ЖЫЛУ ФИЗИКАСЫ ЖӘНЕ ТЕОРИЯЛЫҚ ЖЫЛУ ТЕХНИКАСЫ
ТЕПЛОФИЗИКА И ТЕОРЕТИЧЕСКАЯ ТЕПЛОТЕХНИКА
THERMOPHYSICS AND THEORETICAL THERMOENGINEERING

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Determination of the diameter of the main steam pipelines of the supply pipelines of the Heat electric generation with a capacity of 325 MW

Due to the high pace of industrialization of the Republic of Kazakhstan, the electric power industry is becoming one of the priorities in our country. To increase the volume of electricity, the power industry is being re-equipped with an increase in the technical and economic level of electricity production. In this light, the re-equipment of the Electric central heat looks the most promising. Leads to the effective production of not only electricity, but also thermal energy. The main indicator of the economical operation of a thermal power plant is the specific consumption of thermal energy for the generation and release of a unit of electrical energy. The article provides calculations of the diameter of the main steam pipelines of the supply pipelines of the Electric central heat with the capacity of 325 MW. Data on the choice of steam generators and turbines (drum with natural circulation and without reheat) are given. The authors proposed a block diagram with the same type of steam generators using a common station steam main. In order to use the redundant production selection at the Electric central heat, a sectional layout of the main steam pipelines is selected in connection with the fact that it is a more universal and reliable scheme. The authors make an initial calculation of the internal diameter associated with the water speed, which is compared with the recommended values. The diameter of the line from the deaerator to the collector of the pump of the electric pump is determined.

Keywords: heat power engineering, CHPP, heat electric generation, steam line, pipeline.

The electricity industry is one of the priorities in the state policy of Kazakhstan. In order to ensure the growth of power consumption, energy security and reliability of the operation of thermal power plants, a plan of measures for the development of the electric power industry of the Republic of Kazakhstan has been developed [1].

The technical re-equipment of the energy industry includes a set of measures to increase the technical and economic level of certain processes for the production of electric and thermal energy at thermal power plants on the basis of the introduction of advanced technology and technology to raise the level of mechanization to automate the process as a whole, to replace obsolete and physically worn out equipment with more productive, and to improve the organizational structure and management services of enterprises. The main objective of technical re-equipment is to increase the efficiency of production and reduce the specific operating costs for the generation of a unit of electric and thermal energy.

The main indicator of the economical operation of a thermal power plant is the specific consumption of thermal energy for the generation and release of a unit of electrical energy. In modern high-power thermal power plants, steam turbines are used to convert the heat of organic fuel to the mechanical operation of the turbine generator rotation, which are the main units whose technical qualities determine the most important features and technical and economic indicators of thermal power plants.

The aim of the work is to determine the diameter of the main steam lines of the supply pipelines of the Heat electric generation with the capacity of 325 MW.

When selecting steam generators, it was stated that a block diagram of the main steam pipeline is possible at the CHP *(central heat power),* but for redundant production selection, since the steam load predominates at the CHP, a sectional layout of the main steam pipelines is selected, which is more reliable than the centralized scheme of the main steam pipelines, and the sectional scheme allows to work and by block, and by a centralized scheme. The sectional diagram is a universal type

The main steam pipelines of Heat power station are: pipelines of fresh steam from generators to turbines; a pair of intermediate overheating («cold» and «hot lines»); The supply lines to the Reduction cooling plant *(next - RCP)* and High-speed reduction cooling plant *(next - HRCP)*. The turbines installed at the station operate without reheating, and the HRCPs are not installed. The calculation will be carried out to determine the diameter of the steam pipelines from the boiler to the tapping to the switching line to the turbine, the supply lines to the RCP, the diameter of the switching line; the bends to it have the same diameter as it.

All steam pipelines (main) are made of steel of the same brand 12H1MFu.

Calculation initially determines the calculated internal diameter according to the adopted steam velocity, and then the speed of the steam is determined for the selected commercially available pipelines and compared with the recommended values.

Determine the diameter of the steam pipe from the boiler to the tap of the switching line [2].

$$D_p = \sqrt{\frac{4 * D * \vartheta}{П * c}} = 0,2774 м = 277,6,$$

where D — Boiler productivity is 139 kg / s; C — Speed of steam 50 m / s; ϑ -Specific volume of steam is determined by the average pressure in the steam pipe according to the tables of water and steam.

$$p_{cp} = \frac{p_{пг} + p_{пм}}{2} = \frac{13,8 + 13,3}{2} = 13,55 \text{ MPa},$$

where $p_{пг}$ — Steam pressure behind the first boiler latch 13.8 MPa; $p_{пм}$— Steam pressure in the switching line is assumed to be 13.3 MPa.

Consequently $\vartheta = 0.0262$ m^3/*kg*:

$$D_p = \sqrt{\frac{4 * 116 * 0.0262}{3.14 * 50}} = 0,2774 м = 277,6 \text{ mm}.$$

According to the tables of high-pressure steam pipes, we choose a 325x38 steam pipe with an internal diameter of 249 mm.

Let's determine the speed of steam in the steam pipe from the boiler to the tapping of the switching line.

$$C_к = \frac{4 * D * \vartheta}{П * D_в^г} = \frac{4 * 116 * 0,262}{3,14 * 0,062001} = 62,4 \text{ m/s}.$$

Value obtained in the calculation corresponds to the normal requirements.

From the condition that it is advisable to install the entire steam pipe (except steam supply to the RCP) of the same diameter (325x38), we will determine. The speed of steam in the switching line with its capacity equal to that of a single boiler:

$$c_{пм} = \frac{4 * D * \vartheta}{П * D_в^2} = 54.6 \text{ m/s},$$

where ϑ — Specific volume of steam in the switching line at $p_{пм} = 13,3$ MPa.

$$\vartheta = 0,027 \text{ m}^3\text{/kg}.$$

$$c_{пм} = \frac{4 * 130,5 * 0,027}{3,14 * 0,282} = 54.6 \text{ m/s}.$$

The speed of steam in the switching line is in line with the recommendations. The speed of the steam from the tapping of the trunk line to the turbine:

$$c_т = \frac{4 * D_0 * \vartheta}{П * D_в^2} = 54.4,$$

where ϑ — Specific volume of steam in the steam line to the turbine at medium pressure.

$$p_{cp} = \frac{p_{псм} + p_0}{2} = \frac{13,3 + 12,75}{2} = 13 \text{ MPa}$$

$$\vartheta = 0,0269 \text{ m}^3\text{/kg.}$$

$$c_m = \frac{4 * 130.5 * 0.0269}{3.14 * 0.82369} = 54.4 \text{ m/s.}$$

The speed of steam in the steam pipe to the turbine is in line with the recommendations. Determination of the diameter of the steam pipe to the RCP [3]:

$$D_{роу} = \sqrt{\frac{4 * D_{роу} * \vartheta}{П * c}} = 0,1256 м = 125,8 \text{ mm}$$

where $D_{роу}$ — Capacity of the RCP 150 t/h 41.667 kg/s; C = 90 m/s — speed of steam from the switching line to the RCPinstallation; $\vartheta = 0.0269$ m^3/kg — specific volume of steam.

$$D_{роу} = \sqrt{\frac{4 * 41.667 * 0.0269}{3.14 * 90}} = 0.1256 м = 125,8 \text{ mm.}$$

According to the tables of high-pressure steam pipes, we choose a steam pipe 194x23 with an internal diameter of 148 mm.

Let's determine the speed of steam in the steam line from the switching line through the RCP.

$$C_{роу} = \frac{4 * D * \vartheta}{П * D_в^2} = \frac{4 * 41.667 * 0.0269}{3.14 * 0.21904} = 65.26 \text{ m/s.}$$

The value obtained in the calculation C_{rcu} satisfies the requirements.

Feeding lines are the lines from deaerators to feed pumps, collectors of the pump and pressure of feed pumps of the high-pressure heater line and cold risers to economizers for boilers, a collector of hot power for steam generators [4].

At the Heat electric generation, a sectional diagram of feeding pipelines is applied. Initially, we determine the calculated internal diameter by the accepted water velocity, and then, using the selected water conduit, determine the water velocity and compare it with the recommended values.

Determine the diameter of the line from the deaerator to the collector of the Heating pump with electric drivepump, the line productivity is equal to the capacity of the deaerator.

$$D_p = \sqrt{\frac{4 * G_д * \vartheta}{П * c}} = 0,423 м,$$

where $G_д = 138,8$ — Kg / s — the capacity of the deaerator; $\vartheta = 0,001112$ m^3/kg is the specific volume of water; $c = 1,1$ m/s — water velocity.

$$D_p = \sqrt{\frac{4 * 138,89 * 0,001112}{3,14 * 1,1}} = 0,423 м = 423 \text{ mm}$$

According to the tables of welded pipes, we choose the conduit with a nominal pass of 450 mm with nominal dimensions of 478x7 (464 mm). Determine the speed of water movement:

$$C = \frac{4 * D * \vartheta}{П * D_в^2} = \frac{4 * 138,89 * 0,001112}{3,14 * 0,464^2} = 0,91 \text{ m/s.}$$

The received speed of movement of water corresponds to recommendations.

We determine the diameter of the pump intake collector pump with the electric drive and the supply from the manifold to the pumps, with the water flow in them equal to the pump capacity:

$$D = \sqrt{\frac{4 * G_{пэн} * \vartheta}{П * c}} = 0,455 м,$$

where $G_{пэн} = 580$ t/h — Capacity of the feed pump.

$$D = \sqrt{\frac{4 * 161 * \vartheta}{П * c}} = 0,455 м = 455 \text{ mm.}$$

It will be advisable to take the collector of the pump pump with the electric drive and the lines from the deaerator of one diameter 478x77. Let's define speed in a collector:

$$C = \frac{4 * G_{пэн} * \vartheta}{П * D_в^2} = \frac{4 * 161{,}11 * 0.001112}{3.14 * 0{,}464^2} = 1{,}06$$

Determine the diameter of the head collector of the feed pump with the electric drive and the connections to it from the pumps at the rated output of the feed pump with electric drive.

$$D = \sqrt{\frac{4 * G_{пэн} * \vartheta}{П * C}} = 0{,}274м,$$

where $C = 3$ *m/s* — speed of water movement;

$$\vartheta = 0.0011 \text{ m}^3\text{/kg}$$

$$D = \sqrt{\frac{4 * 161.11 * 0.0011}{3.14 * 3}} = 0{,}274м = 274 \text{ mm}$$

According to the tables of high-pressure feed pipes, we choose a conduit with a nominal diameter of 300 mm with nominal dimensions of 377x32 (313 mm).

Determine the speed of water movement.

$$C = \frac{4 * G_{пэн} * \vartheta}{П * D_в^2} = \frac{4 * 161{,}11 * 0.0011}{3.14 * 0{,}313^2} = 2.3 \text{ m/s}$$

The speed calculated in the calculation corresponds to the recommendations.

In addition to the high-pressure turbine heater, it is advisable to accept the line diameter as well as for the head of the feed pump with electric drive (377x32). Speed, specific volume and their number correspond to the lines from the feed pumps to the pressure collector of the feed pump with the electric drive.

The lines of the turbine high-pressure heater must be calculated for a capacity equal to the maximum steam flow rate to the turbine plus a reserve of 5% (consumption for turbine seals, boiler blowing).

$$G_{пвд} = G_0 * 1.05 = 470 * 1.05 = 493.5 = 137 \text{ kg/s.}$$

It is advisable to install a line of a high-pressure heater of the same diameter both before and after it and in the calculation take the average value of the specific volume of water [5].

$$\vartheta_{ср} = \frac{\vartheta'_{пвд} + \vartheta''_{пвд}}{2} = 0{,}001165 \text{ m}^3\text{/kg,}$$

where $\vartheta'_{пвд} = 0{,}0011 \text{ m}^3/kg$ — Specific volume of water on the feed pump with electric drive. $\vartheta''_{пвд} = 0.00123 \text{ m}^3/kg$ — Specific volume of water in a high-pressure heater

$$\vartheta_{ср} = \frac{0.0011 + 0.00123}{2} = 0{,}001165 \text{ m}^3\text{/kg}$$

Then the diameter of the high preheater heater will be:

$$D_{пвд} = \sqrt{\frac{4 * G_{пвд} * \vartheta_{ср}}{П * C}} = \sqrt{\frac{4 * 137 * 0{,}001165}{3{,}14 * 3}} = 0{,}26м = 260 \text{ mm.}$$

According to the tables of high-pressure feed pipes, we choose a conduit with a conditional pass of 250 mm with nominal dimensions of 325x28 (269) mm.

Let's determine the speed of water movement in the heater's high-pressure line:

$$C_{пвд} = \frac{4 * G_{пвд} * \vartheta}{П * D_в^2} = 2{,}8 \text{ m/s}$$

$$C_{пвд} = \frac{4 * 137 * 0{,}001165}{3{,}14 * 0{,}269^2} = 2{,}8 \text{ m/s.}$$

The calculated speed of water flow in the line of the high-pressure heater corresponds to the recommendations.

Determine the diameter of the collector of hot supply of boilers and the line from it to the boilers at the maximum flow of feed water:

$$D_к = \sqrt{\frac{4 * G_{пвд} * \vartheta''_{пвд}}{П * C}} = \sqrt{\frac{4 * 140{,}3 * 0{,}00123}{3{,}14 * 3}} = 0{,}271м = 271 \text{ mm}$$

According to the tables of high-pressure feed pipes, we choose the conduit with a conditional pass of 300 mm with nominal dimensions of 377x32.

Determine the speed of movement of water:

$$C_к = \frac{4 * G_{пв} * \vartheta^{''}_{пвд}}{П * С} = \frac{4 * 140,3 * 0,00123}{3,14 * 0,313^2} = 2,24 \text{ m/s}.$$

The speed of water flow calculated in the calculation corresponds to the recommendations.

In accordance with the recommendations for deaerators of the DP-500M-2 type, pipes with the nominal diameter of 300 mm are accepted as the steam and water equalizing pipes.

References

1 Послание Президента Республики Казахстан — Лидера Нации Н.А. Назарбаева народу Казахстана от 14.12.12 «Стратегия «Казахстан – 2050»: новый политический курс состоявшегося государства». — Астана. — 2012. — [Электронный ресурс]. — Режим доступа: www.akorda.kz

2 Рожкова Л.Д. Электрооборудование электрических станций и подстанций: учебник / Л.Д. Рожкова, Л.К. Карнеева, Т.В. Чиркова. — 4-е изд., стер. — М.: Академия, 2007. — 446 с.: ил.

3 Булатбаев Ф.Н. Проектирование электрической части понизительной подстанции: метод. указания для студентов вузов энергетических специальностей; форма обучения: очная, заочная и дистанционная / Ф.Н. Булатбаев. — Караганда: КарГТУ, 2007. — 32 с.: ил.

4 Конюхова Е.А. Электроснабжение объектов: учеб. пос. для студентов образовательных учреждений среднего профессионального образования / Е.А. Конюхова; М-во образования РФ. — 3-е изд., стер. — М.: ACADEMIA, 2006. — 319 с.: ил.

5 Рожкова Л.Д. Электрооборудование электрических станций и подстанций: учебник / Л.Д. Рожкова, Л.К. Карнеева, Т.В. Чиркова., А.В. Волковицкая. — 3-е изд., стер. — М.: Академия, 2006. — 447 с.: ил.

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Қуаттылығы 325 МВт ЖЭО нәрлендіру құбырларының басты буқұбырлары диаметрін анықтау

Қазақстан Республикасындағы жоғары индустрияландыру қарқынына байланысты электр энергетикасының саласы еліміздегі басым бағыттардың бірі болып отыр. Электр энергиясының көлемдерін ұлғайту үшін электр энергиясы өндірісінің техникалық-экономикалық деңгейін көтеру арқылы энергетика саласын қайта жарақтандыру жүргізіліп жатыр. Осыған байланысты ЖЭО қайта жабдықтау барынша перспективті болып табылады, себебі тек электр энергиясын ғана емес, сондай-ақ жылу энергиясын да тиімді өндіруге әкеледі. Жылу электр станциясының жылу үнемділігінің негізгі көрсеткіші – электр энергиясының бірлігін өндіруге және босатуға жылу энергиясының үлестік шығыны. Мақалада қуаттылығы 325 МВТ ЖЭО нәрлендіру құбыр жолдарының бас буқұбырлары диаметрінің есептері келтірілген. Бугенераторлары мен турбиналарын таңдау бойынша деректер келтірілген (табиғи айналымды және өнеркәсіптік қызып кетусіз барабанды). Авторлар жалпы станциялық бу магистралін пайдалану арқылы бір үлгілі бугенераторлары мен блок-сұлбасын ұсынды. Өндірістік қорды іріктеуді пайдалану мақсатында ЖЭО-да негізгі буқұбырларының секциялық сұлбасы таңдалады, себебі ол барынша әмбебап және сенімді болып табылады. Авторлармен ұсынылған мәндермен салыстырылатын судың жылдамдығымен байланысты ішкі диаметрдің бастапқы есебі жасалған. Сондай-ақ деаэратордан ҚЭС сору коллекторына дейін желінің диаметрі анықталған.

Кілт сөздер: жылуэнергетика, ЖЭО, жылу электрорталығы, бу құбыры, құбыр, бугенераторлар.

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Определение диаметра главных паропроводов питательных трубопроводов ТЭЦ мощностью 325 МВт

В связи с высокими темпами индустриализации Республики Казахстан электроэнергетическая отрасль становится одной из приоритетных в нашей стране. Для увеличения объемов электроэнергии происходит перевооружение энергетической отрасли с увеличением технико-экономического уровня производства электроэнергии. В этом свете переоснащение ТЭЦ выглядит наиболее перспективным, так как ведет к эффективному производству не только электро-, но и тепловой энергии. Главным показателем экономичности работы тепловой электростанции является удельный расход тепловой энергии на выработку и отпуск единицы электрической энергии. В статье приводятся расчеты диаметра главных паропроводов питательных трубопроводов ТЭЦ мощностью 325 МВт. Приводятся данные по выбору парогенераторов и турбин (барабанные с естественной циркуляцией и без промперегрева). Авторами была предложена блочная схема с однотипными парогенераторами с использованием общестанционной паровой магистрали. С целью использования резервированного производственного отбора на ТЭЦ выбирается секционная схема главных паропроводов в связи с тем, что она является более универсальной и надежной. Авторами производится первоначальный расчет внутреннего диаметра, связанного со скоростью воды, который сравнивается с рекомендуемыми значениями. Определен диаметр линии от деаэратора к коллектору всоса ПЭНа.

Ключевые слова: теплоэнергетика, ТЭЦ, теплоэлектроцентраль, паропровод, трубопровод, парогенератор.

References

1 Poslanie Prezidenta Respubliki Kazakhstan — Lidera Natsii N.A. Nazarbaeva narodu Kazakhstana ot 14.12.12 «Stratehiia «Kazakhstan – 2050»: novyi politicheskii kurs sostoiavshehosia hosudarstva» [Message of the President of the Republic of Kazakhstan — the Leader of the Nation N.A. Nazarbayev to the people of Kazakhstan from 14.12.12 «Strategy» Kazakhstan – 2050»: a new political course of the state»], 2012. Astana. *akorda.kz*. Retrieved from www.akorda.kz [in Russian].

2 Rozhkova, L.D., Karneeva, L.K., & Chirikova, T.V. (2007). *Elektrooborudovanie elektricheskikh stantsii i podstantsii [Electrical equipment of power plants and substations]*. Moscow: Akademiia [in Russian].

3 Bulatbaev, F.N. (2007). Proektirovanie elektricheskoi chasti ponizitelnoi podstantsii [Designing of the electrical part of the step-down substation]. Karaganda: KarGTU [in Russian].

4 Konyukhova, E.A. (2006) *Elektrosnabzhenie obektov [Power supply of facilities]*. Moscow: Academy [in Russian].

5 Rozhkova, L.D., Karneeva, L.K., Chirikova, T.V., & Volkovitskaya, A.V. (2006). *Elektrooborudovanie elektricheskikh stantsii i podstantsii [Electrical equipment of power plants and substations]*. Moscow: Academiia [in Russian].