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# ENERGY SAVING IN THE STEAM SYSTEM AND CONDENSATE RECOVERY IN THE HEALTH INDUSTRY

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***Abstract.*** *The present investigation was carried out in the force area of a hospital, whose main activity is the production of steam for the different areas such as the laundry and the kitchen; the condensate recovery system is studied. The purpose of this investigation is to evaluate a Flash Tank to reuse the condensate, hoping to obtain an increase in the thermal efficiency of the process, also achieving a saving in fuel consumption and the economic decrease in the billing of the same; besides reducing the emission of pollutants into the atmosphere; because steam production nowadays is a very valuable resource for any industry. It is evident that when implementing the Flash Tank to the condensate recovery system, it will be possible to improve the Technical Energetic Indicator by 3.86% and the Economic Energetic Indicator by 4%, as well as by reducing 234 gallons of B2 diesel per year equivalent to 3.86%, in addition to obtaining savings in fuel consumption equivalent to $ 696.64 dollars in the next 12 months.*

***Keywords:*** *condensate recovery system, energy saving, flash tank, health industry, steam.*

## 1. INTRODUCTION

Currently in the steam and condensate industrial circuits there are losses of thermal energy which are usually not taken into account by the personnel in charge of maintenance and production of the plant, these losses in the long run represent considerable amounts of money. This is due to the poor recovery of condensates, steam leaks, poorly dimensioned distribution pipes without thermal insulation, steam traps in poor condition and failure, these are some of the most common problems that occur in industrial and craft plants that They use steam as a working fluid in their production processes.

There are companies, including hospitals that are steam generators in which the boilers are fed by several liters of fuel and water to keep burning.
As a result, it remains in operation all day and throughout the production, causing high fuel consumption and exhausting energy resources that are often non-renewable in a certain way.

Due to this concern, several companies have implemented energy saving and reuse systems, one of which is the flash steam system, to recover the condensates produced by the steam transformation and then to give them a correct treatment and use, with the idea of reusing energy resources and save fuel. Flash tanks are equipment that are fed with a condensate at a pressure, but that, inside, support a lower pressure (Abed *et al.*, 2016; Hui *et al.*, 2016; Sirwan *et al.*, 2013; Qiao *et al.*, 2012).

In the same way in the last years, the energetic conscience and the environmental perception have transformed the condensate system. What was once a modest by-product of steam distribution has now become a very valuable resource for any industry (Guo *et al.*, 2013; Heo *et al.*, 2010; Khanam *et al.*, 2010).

On the other hand, once the flash steam is generated it needs to be distributed in a low-pressure steam system or also called a flash steam system, which is one of the objectives of this investigation. Since flash steam is of the same quality as live steam, modern installations usually try to reuse significant amounts of flash steam wherever possible (Mosaffa *et al.*, 2016; Muthusamy *et al.*, 2017). A flash steam system is where the vapor circulation is generated by pressure difference, from the condensates as in hot water systems (Polzot *et al.*, 2017; Barma *et al.*, 2017; Wei *et al.*, 2017).

The circulation of steam is made with systems of one or more pipes, these return the water formed by condensation to the boiler. To solve this problem, the present investigation proposes to the "La Caleta" hospital the implementation of the system of pressurized condensates mentioned above, using a flash tank, where the condensates of the equipment will be recovered and will generate a flash vapor, which will be used in a low-pressure steam system, thus saving the fuel that was used to generate this amount of steam. This way you can compare how much energy (fuel) will save the force area of the Hospital by implementing this type of system instead of using a condensate collection tank venting to the atmosphere (Villacrés and Andrade, 2012; Bohórquez, 2013).

Inside the "La Caleta" hospital is located the force area, which has 2 U-HD series boilers, Loos International, currently one in operation of 15 BHP; likewise, the steam distribution network system is installed, which is connected to a de-aeration tank; the water supply system is also located, in which the fluid is stored in a 500-liter tank, and it counts with the storage tanks of the B2 diesel oil. The condensate recovery system of the force area of the "La Caleta" hospital, has a deaerator tank in which 71% of the steam provided by the 15 BHP boiler meets; This steam that is already condensed is the one that reaches the deaerator tank coming from the different areas such as the laundry and the kitchen, and the rest is eliminated to a pipeline that takes the non-usable waters of some other process. The boiler to generate 100% of the steam consumes 21 gallons of B2 diesel oil daily during its 7 hours of operation.

In response to the use of condensates, the implementation of the flash tank is presented, with the aim of saving the fuel used daily in steam production.

## 2. METHODOLOGY

The following methodology is used for the correct development of the research.

### 2.1 Combustion Efficiency

$$n = \frac{\dot{m}_s * (h_g - h_i)}{\dot{m}_f * PCI} \tag{1}$$

Where: $m_s$ is the steam mass flow, $m_f$ is the flow of employee fuel, PCI is the lower caloriff power, $h_g$ saturated steam enthalpy at operating pressure and $h_i$ is the compressed liquid enthalpy at operating pressure.

### 2.2 Flash vapor percentage

$$\%_{flash\ steam} = \frac{\boldsymbol{h_{f\,P\,high}} - \boldsymbol{h_{f\,P\,low}}}{\boldsymbol{h_{fg\,P\,low}}} \tag{2}$$

Where: $h_{f\,p\,high}$ is the saturated liquid enthalpy at high pressure, $h_{f\,p\,low}$ is the saturated liquid enthalpy at low pressure and $h_{fg\,p\,low}$ saturated water enthalpy (liquid-steam) at low pressure.

### 2.3 Technical Energetic Indicator (TEI)

#### 2.3.1 Influence on the production energy indicator ($TEI_1$)

For the calculation of the Technical Energetic Indicator of production, it is determined by the following:

$$TEI_1 = \frac{gallons\ of\ B2\ diesel}{tons\ of\ steam\ produced} \tag{3}$$

#### 2.3.2 Influence on the flash steam generation indicator ($TEI_2$)

For the calculation of the Technical Energetic Indicator of flash steam generation, the following equation is used:

$$TEI_2 = \frac{flash\ steam\ at\ low\ pressure\ (kg)}{tons\ of\ steam\ produced} \tag{4}$$

### 2.4 Economic Energetic Indicator (EEI)

$$EEI = \frac{dollars\ \$}{tons\ of\ steam\ produced} \tag{5}$$

In this way it can be verified that the behavior of the indicators varies depending on the generation of flash steam and on fuel saving, which gives more support to our investigation since it is verified the influence of the flash steam system with the behavior and the improvement of energy indicators.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Initial considerations

The necessary parameters for calculating the energy balance are:

Table 1. Income data for determining the energy balance

| Physical parameters | Values |
|---|---|
| For the Caldera | |
| Series | U-HD, Loos International |
| Production range | (117 - 834) kW = (11 - 85) BHP |
| Max. Design temperature | 477 K |
| Capacity | 15 BHP |
| Nominal pressure | 800 kPa |
| Operating pressure | 700 kPa |
| Combustion efficiency | 88 % |
| Work hours | 7 h/day |
| Real steam consumption | 70% Nominal steam consumption |
| For the B2 Diesel | |
| Lower Calorific Power | 42500 kJ/kg |
| Density | 870 kg/m$^3$ |
| Mass flow of fuel | 3 gal/h |

### 3.2 Evaluation and analysis of the current energy system

The hospital requires an estimated flow of steam to meet the demand demanded by the different processes. In Fig. 1 the current steam system is shown.

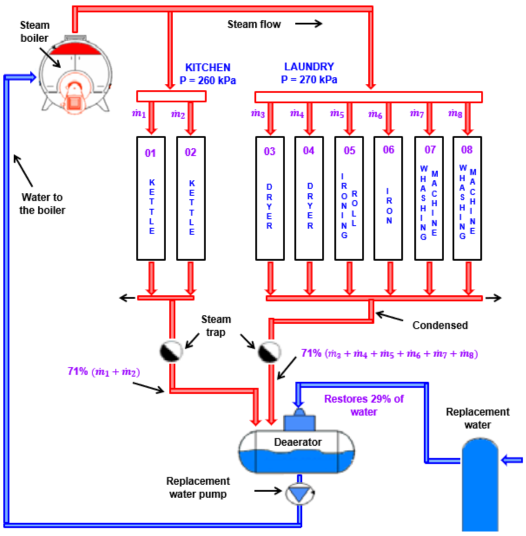


Figure 1. Schematic of the current hospital steam system

To perform the energy analysis of the current system we must take into account the above parameters. The distribution of equipment consumption is shown in Table 2.

Table 2. Steam consumption of the various kitchen and laundry equipment

| Kitchen | |
|---|---|
| Kettle 01 | $\dot{m}_1 = 14\% * real\ steam$ |
| Kettle 02 | $\dot{m}_2 = 14\% * real\ steam$ |
| Laundry | |
| Dryer 01 | $\dot{m}_3 = 12\% * real\ steam$ |
| Dryer 02 | $\dot{m}_4 = 12\% * real\ steam$ |
| Ironing roll | $\dot{m}_5 = 11\% * real\ steam$ |
| Iron | $\dot{m}_6 = 11\% * real\ steam$ |
| Washing machine 01 | $\dot{m}_7 = 13\% * real\ steam$ |
| Washing machine 02 | $\dot{m}_8 = 13\% * real\ steam$ |

Source: Maintenance reports of the force area of “La Caleta” Hospital

### 3.2.1 Actual fuel consumption

Multiplying by density of B2 diesel (870 kg/m$^3$) and dividing it by the conversion factor of cubic meters to gallons (1 m$^3$ = 264,172 gal) and the conversion factor from hour to second (1 h = 3600 s) to convert to kilogram per second.

$$\dot{m}_{real\ fuel} = 3\ \frac{gal}{h} * \frac{1}{264{,}172}\frac{m^3}{gal} * 870\ \frac{kg}{m^3} * \frac{1}{3600}\frac{h}{s}$$

$$\dot{m}_{real\ fuel} = 2.74415 * 10^{-3}\frac{kg}{s}$$

### 3.2.2 Nominal steam mass flow

The capacity range of the boiler is (11 – 85) BHP
Multiplying by the conversion factor from BHP to kilowatts (9.81 kW = 1 BHP)

$$15\ BHP * \frac{9.81}{1}\frac{kW}{BHP} = 147.15\ kW = \dot{m}_{nom.\ steam} * (h_g - h_i)$$

BHP: Steam boiler operation power
$h_g$: Saturated steam enthalpy at the pressure of 800 kPa
$h_i$: Compressed liquid enthalpy at the pressure of 800 kPa and temperature of 358 K

$$\dot{m}_{nom.\ steam} = 147.15\frac{kw}{(h_g - h_i)} = \frac{147.15}{(2769.1 - 356.5)}\frac{kJ/s}{kJ/kg}$$

$$\dot{m}_{nom.\ steam} = 0.0609\ \frac{\mathrm{kg}}{\mathrm{s}}$$

Is divided by the conversion factor of kilograms to tons (1000 kg = 1 ton) and multiply by the conversion factor from hour to second (1 h = 3600 s) to convert in tons per hour.

$$\dot{m}_{nom.\ steam} = 0.2196\ \frac{ton}{h}$$

In 7 hours: $\dot{m}_{nom.\ steam} = 1.5370\ ton$

### 3.2.3 Nominal fuel consumption

$$\eta_{nominal} = \frac{\dot{m}_{nom.\ steam} * (h_g - h_i)}{\dot{m}_{nom.\ fuel} * PCI}$$

$h_g$: Saturated steam enthalpy at the pressure of 800 kPa
$h_i$: Compressed liquid enthalpy at the pressure of 800 kPa and temperature of 358 K

$$\dot{m}_{nom.\ fuel} = \frac{0.0609\ \frac{kg}{s} * (2769.1 - 356.5)\frac{kJ}{kg}}{88\% * 42500\ \frac{kJ}{kg}}$$

$$\dot{m}_{nom.\ fuel} = 3.92949 * 10^{-3}\frac{kg}{s}$$

### 3.2.4 Real steam mass flow

$$\dot{m}_{real\ steam} = 70\% * \dot{m}_{nom.\ steam}$$

$$\dot{m}_{real\ steam} = 0.04118\frac{kg}{s}$$

Is divided by the conversion factor of kilograms to tons (1000 kg = 1 ton) and multiply by the conversion factor from hour to second (1 h = 3600 s) to convert in tons per hour.

$$\dot{m}_{real\ steam} = 0.1483\ \frac{ton}{h}$$

In 7 hours: $\dot{m}_{real\ steam} = 1{,}0381\ ton$

### 3.2.5 Real efficiency

$$\eta_{real} = \frac{\dot{m}_{real\ steam} * (h_g - h_i)}{\dot{m}_{real\ fuel} * PCI}$$

$h_g$: Saturated steam enthalpy at the pressure of 800 kPa
$h_i$: Compressed liquid enthalpy at the pressure of 800 kPa and temperature of 358 K

$$\eta_{real} = \frac{0.04118\frac{kg}{s} * (2763.5 - 356.4)\frac{kJ}{kg}}{2.74415 * 10^{-3}\frac{kg}{s} * 42500\frac{kJ}{kg}} * 100\%$$

$$\eta_{real} = 85\%$$

### 3.2.6 Replacement water

$7\ hours \rightarrow 60\% * 500\ l = 300\ l$, consumes the boiler

$1\ hours \rightarrow 42.85\ l$, consumes the boiler

$$x\ \% * \dot{m}_{real\ steam} = mass\ flow\ of\ water$$

$$x\ \% = \frac{\dot{m}_{H_2O}}{\dot{m}_{real\ steam}} = \frac{42.85}{0.1483}\frac{l}{ton} * \frac{1}{1000}\frac{ton}{kg} * \frac{1000}{1}\frac{kg}{m^3} * \frac{1}{1000}\frac{m^3}{l} * 100\%$$

$$x\ \% = 29\ \%\ of\ replacement\ water$$

In the process 29% of the water is lost and this is the same amount that is replenished, 71% returns to the desareador tank.

### 3.2.7 Steam consumption in each area

Consumption and output steam of each area are shown in table 3.

Table 3. Entry and exit of steam from the various kitchen and laundry equipment

| Steam consumption of each equipment | | | |
|---|---|---|---|
| Area | Equipment | $\dot{m}$ (kg/s) | $\dot{m}$ (kg/s) |
| Kitchen | $\dot{m}_1$ | 0.00576 | 0.01152 |
| | $\dot{m}_2$ | 0.00576 | |
| Laundry | $\dot{m}_3$ | 0.00494 | 0.02962 |
| | $\dot{m}_4$ | 0.00494 | |
| | $\dot{m}_5$ | 0.00452 | |
| | $\dot{m}_6$ | 0.00452 | |
| | $\dot{m}_7$ | 0.00535 | |
| | $\dot{m}_8$ | 0.00535 | |
| $\dot{m}_{real\ steam}$ $of\ entry$ | | 0.04118 | |
| Steam output of each equipment | | | |
| Area | Equipment | $\dot{m}$ (kg/s) | $\dot{m}$ (kg/s) |
| Kitchen | $\dot{m}_1'$ | 0.00409 | 0.00818 |
| | $\dot{m}_2'$ | 0.00409 | |
| Laundry | $\dot{m}_3'$ | 0.00350 | 0.02102 |
| | $\dot{m}_4'$ | 0.00350 | |
| | $\dot{m}_5'$ | 0.00321 | |
| | $\dot{m}_6'$ | 0.00321 | |

| | | | |
|---|---|---|---|
| | $\dot{m}_7{}'$ | 0.00380 | |
| | $\dot{m}_8{}'$ | 0.00380 | |
| $\dot{m}_{real\ steam}$ *of output* | | 0.02920 | |

### 3.3 Evaluation and analysis of the energy system using the flash tank

A Flash Tank in the condensate system is not a luxury, but it is a necessary component to maximize or increase the efficiency of the steam system.

Figures 2, 3 and 4, shows how the condensate returns directly to the so-called "flash tank" of high pressure installed in the boiler room, at a pressure of 250 kPa, and the low pressure is 100 kPa.

Once mentioned the advantages of using the Flash Tank in the condensate recovery system, we proceed to calculate the energy savings obtained with the use of it.

For this, 3 cases will be made, which will be compared and the case that represents the greatest saving for the system will be chosen, the cases are shown below.

#### 3.3.1 Implementation of the flash tank in the condensate system that comes out of the kitchen

The scheme representing this scheme is shown in Fig.2.

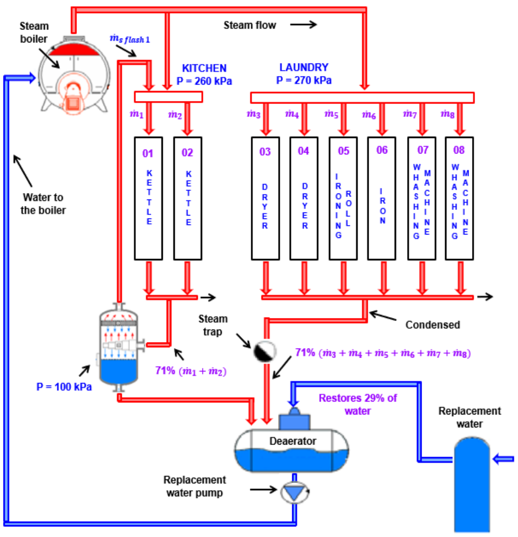


Figure 2. Scheme using the flash tank in the system recovering the condensate coming from the kitchen

To perform the energy analysis of the system of case 01, we must take into account the previous parameters.

Flash steam percentage 1:

$$\%_{flash\ steam\ 1} = \frac{h_{f\ P\ high} - h_{f\ P\ low}}{h_{fg\ P\ low}}$$

$h_{f\ p\ high}$: Saturated liquid enthalpy at the pressure of 260 kPa
$h_{f\ p\ low}$: Saturated liquid enthalpy at the pressure of 100 kPa
$h_{fg\ p\ low}$: Saturated water enthalpy (liquid-vapor) at the pressure of 100 kPa

$$\%_{flash\ steam\ 1} = \frac{(540.59 - 417.46)\frac{kJ}{kg}}{2258\ \frac{kJ}{kg}}$$

$$\%_{flash\ steam\ 1} = 0.0545 = 5.45\ \%$$

Flash steam mass flow 1:

$$\dot{m}_{flash\ steam\ 1} = \%_{flash\ steam\ 1} * \dot{m}_{kitchen\ exit}$$

$$\dot{m}_{flash\ steam\ 1} = 0.0545 * 0.00818\ \frac{kg}{s}$$

$$\dot{m}_{flash\ steam\ 1} = 4.4581 * 10^{-4}\,\frac{kg}{s}$$

Saving the mass flow of fuel:

$$\dot{m}_f = \frac{\dot{m}_{flash\ steam\ 1} * (h_g - h_i)}{\eta_{real} * PCI}$$

$h_g$: Saturated steam enthalpy at the pressure of 700 kPa
$h_i$: Compressed liquid enthalpy at the pressure of 700 kPa and temperature of 358 K

$$\dot{m}_f = \frac{4.4581 * 10^{-4}\,\frac{kg}{s} * (2763.5 - 356.4)\,\frac{kJ}{kg}}{0.85 * 42500\,\frac{kJ}{kg}}$$

$$\dot{m}_f = 2.9705 * 10^{-5}\,\frac{kg}{s}$$

It is divided by density of B2 diesel (870 kg/$m^3$), he conversion factor of cubic meters to gallons (1 $m^3$ = 264.172 gal) and multiply by the conversion factor from hour to second (1 h = 3600 s) to convert into gallons per hour.

$$\dot{m}_{real\ fuel} = 0.0325\ \frac{gal}{h}$$

### 3.3.2 Implementation of the flash tank in the condensate system that leaves the laundry

The scheme representing this scheme is shown in Fig.3.

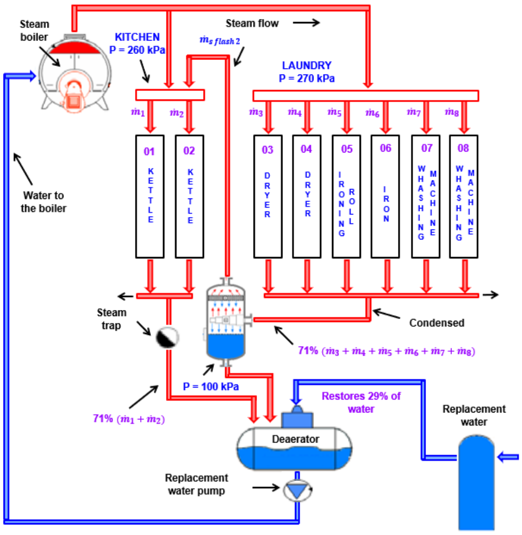


Figure 3. Scheme using the flash tank in the system recovering the condensate coming from the laundry

To perform the energy analysis of the system of case 02, we must take into account the previous parameters.

Flash steam percentage 2:

$$\%_{flash\ steam\ 2} = \frac{h_{f\ P\ high} - h_{f\ P\ low}}{h_{fg\ P\ low}}$$

$h_{f\ p\ high}$: Saturated liquid enthalpy at the pressure of 270 kPa
$h_{f\ p\ low}$: Saturated liquid enthalpy at the pressure of 100 kPa
$h_{fg\ p\ low}$: Saturated water enthalpy (liquid-vapor) at the pressure of 100 kPa

$$\%_{flash\ steam\ 2} = \frac{(545.81 - 417.46)\frac{kJ}{kg}}{2258\ \frac{kJ}{kg}}$$

$$\%_{flash\ steam\ 2} = 0.0568 = 5.68\ \%$$

Flash steam mass flow 2:

$$\dot{m}_{flash\ steam\ 2} = \%_{flash\ steam\ 2} * \dot{m}_{laundry\ exit}$$

$$\dot{m}_{flash\ steam\ 2} = 0.0568 * 0.02102\ \frac{kg}{s}$$

$$\dot{m}_{flash\ steam\ 2} = 1.1939 * 10^{-3}\frac{kg}{s}$$

Saving the mass flow of fuel:

$$\dot{m}_f = \frac{\dot{m}_{flash\ steam\ 2} * (h_g - h_i)}{\eta_{real} * PCI}$$

$h_g$: Saturated steam enthalpy at the pressure of 700 kPa
$h_i$: Compressed liquid enthalpy at the pressure of 700 kPa and temperature of 358 K

$$\dot{m}_f = \frac{1.1939 * 10^{-3}\frac{kg}{s} * (2763.5 - 356.4)\frac{kJ}{kg}}{0.85 * 42500\ \frac{kJ}{kg}}$$

$$\dot{m}_f = 7.9553 * 10^{-5}\frac{kg}{s}$$

It is divided by density of B2 diesel (870 kg/m$^3$), he conversion factor of cubic meters to gallons (1 m$^3$ = 264.172 gal) and multiply by the conversion factor from hour to second (1 h = 3600 s) to convert into gallons per hour.

$$\dot{m}_{real\ fuel} = 0.0869\ \frac{gal}{h}$$

### 3.3.3 Implementation of the flash tank in the condensate system that leaves the kitchen and laundry

The scheme representing this scheme is shown in Fig.4.

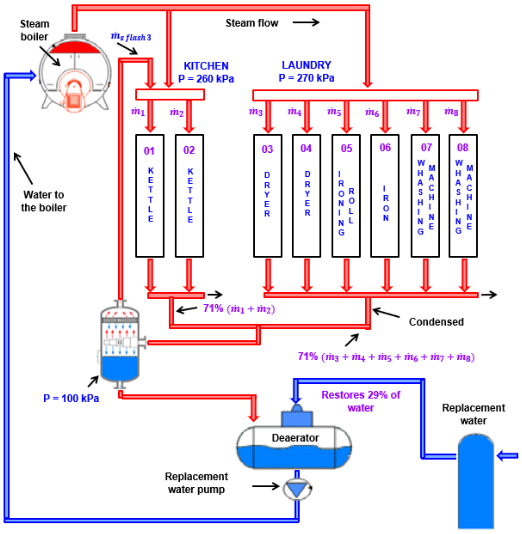


Figure 4. Scheme using the flash tank in the system recovering the condensate coming from the kitchen and the laundry

To perform the energy analysis of the system of case 03, we must take into account the previous parameters.

Flash steam percentage 3:

$$\%_{flash\ steam\ 3} = \frac{h_{f\ P\ high} - h_{f\ P\ low}}{h_{fg\ P\ low}}$$

$h_{f\ p\ high}$: Saturated liquid enthalpy at the pressure of 260 kPa
$h_{f\ p\ low}$: Saturated liquid enthalpy at the pressure of 100 kPa
$h_{fg\ p\ low}$: Saturated water enthalpy (liquid-vapor) at the pressure of 100 kPa

$$\%_{flash\ steam\ 3} = \frac{(540.59 - 417.46)\frac{kJ}{kg}}{2258\ \frac{kJ}{kg}}$$

$$\%_{flash\ steam\ 3} = 0.0545 = 5.45\ \%$$

It means that 5.45% of the available mass is recovered with a tank at 1 bar.

Flash steam mass flow 3:

$$\dot{m}_{flash\ steam\ 3} = \%_{flash\ steam3} * \dot{m}_{kitchen\ and\ laundry\ exit}$$

$$\dot{m}_{flash\ steam\ 3} = 0.0545 * (0.00818 + 0.02102)\frac{kg}{s}$$

$$\dot{m}_{flash\ steam\ 3} = 1.5914 * 10^{-3}\frac{kg}{s}$$

Saving the mass flow of fuel:

$$\dot{m}_f = \frac{\dot{m}_{flash\ steam\ 3} * (h_g - h_i)}{n_{real} * PCI}$$

$h_g$: Saturated steam enthalpy at the pressure of 700 kPa
$h_i$: Compressed liquid enthalpy at the pressure of 700 kPa and temperature of 358 K

$$\dot{m}_f = \frac{1.5914 * 10^{-3}\frac{kg}{s} * (2763.5 - 356.4)\frac{kJ}{kg}}{0.85 * 42500\ \frac{kJ}{kg}}$$

$$\dot{m}_f = 1.0604 * 10^{-4}\frac{kg}{s}$$

It is divided by density of B2 diesel (870 kg/m$^3$), he conversion factor of cubic meters to gallons (1 m$^3$ = 264.172 gal) and multiply by the conversion factor from hour to second (1 h = 3600 s) to convert into gallons per hour.

$$\dot{m}_{real\ fuel} = 0.1159\ \frac{gal}{h}$$

Considering that the operation of the boiler is 7 hours a day, 6 days a week and 48 weeks a year, it is obtained that:

$$fuel\ saving = 233.65\ \frac{gal}{year}$$

For our case, the actual fuel consumption is 21 gallons of Diesel B2 evaluated at 7 hours of operation per day, with 3 gallons of B2 diesel per hour, of this year.

$$fuel\ consumption = 6048\ \frac{gal}{year}$$

Savings percentage:

$$\%\, fuel\ saving = \left(100 - \frac{6048 - 233.65}{6048}\right) * 100\ \%$$

$$\%\, fuel\ saving = 3.86\ \%$$

Therefore, when developing the three cases, we observe that in the third case we have the greatest fuel savings and we verify that using a flash tank at 100 kPa of internal pressure we can reduce 0.1159 gal/h of fuel in the days of production. Therefore, the sizing of the flash tank will depend on the working pressure that we will use for condensate recovery and flash steam production.

## 3.4 Economic evaluation

The cost of steam or steam generation cost is a good way to know the efficiency of a steam system. This cost depends on the type of fuel used, the cost of the fuel, the efficiency of the boiler, the water supply temperature and the steam pressure.

The maximum fuel savings is obtained in case 03, in which the quantity is:

$$\dot{m}_{real\ fuel} = 0.1159\ \frac{gal}{h}$$

It is multiplied by the price of Diesel B2 which is ($ 2.99 dollars per gallon) and the hours of operation per year to obtain the net savings in soles per year.

$$net\ saving = 0.3465\ \frac{\$}{h}$$

Considering that the operation of the boiler is 7 hours a day, 6 days a week and 48 weeks a year, it is obtained that:

$$net\ saving = 696.64\,\frac{\$}{year}$$

In this value, only fuel savings are being considered, which is why we must add the savings in water and the savings of chemical product used for its treatment if it were so.

## 3.5 Determination of energy indicators

Likewise, the calculation corresponding to the behavior of the indicators was performed and verified how they behave and improve with the recovery of condensates and the generation of flash steam.

### 3.5.1 Influence on the production technical energy indicator ($TEI_1$)

For our case, the actual fuel consumption is 21 gallons of B2 diesel evaluated at 7 hours of operation per day, with 3 gallons of B2 diesel per hour, of this year.

**a) The current energy indicator**

$$TEI_1 = 20.23\,\frac{gal\ B2\ diesel}{tons\ of\ steam\ produced}$$

Fuel saved by the generation of flash steam at 1 kPa is 0,1159 gallons of B2 diesel per hour.

**b) New improved technical energy indicator**

$$TEI_1\ improved = 19.45\,\frac{gal\ B2\ diesel}{tons\ of\ steam\ produced}$$

**c) Percentage of improvement of the thermal energy technical indicator**

$$\%\, TEI_1\ improved = \frac{(20.23 - 19.45)}{20.23} * 100\%$$

$$\%\, TEI_1\ improved = 3.86\%$$

### 3.5.2 Influence on the flash steam generation technical indicator ($TEI_2$)

For our case, the flash steam generation is 5.729 kg/h of flash steam at 100 KPa.

**a) Flash steam generation indicator**

$$TEI_2 = 38.63 \frac{flash\ steam\ at\ 100\ kPa\ (kg)}{tons\ of\ steam\ produced}$$

### 3.5.3 Economic Energetic Indicator (EEI)

For our case the price of B2 diesel is $ 2.99 dollars per gallon and the actual fuel consumption is 21 gallons of B2 diesel evaluated at 7 hours of operation per day, with 3 gallons of B2 diesel per hour, of the present being consumed per year.

**a) Current economic energetic indicator**

$$EEI = 60.42 \frac{\$}{tons\ of\ steam\ produced}$$

Fuel saved by the generation of flash steam at 1 kPa is 0.1159 gallons of B2 diesel per hour.

**b) New improved economic energetic indicator**

$$EEI\ improved = 58.01 \frac{\$}{tons\ of\ steam\ produced}$$

**c) Percentage of improvement of the economic energetic indicator**

$$\%\ EEI\ improved = \frac{(60.42 - 58.01)}{60.42} * 100\%$$

$$\%\ EEI\ improved = 4\%$$

The result obtained with respect to the objective of applying the evaluation of a flash tank for energy saving in the condensate recovery system; we realize that when evaluating the three presented cases, in the latter there is a greater use of condensate since it comes from the kitchen and the laundry, which leads to a better energy saving.

Analyzing and comparing the energy savings obtained by implementing a flash tank in the condensate recovery system in the force area of "La Caleta" Hospital, we can see that you can save 234 gal B2 diesel, which is equivalent to 3.86% of consumption of total fuel for one year.

The hospital could save $ 696.64 dollars per year only in fuel, without taking into account the savings of water and chemicals.

The energy indicators were determined before and after implementing a flash tank in the condensate recovery system, in which the following improvements were obtained. Technical Energetic Indicator improved by 3.86% and the Economic Energetic Indicator improved by 4%.

## 4. CONCLUSIONS

The implementation of this project should be carried out as soon as possible due to the improvements that are presented for the force area of "La Caleta" hospital, both energy improvements and obtaining savings in production.

Likewise, steam and condensate flow meters must be implemented at strategic points, in order to record the steam consumption at each moment of the process and thus quantify the condensate that returns, since in this way the data can be obtained with greater precision and get better results in the future.

## 5. ACKNOWLEDGEMENTS

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## 6. REFERENCES

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