UDC 412.625

APPLICATION OF HYDRAULIC TURBINES IN THE MAIN OIL PIPELINES

VLADISLAVA KOVRIZHNYKH, ALIAKSEI VARONIN
Polotsk State University, Belarus

In this article, in order to follow the world trends in energy savings and finding alternative ways of generating electricity the possibility of using hydro turbines on the main oil pipeline has been offered. A placement of hydraulic turbine on the main oil pipeline was proposed by the end of the gravity section of the pipeline route.

Over the past few decades in most industrialized countries fairly sophisticated systems for the conversion of fossil fuel energy into electricity have been established and implemented. A further increase in the technical and economic indicators of those facilities requires finding new non-traditional methods with which it would be possible to significantly improve technical and economic performance of power equipment and improve environmental performance at the same time.

One of possibilities to solve this problem at industrial plants which use natural gas, liquid as fuel is the use of detanders or hydraulic turbines.

The turbine is a device that converts the potential energy of substance into mechanical energy. These devices can be divided into liquid (hydraulic turbine) and gas (detanders) according to the type of used energy sources.

Detanders are used in the technological processes with the use of steam as the primary energy source (oil refineries and chemical plants) as well as in oil and gas fields with the use of the transported material.

Hydraulic turbines are categorized into active and reactive. The wheel of reactive turbines is completely submerged in the water flow as well as in the active turbines working wheel operates at atmospheric pressure and is driven by individual water jets. The most powerful of hydraulic turbines are reactive [1].

According to their embodiment hydraulic turbines can be divided into direct-flow and radial-axial.

Hydraulic units which equipped with direct-flow tube hydraulic turbines are designed for installation on flat water courses with a pressure of 3 to 15 m. The maximum capacity of units depending on the existing pressures and flow rates changes in the range of 30 to 300 kW. These units can produce sustainable energy for independent consumers and as a part of energy system.

Hydraulic units which are equipped with radial-axial turbines are designed for installation on the mountain and foothill streams with a pressure of 35 to 165 m. The maximum power capacity of the unit depending on the existing pressures and flow rates changes in the range of 250 to 630 kW [2].

Operation of hydraulic turbines is characterized by the following basic parameters: pressure of water before entering into turbine, efficiency and water flow.

In the world hydraulic turbines are installed at hydroelectric power stations. Hydroelectric power plants are usually built at or by natural water bodies (rivers), i.e. at open water channels with construction of dams and reservoirs. For efficient production of electricity hydroelectric power stations require two main factors: a guaranteed supply of water throughout the year and possibly steep slopes of the river.

In order to follow the world trends in energy saving and search for alternative ways of energy it was offered to use hydraulic turbines on the main oil pipeline, i.e. in a closed oil channel of the technology object.

Taking into account that hydraulic turbine at its operating process requires the constant presence of fluid flow and the large slope of the stream (pipeline) it is the most rational and expedient to locate hydraulic turbine at the end gravity section of the main pipeline.

A gravity section presents the part of pipeline in which fluid moves filling the tube partially partial section under influence of gravity force. The pressure in the gas space above the free surface of the oil remains constant; therefore oil flow in pipeline is called pressureless. At the same time the difference in pressure between the beginning of the gravity section and the end section exists and equals to the difference of geodesic heights of these points. Stationary gravity areas can only exist in the downstream directions.

The hill on the route from which oil flows to the end point of the pipeline by gravity called a saddle point. There may be several points.

The distance from the initial point of the pipeline to the nearest saddle point is called the gauge length of the pipeline. In hydraulic calculations the length of the pipeline is considered as gauge length. If the line of hydraulic gradient drawn from the end point of the route never intersects the profile of pipeline it can be concluded that there is no saddle point and the estimated length is equal to the total length of the pipeline.

The line of hydraulic gradient on gravity section runs parallel to the profile of the pipeline at a distance $p_0/\rho g$ over it (p_0 – the gas pressure in the area above the liquid). The slope of the line of hydraulic gradient on the gravity section is characterized by the tangent of the angle formed by the profile of the pipeline and the horizon.

After saddle point the oil moves partially filling pipeline. The pressure on this area is lower than at any other point in the pipeline: it is equal to the saturated oil vapor pressure [3].

The energy lost by movement of oil after saddle point is used inefficiently. Installation of hydraulic turbine at the end of gravity section will allow using this energy of oil movement.

In the oil pipeline system of our country a gravity section exists on the route of the main oil pipeline «Druzhba Polotsktransneft». It was formed by exceeding the geodesic heights of saddle point over the rest of the points in the course of the movement of oil to the end station.

For the selection of hydraulic turbine it is necessary to have data on the disposable flow Q and pressure H at the end of gravity section. The consumption in the pipeline is 1640 m^3/h, the geodesic difference in height between the pump stations is 68 m, and the pressure before the final station is 46m.

As a result of comparison of the known values of pressure and consumptions to the areas of working fields of hydraulic turbines it became clear that the turbine could generate 100 kW of electricity. The installation of this unit will provide electricity from the energy of oil flow and will solve the problem of the partial energy supply of the station, i.e. makes it possible to reduce the consumption of electricity from third-party suppliers. The received electric power from the hydraulic turbine can be consumed by electric pumps or other processing units at the station.

In terms of operation of the main pipeline installation of hydraulic turbine before the final station requires solving several engineering and operational tasks.

Mounting of hydraulic turbine into the main pipeline will restrict the square of oil flow that will cause the inability to launch the treatment devices and intelligent inspection equipment. The location of the turbine at the bypass line causes the fluid flow separation and twice flow reduction that affects the corresponding decrease in power generation by hydraulic turbine generator.

The placement of hydraulic turbine in pipeline, filled incompletely, will decelerate fluid layers and ingoing of oil saturated vapors into a liquid. This results in cavitations that will trigger cavitations' corrosion and destruction of the metal pipe.

The location of hydraulic turbine at the end of the gravity section at a considerable distance from the terminal station raises the question of the method of power transmission to the final station. As a consequence the final pressure may not be enough for the processes within the end station.

Despite these operational tasks we have proposed the idea of installing hydraulic turbine at the end of gravity section of the main pipeline because it is innovative and has its own advantages as it allows to consume unused energy of oil flow.

REFERENCES

1. Modern engineering [Electronic source]. – 2016. – Access mode: http://www.magi.ru. – Date of access: 20.10.2016.
2. Enegy. [Electronic source]. – 2017. – Access mode: http://www.energetika.in.ua/ru. – Date of access: 15.01.2017.
3. Main pipeline transport / S.M. Vainshtok [et al.]. – M. : JSC «Nedra-biznescentr», 2004. – 624 p.