3. Specification for general purpose natural gas: AS 4564-2005. Published by Standards Australia, GPO Box 476, Sydney, NSW 2001, Australia, ISBN 0 7337 6880 64.

4. Natural gas. Quality designation: ISO 13686:2013. [Чинний від 2013-06]. – 48 p.

5. Природний газ. Розширений аналіз. Метод газової хроматографії: ДСТУ ISO 6975:2012. [Чинний від 2013-07-01]. – К.: Мінекономрозвитку України, 2013 – 24 р.

6. Природний газ. Визначення складу із заданою невизначеністю методом газової хроматографії: ДСТУ ISO 6974-1…5:2007. – [Чинний від 2008-10-01]. – К.: Держспоживстандарт України, 2008.

7. Natural gas. Performance evaluation for analytical systems: ISO10723:2012. [Чинний від 2012-12]. – 32 p.

8. Test gases. Test pressures. Applience categories: EN 437:2003. [Чинний від 2003-05]. – 39 p.

9. Газы горючие природные. Расчетный метод определения теплоты сгорания, относительной плотности и числа Воббе: ГОСТ 22667-82. – [Введен с 1983-07-01]. – М.: Изд-во стандартов, 2006. – 3 с. – (Межгосударственный стандарт).

10. Газ природный. Методы расчета физических свойств. Определение физических свойств природного газа, его компонентов и продуктов его переработки: ГОСТ 30319.1-96. – [Введен с 2000-01-01]. – К.: Госстандарт Украины, 1999. – 16 с. – (Межгосударственный стандарт).

11. Газы горючие природные. Метод определения теплоты сгорания водяным калориметром: ГОСТ 27193-86. – [Введен с 1988-01-01]. – М.: Стандартинформ, 2006. – 9 с. – (Межгосударственный стандарт).

12. Газы природные горючие. Метод определения удельной теплоты сгорания: ГОСТ 10062-75. [Введен с 1976-07-01]. – М.: Стандартинформ, 2006. – 19 с. – (Межгосударственный стандарт).

13. Газы горючие природные. Методы определения содержания водяных паров и точки росы влаги: ГОСТ 20060-83. – [Чинний від 1984-07-01]. – М.: ИПК издательство стандартов, 2004. – 12 с.

14. Natural gas. Determination of water content at high pressure: ISO 11541:1997. – [Чинний від 1997-02]. – 8 p.

15. Natural gas. Determination of water by the Karl Fischer method: ISO 10101-1…3:1993. – [Чинний від 1993-09].

16. Natural gas. Calculation of methane number: ISO/TR 22302:2014. – [Чинний від 2014-07]. – 11 p.

17. Природний газ. Визначення енергії: ДСТУ ISO 15112:2009. – [Чинний від 2011-01-01]. – К.: Держспоживстандарт України, 2010. – 48 с. – (Національний стандарт).

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USE OF HOT WATER FOR HEATING HIGH VISCOSITY OIL AND PETROLEUM PRODUCTS IN TANKS

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There is a problem of heating fuel oil and high viscosity oil in tanks. Dark oil products (fuel oil, VGO) entering the tanks at a temperature of 60-70°C, which must be maintained constant for shipment of petroleum products. This high temperature due to the high pour point, which can reach 40°C. In order to prevent freezing of petroleum products at its pumping, it should be heated

Today, most of oil terminals in Ukraine are used to heat the oil in tank by steam. The main problem for these companies is outdated transportation systems of steam, which is not using high temperature condensate formed after condensation of steam in the heat exchanger. To collect and transport the condensate it is necessary to design system of returning and using of condensate, which is quite expensive at the present time.

Use of another type of coolant - overheated hot water is offered. In some cases it is possible to transfer boilers to hot water mode, i.e. at existing facilities instead of steam, boiler can produce overheated hot water. In our view, the use of hot water in the case of heating fuel oil in the tanks is competitive in the economic and technical point of view.

To do this calculation was adopted vertical steel tank TVS-10000m^3, which stores fuel oil brand M-100. Was calculated required amount of thermal energy for its heating, considering the heat loss from the body of the tank [1]. For the average daily temperature in November this value is 3,5 GJ/h.

Consider the heat exchange between oil fuel oil and heat exchanger in the tank in two cases: 1) for heat transfer agent - overheated water at a temperature 120°C, 2) for heat transfer agent - saturated steam with a temperature 150 ° C.

The equation for heat exchanger is as follows:

$$F = \frac{Q}{K \cdot \Delta t}$$

where, K**Помилка! Джерело посилання не знайдено.** – heat transfer coefficient, W/m^2·K; F – heat exchanger area, m^2; Δt – log mean temperature difference, °C; Q – capacity of heat exchanger, W.

Determine how differs heat transfer area for heating oil products by steam and by hot water in heat exchanger for the same capacity. For this, we consider each part of the equation (2).

1. Heat transfer coefficient Помилка! Джерело посилання не знайдено.

$$K = \frac{1}{\frac{1}{\alpha_{FO}} + \frac{\delta_{st}}{\lambda_{st}} + \frac{1}{\alpha_{HTA}}}$$

where, α_{FO} **Помилка! Джерело посилання не знайдено.** – heat transfer coefficient from fuel oil to the wall of the heat exchanger, W/m^2·K; α_{HTA} **Помилка! Джерело посилання не знайдено.** – heat transfer coefficient from heat transfer agent (steam or hot water) to the wall of heat exchanger, W/m^2·K; δ_{st} **Помилка! Джерело посилання не знайдено.** – thickness of wall of exchanger, m; λ_{st} – thermal conductivity of steel, W/m·K.

In the case of heating fuel oil when storage it in tanks, from the side of fuel oil observed viscous gravity mode in which the calculated heat transfer coefficient is in the range of 30-60 W/m^2·K. The heat transfer coefficient for water and steam in the turbulent flow is much greater than in viscous gravity mode for fuel oil. So determining factor in the formula (2) is the α_{FO}. Thus, the heat transfer coefficient of steam and water in this case is almost the same:

$$K_{steam} \approx K_{water}$$

2. Log mean temperature difference Помилка! Джерело посилання не знайдено.

Define log mean temperature difference by formula (3) for two heat transfer agents with temperature parameters shown in Fig. 1. It should be noted that the calculation of the temperature difference for steam divided into two stages: stage 1 - condensation of steam; Stage 2 – cooling of condensate [2].

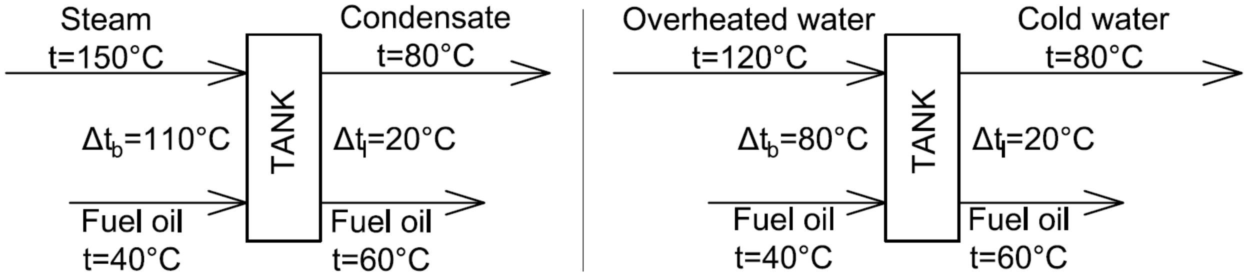

Fig. 1 – Temperature flows for “fuel oil – overheated water” and “fuel oil – steam”

$$\Delta t = \frac{\Delta t_b - \Delta t_l}{\ln\left(\frac{\Delta t_b}{\Delta t_l}\right)}$$

The calculations showed that log mean temperature difference for steam in this case is 25% higher than for water.

Basing on the above calculations, we can write:

$$F_{exchanger}^{water} / F_{exchanger}^{steam} \approx 1{,}25$$

For the accepted parameters of heat transfer agent to transfer heat in an amount of 3.5 GJ/h:

Overheated water (**Помилка! Джерело посилання не знайдено.**=40°C) – 20,8 m^3/h.

Saturated steam (h=2734 кДж/кг) – 1,5 tons/h.

However, the increase in the surface area of heat in existing reservoirs is not always possible and appropriate. Consider how much will be different levels of heating fuel oil when replacing the coolant from steam to hot water at the existing heat exchanger.

The heat exchanger of tank consists of ten sections of steel pipe nominal diameter DN100. The total area of the heat exchanger - 328m^2. Calculate the daily rate of heating fuel oil in the tank, as this is an important parameter for the storage of petroleum products in tanks.

Calculations showed that the full tank TVS-10000m^3 with thermal insulation, which stores fuel oil brand M-100 daily level of heating in case of using steam is 1-1,2°C/day (during the winter). When replacing steam to overheated water with temperature 120°C daily rate of heating will be 0,7-0,9°C/day.

Thus, the transition from steam to water at the existing equipment will reduce the daily rate of heating of 1-1,2°C/day up to 0,7-0,9°C/day.

Using of saturated steam for heating oil, as compared to hot water, is characterized by a high heat removal and less heat exchange surface.

Using of saturated steam in a heat exchanger to heat the high viscosity oil products economically feasible if the condensate that forms after heat exchangers would not be used.

It is possible to transfer existing heat exchangers in tanks from steam to hot water. Comparative reduce of heat removal and temperature of oil products practically does not affect its rheological properties.

Recommended to equip oil terminals boilers, which can run in the steam and water production mode.

1. Андерсон А.Ю., Кологривов М.М. Подогрев мазута в резервуаре геотермальной энергией /Промышленная теплотехника. – 2015, - Том 37. - № 7. – С. 201-207.
2. Безгрешнов А.Н. Расчет паровых котлов в примерах и задачах. Уч. пособие для ВУЗов / А.Н. Безгрешнов, Ю.М. Липов, Б.М. Шлейфер. – М.: Энергоатомиздат, 1991. – 240с.