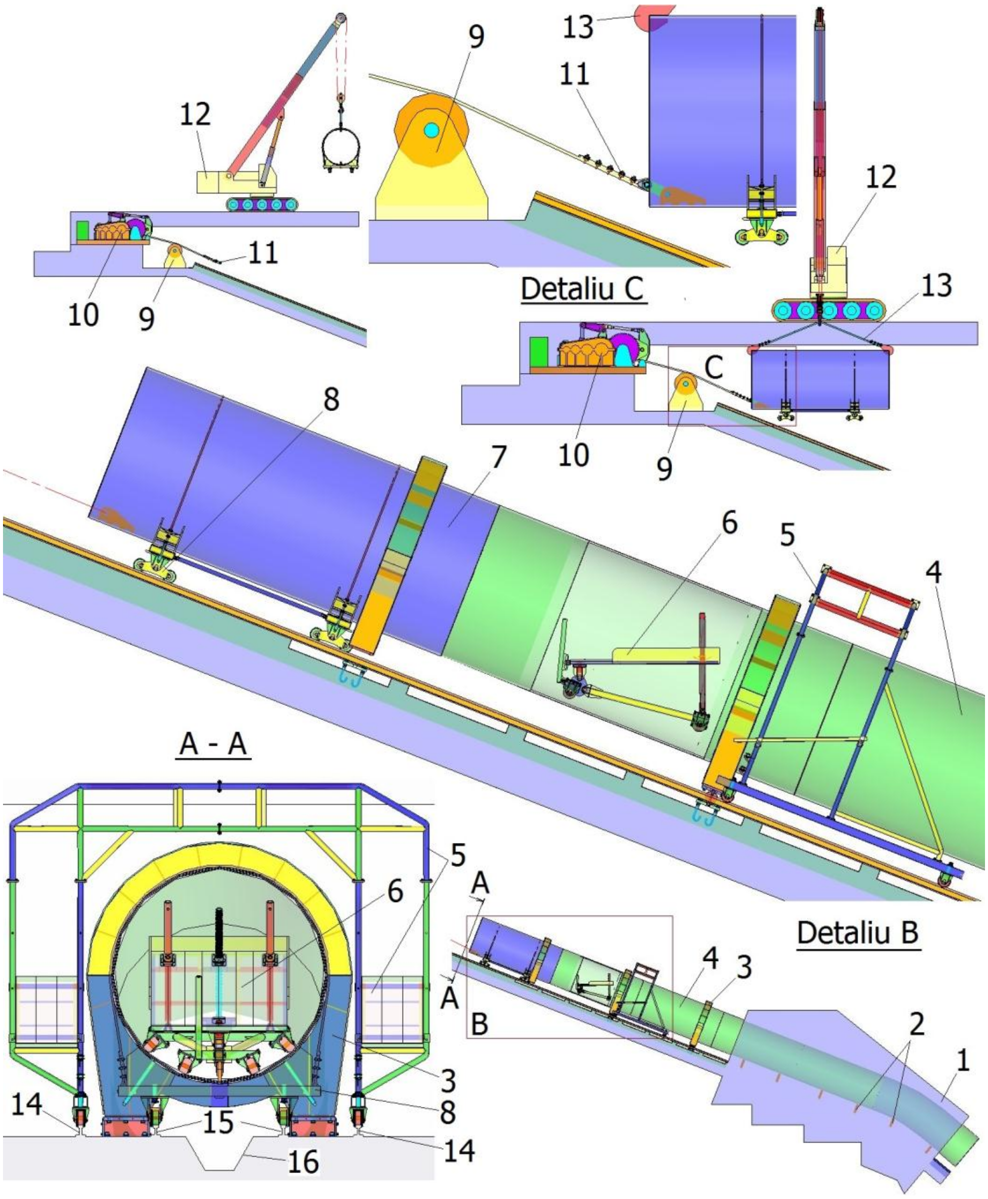

Fig. 3. The technology of assembling the pipe at the superior level

After welding in the sections 29, 27,26 and elbow bend 28 the anchor block is made out of armored concrete, no. 1.

On the area of the first inclined level, (inclined at 21,39 degrees) two railways are assembled, using light railway rails (type 18 or type 40), one with the track spacing of 1435 mm, no.15, for launching the pipe section, no.6, with the help of the trolley, no.7. The second railway has the track spacing of 3.200 mm, no.14, and its purpose is to roll the exterior platform, no.4.

The inner diameter of the pipe section no.6, is 2.500 mm, and the thickness of the sheet is 25 mm. The length of the section is 6 metres and it is made of steel for under pressure containers R510 STAS 2883/2-91.

The functioning of the installations for launching the sections on an inclined plane (figure 3) is done in the following stages:

1. With the help of the auto transport platform the pipe section is brought, no. 6, with a

2550 mm diameter, a length of 6.000 mm, and a mass of 9365 kg, on the platform placed at the mouth of the adduction gallery. The section is lifted by a crane on tracks, (no. 10, with a lifting capacity of 60 tons) from the transportation platform an dis placed on the two trolleys, no. 7, with a good centring of the trolleys in regard to the ends of the section and with an S hook at the inferior part. The section is placed on the two trolleys with the help of two dead-eye cables, that are tightened with the help of a cable tightener type C-C;

2. The section and the trolleys are lifted (a mass of 10.120 kg) with the crane on tracks, with the help of the hooked cable, no 11. First a test is done at ground level (lift up at 200 mm off the ground) and then the crane lifts and pivots, until the section and the trolleys are on the right rolling track;

3. A link is made between the traction cable of the launching trolley, no. 9, and the S medium eyelet welded on the pipe section, by way of a thimble S412 (1037229), of 5 collars size 30 DIN 741, and two junction plates of 25 mm and of two pins of **F**60x150 mm;

4. On the rollway is launched the assemblage formed by the pipe's section and the trolleys by using the electric trolley with the charge of 12,5 tF, until we get into the assembly position, at 50 … 60 mmm from the end of the assembled section. The movement of the section on the railway must be permanently supervised from the stairs built along the railway. We must also supervise the fitting of the cable on the pulleys that were placed along the pipe's course.

5. The trolleys are blocked on the railway, the pipe section is taken down from the trolleys and the section is grossly centered with the help of the filleted rods M40 from the trolleys and we continue getting the section near until we make the joint (the 3 mm blank) of welding between the sections;

6. We fit in the abutment for sustaining the section's downstream end, the linkage pipes between the trolleys are taken apart, the filleted rods from the downstream trolley are weakened and the trolley is pulled and linked with the upstream trolley;

7. The second support for sustaining the first section downstream from the trolleys, the final centering of the section on the abutment is made and topographical measurements are made in order to determine the correct position of the section in respect to the pipe's axis;

8. We take down the link of the cable of the launching trolley of the section and we tie the cable to the central eyelet of the upstream trolley, the filleted rods from the upstream trolley are weakened and the trolleys are pulled from under the section to the superior side, where they are taken by the crane and placed on the assembly platform.

These 8 stages are repetead (1 … 8) for transporting the second section. When the second section is lowered, the two working platforms (for the exterior and the interior of the pipe) are also lowered. The platform for working on the inner side is introduced in the pipe section an dis anchored to the S eyelet of the section. The exterior platform is placed by crane on the exterior railway, with the spacing of 3.200 mm and is anchored to the trolley's sections.

1. The momentary linkage by welding of the two pipe sections is done, the centring of the section is checked and the final welding of the sections is made;

2. We check the welding bead and repair it if necessary, after which we undertake the thermical treatment for detensioning the welding bead;

3. Anti-corrosive protection is made on the area of the welding bead between the sections;

For the second section, we repeat stage 1 to 11 and after assembling the three sections they are given to cementing and the anchor block is made, no. 1

For the next 23 pipe sections, we repeat stages 1 to 11. For these sections we must also assembly the mobile support of the section, which is transported with the section, and is assembled. This support can be used as a sustaining element of the section to be assembled, due to the possibility of vertically regulating the two base plates, of sustaining the pulleys, of compensating the dilatation or the contraction of the pipe.

After launching section number three, the launching installation will be dismanteled, and teh launching of sections 2 and 1 will be done directly by the 60 tons crane with tracks. The sections will be placed on some abutments which will become part of the concrete from the mouth of the aduction gallery.

In order to move the working platforms from inside and outside the pipe we can use the transportation trolley of the sections, on an inclined plane. The working platform at the exterior of the pipe can be blocked by two dead-eye cables, which can be fixed on the feet of the mobile abutment of the upstream section. The working platform inside the pipe will be anchored to the launching eyelet of the section that is being assembled.

Conclusions

With the help of the diagrams shown here, we can quickly determine the percentual loss of hydraulic power, the optmisation of choosing the inner diameter of the pipe and of the thickness of its wall. These can also be used in the case of concrete instances of hydroelectrical emplacement, on a previously established pipe route and can be used for building microhydroplants with installed flows of under 10 cubic metres/second.

Determining the inner diameter and the thickness of the pipe's wall are basic elements for building up the assembling technology of the pipe. This technology is made up of determining:

- The length of the pipe sections regarding mass, weight and manouvre space;
- The necessary devices and equipments necessary for the transportation and manouvering of the pipe sections;
- The technology of assemblage by welding one to another the pipe sections;

An important problem on the construction site is represented by transportation on an inclined plane and the centering of the pipe sections. In order to solve this, a transportation sledge was designed and the centring of the pipe section is made using lifting jacks with screws.

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