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The use of a heat pump at an industrial enterprise in the region

Abstract

Main problem: The use of waste heat is most often solved by installing heat exchangers, but this is not effective when the temperature of this heat does not exceed 10-15 °C, in which case this heat can be used using a heat pump. Where can I get this heat? Almost any enterprise needs cooling of any equipment elements or substances – working fluids; the heat received from them can be sent to a heat pump and used here at the enterprise.

Purpose: Consideration of the possibility of using the heat of cooling water from the pump CNS 60-165 and the proposal of a new scheme with the installation of a heat pump that uses this heat. *Methods:* This is achieved due to the fact that it is proposed not to discard the heat, but after its use in the heat pump evaporator, transfer it to the heated medium - water, which is then sent to the shower cabins of the enterprise. Since the showers are located in the same room, the cost of transporting heat and losses will be minimal.

Methods: In the course of the research, the possibility of using the waste heat of an industrial enterprise for using it here at the enterprise for the purposes of hot water supply was considered. For these purposes, it is proposed to install a heat pump, thanks to which the thermal potential increases, which makes it possible to fully use the received heat.

Results and their significance: As the experience of foreign countries has shown, heat pumps can be widely used in many industrial enterprises, and in conditions of increased competitiveness, in order to reduce energy costs and the cost of manufactured products, install heat pumps to utilize excess heat, for example, process water, which is available in many production allows you to have a significant economic effect.

Key words: heat pump, evaporator, condenser, throttle valve, pipeline, low-grade heat source, secondary energy resources, efficiency.

Introduction

Now the question of how, nevertheless, to find such an alternative source of energy, which would not require large economic costs and would be profitable in use, is very relevant. Such a source already exists and is not a great luxury. This source is a heat pump.

Materials and methods

A heat pump is a device that transfers heat from a less heated source and for this it is necessary to have so-called low-grade heat to a more heated one - a heat sink [1]. What is characteristic of this device? Well, of course, simplicity, everyone knows a refrigerator that works the other way around, which means: the refrigerator produces cold, and the heat pump produces heat. In terms of the content of the main elements, they are also identical: a compressor for compressing the working medium, a condenser for condensing the vapors resulting from compression, a throttle valve for reducing the pressure and temperature of the working agent to a value lower than the substance that will give off heat further along the cycle to the evaporator. After evaporation there, the formed vapors are sucked off by the compressor and then the cycle is repeated. The only difference is that in the refrigerator, the main process takes place in the evaporator: heat is taken from the cooled volume and transferred to the working medium - most often to freon, which due to this heat (having a very low pressure after the process in the throttle valve) boils and turns into a dry saturated steam, and in a heat pump, the useful part falls on the process in the condenser - it is here that the heat of condensation is removed to the heat receiver, which, after receiving the heat energy, is directed to the heat receiver. Most often, heat pumps are used to supply heat to private houses. An example is Latvia, where a quarter of the premises are heated using heat from heat pumps. Unfortunately, there are not many examples of the use of heat pumps in industrial plants, although waste heat from technological production can be found in each of them.

Great attention is paid to the issues of energy saving and the search for alternative energy sources, as well as the use of secondary energy resources (SER). Moreover, this is relevant not only for large industrial enterprises, but also for heating and hot water supply systems for private houses [1, 2]. The use of heat pumps can be attributed to one of the options for using SER at enterprises of various purposes, and the use of low-temperature heat as a source of heat for the evaporator in them. Unfortunately, a low-power heat pump is most often used for heating and hot water supply of private cottages and houses, while using soil, underground water, etc., which affects the possibility of using it in enterprises, there are of course not many examples of use here.

The reason for this is most often a competitor of a heat pump, a heat exchanger, which is of course simpler, does not require electricity consumption, but at the same time it is effective only at temperatures above 30 ° C, and if the temperature is much lower, then use SER and waste heat, directing it to the heat exchanger of course not economically viable. The object of the study is a heat pump that uses cooling water as a low-grade heat source, from a CNS 60-165 pump with a temperature of 25 ° C, pumps of this brand are installed at one of the industrial enterprises of Pavlodar and pump fuel oil. The following types of pumps for pumping fuel oil TsNS 60-165 and TsNS 60-198 (Figure 1) are installed in the oil-fueled industrial enterprise. The device of these pumps is shown in Figure 1 and the main characteristics in Table 1.

Table 1 – Technical characteristics of pumps for pumping fuel oil

Model	Flow rate (m ³ / h)	Power (kW)	Head (m)	Speed (rpm)
CNS 60–165	60	55	165	2950
CNS 60–198	60	55	198	2950
CNS 105–147	105	75	147	2950

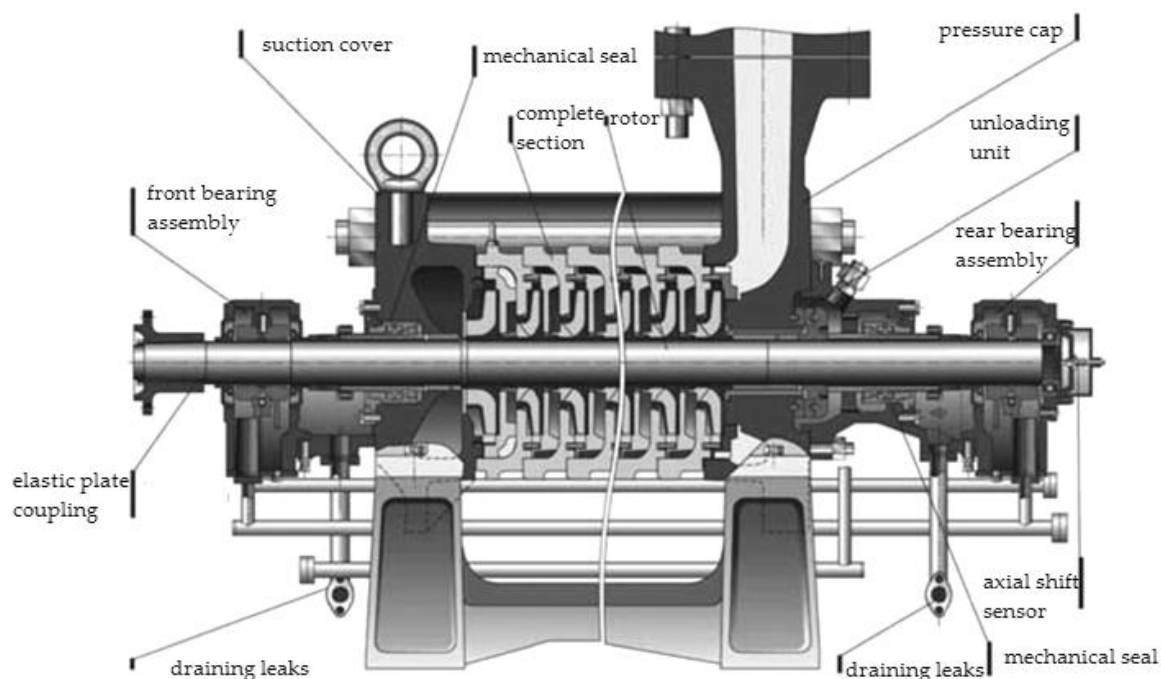


Figure 1 – The device of the pump for pumping oil

As you know, the operation of a heat pump requires a heat source with a fairly low temperature, the so-called waste heat, which most often cannot be used in a heat exchanger for economic reasons, but these flows are perfectly suitable for the operation of heat pumps.

In this case, low-grade heat must meet the following requirements:

- flow rates and temperature of the heat carrier must be stable both in terms of qualitative and quantitative characteristics (temperature, flow rate, pressure) and ensure uninterrupted operation of the heat pump;
- do not require additional purification from impurities that can contaminate and impair the operation of the heat pump;
- the cost of pumping the coolant is either absent or minimal [1].

The scheme of the installation for waste heat utilization of the fuel oil pump cooling system is shown in Figure 2. The waste disposal plant consists of a heat pump containing a condenser 1, a compressor 2 driven by an electric motor 3, an evaporator 4, a throttle (regulating valve) 5, which are interconnected by a piping system 6 for circulating the working fluid of the heat pump. A pipeline 7 is connected to the condenser 1, through which water is supplied to heat it from the heat of condensation of the working fluid of the heat pump in the condenser. Pipeline 8 serves to drain the already heated water to the showers. In the evaporator 4, the working fluid of the heat pump evaporates due to the transfer of heat to the working fluid of the heat pump from the water of the oil cooling system of the fuel oil transfer pump. The vapors of the working fluid enter the compressor 2, where, as a result of compression, the pressure and temperature increase. This steam is then sent to the condenser, where it already gives off heat from condensation to water. The water of the pump oil cooling system, after heat transfer and cooling, is again sent to the pump 9 through pipeline 14. Fuel oil supply pipelines to and from the pump 12, 13.

Table 2 – SP RK 4.01-101-2012. Internal plumbing and sewerage of buildings. Water and waste water consumption by sanitary appliances [3]

Sanitary appliances	Second water consumption, l/s			Hourly water consumption, l/s			Free pressure H_f , m	Effluent consumption from the device q_0^s , l/s	Minimum diameters conditional passage, mm	
	general	cold	hot	general	cold	hot			supply	withdrawal
	q_0^{tot}	q_0^c	q_0^h	$q_{0,hr}^{tot}$	$q_{0,hr}^c$	$q_{0,hr}^h$				
Shower cabin with shallow shower tray and faucet	0,12	0,09	0,09	100	60	60	3	0,2	10	40
Shower cabin with deep shower tray and faucet	0,12	0,09	0,09	115	80	80	3	0,6	10	40
Shower in group installation with mixer	0,2	0,14	0,14	500	270	230	3	0,2	10	50
Hygienic shower (bidet) with mixer and aerator	0,08	0,05	0,05	75	54	54	5	0,15	10	32
Bottom rising shower	0,3	0,2	0,2	650	430	430	5	0,3	15	40

To the consumer of
heat - shower cabins

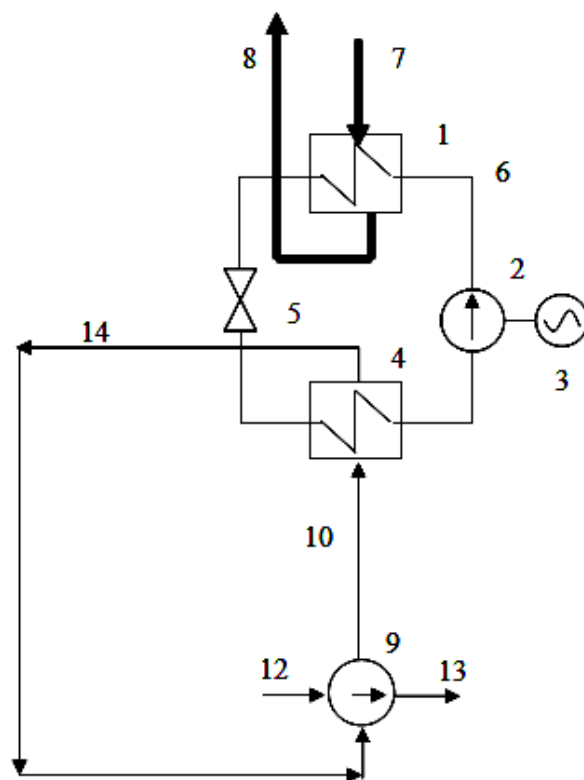


Figure 2 – Scheme of the plant for waste heat recovery of the fuel oil pump cooling system

Results

According to the project, water from the bearing cooling system (crankcase) and mechanical seal is used as a source of heat. According to the available data, the temperature of the cooling water is not more than 25 °C, and the temperature difference is 5 °C. After converting the heat in a heat pump, the resulting heat is used here in industrial showers. The heat of hot water obtained as a result of the operation of the heat pump is used to supply two shower cabins with a shallow shower tray and a mixer, which are located in the building of the oil pumping station. The required consumption of hot water for the supply of two shower cabins with a shallow shower tray and a mixer, which is 0,18 kg/s (2 • 0,09 kg/s) (second consumption) and 500 kg/s (hourly consumption). Thus, the heat obtained at Practical significance: as the experience of foreign countries has shown, heat pumps can be widely used at many industrial enterprises, and in conditions of increased competitiveness, in order to reduce energy consumption and the cost of manufactured products, the installation of heat pumps for utilizing excess heat, for example, process water, which is available in many industries allows have a significant economic effect.

As a result of the calculation, in accordance with the second flow rate and the required outlet temperature, a water-to-water heat pump 35 kW heating model CA-33 was chosen.

Discussion

Starting the calculations, let's ask ourselves the known and necessary data for obtaining [3]:

- Required water temperature for heating to return to the boiler room - 70 °C;
- the water temperature required to provide hot water for one shower cabin, according to SP RK 4.01-101-2012, below - 60 °C;
- average annual actual water temperature for heating - 75 °C;
- hot water consumption 0,572 m³/h;
- consumption of utility and drinking water 1,20 m³/h.

Extract from SP RK 4.01-101-2012 Internal water supply and sewerage of buildings. Quality and temperature of water in water supply systems [3].

1. The quality of cold and hot water supplied for household and drinking needs must comply with GOST. The quality of water supplied for production needs is determined by technological requirements.

2. The temperature of hot water at the points of draw-off should be provided for:

- a) not lower than 60 °C - for centralized hot water supply systems connected to open heat supply systems;
- b) not lower than 50 °C - for centralized hot water supply systems connected to closed heat supply systems;
- c) not higher than 75 °C - for all systems specified in subparagraphs "a" and "b".

3. In the premises of preschool institutions, the temperature of hot water supplied to the water fittings of showers and washbasins should not exceed 37 °C.

4. At public catering establishments and for other water consumers that need hot water with a temperature higher than that specified in clause 2, local water heaters should be provided for reheating water.

5. The temperature of the hot water supplied by the water heaters to the distribution pipelines of the centralized hot water supply systems must comply with the recommendations of the heating substation design manual.

6. In settlements and enterprises where sources of drinking water supply do not provide all the needs of consumers, with a feasibility study and in agreement with the sanitary and epidemiological service, it is allowed to supply non-potable water to urinals and toilet flush tanks.

Water consumption for the above purposes will be equal to:

$$G = \frac{0,18 \cdot 3600}{1000} = 0,65 \text{ t/h}.$$

According to this second consumption and the required outlet temperature, we will select a heat pump. The characteristics of the selected heat pump are shown in table 3.

Table 3 – Characteristics of a 35 kW water-to-water heat pump

Model	Unit of measurement	CA-33
1	2	3
Rated heating power	kVt/ kVt	35
	BTE	119454
hot water supply	t/h	0,75
Rated input power	kVt / kVt	7,43
Rated heating current	A	14,86
Health rate		4,71
Energy Efficiency Ratio	kVt/ kVt	4,7
Maximum current	A	24
Voltage	V/Hz	380V/50 Hz

Continuation of table 3

Noise		dB(A)	55
Power consumption		kVt*h	5,7
Dimensions	width	m	800
	thickness	mm	1080
	height	mm	1050
The weight		kg	220
Choke type		Electronic expansion valve / thermal expansion valve	
Refrigerants		R417A, R407C, R410A, R22, R21	
Maximum leaving water temperature		60°C	
Compressor	type	Toshiba, rotary	
	quantity		2
	stalled motor current	A	60
	Protection and security features	Built-in thermal protection device, series protection, undervoltage protection, delay protection	
Heat exchange in the water source circuit	type	Electronic expansion valve / thermal expansion valve	
	water consumption	m ³ /h	4,69
	outlet water head	kPa	14
	connection tube size	mm	25
Heat exchange in the hot water circuit	type	Efficient tube-in-pipe heat exchanger	
	water consumption	m ³ /h	5,97
	outlet water head	kPa	14
	connection tube size	mm	25

Conclusion

At industrial enterprises there are sources of thermal energy, significant in volume, which can be realized as a source of heat for the operation of heat pumps.

THE LIST OF SOURCES

- 1 Использование низкопотенциальной теплоты: монография: Книга I / Загиров Д.Г., Рыбин А.А. – М.: РУСАЙНС, 2015. – 156 с.
- 2 Использование низкопотенциальной теплоты: монография: Книга II / Загиров Д.Г., Рыбин А.А. – М.: РУСАЙНС, 2015. – 154 с.
- 3 Внутренний водопровод и канализация зданий и сооружений: Свод правил Республики Казахстан СП РК 4.01-101 [Введен в действие в 2012г., внесены изменения 25.12.2007г.].

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Аймақтағы өнеркәсіптік кәсіпорында жылу сорғышты пайдалану

Шығарылатын жылуды пайдалану көбінесе жылу алмастырғыштарды орнату арқылы шешіледі. Бірақ, бұл 10-15⁰ С-дан төмен жылу температурасында тиімді емес. Мақалада ОСБ 60-165 сорғысының көмегімен салқындату үшін судың жылуын пайдалану мүмкіндіктері қарастырылады, осы жылуды қолданатын жылу сорғысын орнатумен жаңа схема ұсынылады. Бұған жылу сорғысының буландырғышында жылуды қолдану және қыздырылған ортаға, яғни кәсіпорынның душына жіберуге болатын суды беру арқылы қол жеткізу ұсынылады. Олар бір бөлмеде болғандықтан, жылу мен шығынды тасымалдау шығындары аз болады.

Шет елдің тәжірибесі көрсеткендей, жылу сорғыларын көптеген өнеркәсіптік кәсіпорындарда кеңінен қолдануға болады. Бәсекеге қабілеттіліктің артуы жағдайында артық жылуды, мысалы,

технологиялық суды кәдеге жарату үшін жылу сорғыларын орнату айтарлықтай экономикалық нәтиже алуға мүмкіндік береді.

Түйінді сөздер: жылу сорғысы, буландырғыш, конденсатор, дроссель клапаны, құбыр, төмен потенциалды жылу көзі, қайталама энергия ресурстары, тиімділік.

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Использование теплового насоса на промышленном предприятии региона

Использование сбросного тепла чаще всего решается установкой теплообменных аппаратов. Однако это не эффективно при температуре тепла ниже 10-15 °С. В этом случае такое тепло можно использовать при помощи теплового насоса. В статье рассматриваются возможности использования тепла воды для охлаждения при помощи насоса ЦНС 60–165, предлагается новая схема с установкой теплового насоса, который использует данное тепло. Предлагается достичь этого путем использования тепла в испарителе теплового насоса и передаче нагреваемой среде, т.е. воде, которую можно направлять в душевые кабины предприятия. Так как они находятся в этом же помещении, то затраты на транспортировку тепла и потери будут минимальными.

Как показал опыт зарубежных стран, тепловые насосы могут широко применяться на многих промышленных предприятиях. В условиях возросшей конкурентоспособности установка тепловых насосов для утилизации избытков тепла, например, технологической воды, позволяет получить значительный экономический эффект.

Ключевые слова: тепловой насос, испаритель, конденсатор, дроссельный вентиль, трубопровод, источник низкопотенциального тепла, вторичные энергетические ресурсы, эффективность.

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