Experimental Investigation of an Effective Condensate Recovery System in a Process Plant

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Abstract: A process plant is producing around 0.07 $m^3$of hot condensate from the vulcanizing tumbler per hour and the rinsing unit is producing 1.56 m^3 of waste hot water per hour. Currently this condensate and hot water is being drained out without any proper usage. This paper tells us a a system for effective utilization of this waste heat energy which include a system consisting of a reservoir, temperature sensor, water level sensor, pump, valves, timer circuit, thermally insulated stainless steel pipes and hot water tank for reuse of this hot water in the mould rinsing unit. The waste hot water containing chemicals from the rinse unit will be collected and clean hot water will be recirculated to the reservoir. From the reservoir the hot water along with condensate will be pumped to hot water tank for reuse. And we will calculate the net energy usage reduction and savings for the company.

Keywords: *Condensate Recovery, Vulcanizing Tumbler, Pumping Circuit*

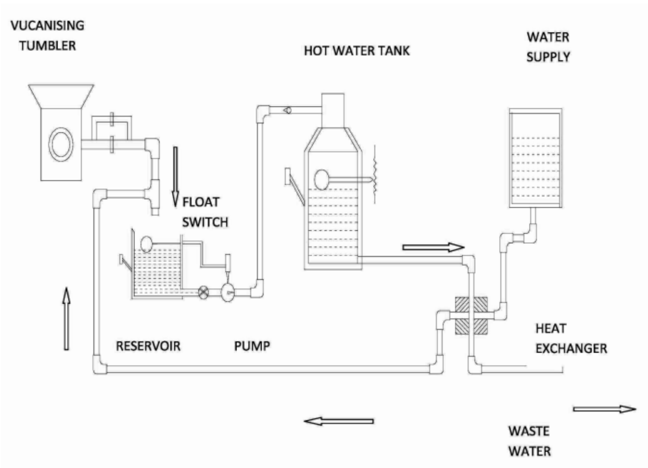
I. INTRODUCTION AND PROBLEM STATEMENT

At present in the process plant a lot of condensate and waste water are being drained out without any reuse . so if we consider the amount of condensate and hot water liberated from the various process , we will understand that there is thermal energy loss in huge amount. These energy if properly utilized by using some re use technology can reduce the daily running cost of factory for producing the excess steam. Especially the cost associated with the usage of LNG for running boiler can be reduced. Which will having a tremendous impact on the annual energy savings .If this waste heat energy is used properly, day to day running cost can be reduced with the help of some reusing units. In the plant, the steam after use from the vulcanizing tumbler is being exhausted out through the mild steel tubes as condensate having a temperature of around 90 ˚c. And this condensate is being currently drained out without any reuse. This condensate can be reused by designing a proper system for its usage. This in turn can be effectively utilized to reduce the steam requirements of the factory.

In the plant rinsing unit, the hot water from the hot water tank at 90°C is supplied to the rinsing jets and after rinsing the moulds, The waste hot water are being drained to earth surface in a continuous manner .This can also be reused by designing a heat exchanger for transferring the heat from the waste hot water to the clean water. And can be in turn supplied to the hot water tank.

In the hot water tank in the plant, water is being heated to 90˚c by using steam. And reuse of these hot water and condensate will reduce the steam requirements. Reduction in steam means reduction in the overall fuel requirements. That is the fuel like furnace oil and the LNG can be reduced tremendously. The cost of LNG fuel put to use is around two lakhs and it can be reduced to a great extend if we implement this project.

II. PROPOSED CIRCUIT FOR EFFECTIVE CONDENSATE RECOVERY



CONDENSATE CIRCUIT

WASTE WATER CIRCUIT

PUMPING CIRCUIT

Here the steam is used in the vulcanizing tumbler for drying the product and steam after use will enter a mild steel tube and will be collected in a reservoir designed for the purpose. It will be stored in the reservoir for some time. The temperature of condensate will be 90°C. The hot water from the hot water supply tank will go to the rinsing unit continuously. After rinsing the moulds it will drain into the inlet of heat exchanger. And eventually the clean water will also enter the exchanger. The use of heat exchanger is necessary because only pure water can be supplied to the hot water tank. And it is stored in the reservoir.

From the reservoir it is pumped by 0.5 hp pump into the hot water tank. Where it is used for giving to the rinsing unit. Temperature sensor is giving in the reservoir for measuring the temperature. The pipe lines for carrying water are completely insulated. And timer circuit are given for timing supply of hot water into the hot water tank. The insulations are given with rockwool. The pump used is 0.5 centrifugal pump. Which will pump water according to the timer circuit. The pump pumps water to a head of around 10 m to the hot water tank. Reservoir designed is having the following dimensions.

Length= 100 cm

Breadth=100 cm

Height=150 cm.

It will be made of stainless steel sheets.

And it will be provided with suitable rock wool insulations for thermal insulations. The pipes used for carrying hot water will also be made of stainless steel. This is because of their ability to resist the corrosion. The entire circuit will be completely insulated for thermal stability.

PUMP AND STEAM CALCULATIONS

1. PUMP CALCULATION

$$WHP = \frac{Q \times H}{3960}$$

Q in gallons /minute.

H in foot.

Flow rate calculated $= 3.41 \times 10^{-4}\ m^3/sec$

$= 1.23\ m^3/hr.$

$1\ m^3/s = 15850.3$ gallons/minute.

Q = 5.4155 gallons/minute.

H = 31.463 foot.

WHP = 0.043 hp

= 30 w

= 0.03kw.

So we have to select 0.5 hp centrifugal pump.

2. STEAM CALCULATIONS

MASS FLOW RATE OF WATER USED IN RINSING UNIT

By measurement

Mass flow rate of water used = 0.433 l/s

$= 1.56\ m^3/hr.$

MASS FLOW RATE OF WATER FLOWING TO RESERVOIR

Condensate flow rate $= 0.07\ m^3/hr.$

Exchanger flow rate $= 1.16\ m^3/hr.$

Total $= 1.23\ m^3/hr.$

Existing system ($30°C\ to\ 90°C$)

For water , $Q_C = \dot{m}_c c_p \Delta T.$

$\rho = 995 kg/m^3$ at $50°C.$

$\dot{m}_c = \rho AV$

$= 995 \times \frac{\pi}{4} \times (0.04)^2 \times 0.199$

$= 0.24$ kg/s.

For water,

$Q_c = \dot{m}_c c_p \Delta T.$

$= 0.24 \times 4.18 \times 60$

= 62.4 kw.

For steam,

$Q_h = \dot{m}_h c_p \Delta T.$

$Q_C = Q_h$

$Q_h = 62.4$ kw

$= \dot{m}_h \times 2.49 \times 60$

$\dot{m}_h = 0.41$ kg/s.

AS PER THE WORK:

$\dot{m}_C = 1.23\ m^3/kg$

for water,

$Q_c = \dot{m}_c c_p \Delta T.$

$$Q_c = \frac{1.23 \times 10}{60 \times 60} \times 418 \times 29$$

= 41.4 kw.

For steam,

$Q_h = \dot{m}_h c_p \Delta T.$

$Q_C = Q_h$

$Q_h = 41.4$ kw

$= \dot{m}_h \times 2.49 \times 60$

$\dot{m}_h = 0.27$ kg/s.

difference = 0.14 kg/s

Steam reduced per day = 6.048 tonnes/day.

Cost of LNG used per day= RS 2,60,000/-

The cost of LNG used can be reduced since the steam reduced per day is around 6 tonnes. And the cost of LNG used per day is about two and a quarter lakhs.Which will have a tremendous impact on cost savings as per the project.

TEMPERATURE OF WATER IN RESERVOIR

$\dot{m} c_p \Delta T = \dot{m} c_p \Delta T$

$\dot{m}_{he} = 1.29\ m^3/l.$

$\dot{m}_{condensate} = 0.07\ m^{3/}l.$

$T_1 = 80°C$ = Temperature of condensate .

T_2=60°C = Temperature of water at heat exchanger outlet.

$$0.07(80 - x) = 1.29(x - 60)$$

$$80 - x = 18.42x - 1105$$

$$19.42x = 1185$$

$$= 61°C$$

The temperature of water available for pumping is 61°c.

FUTURE WORK

Need for a Heat Exchanger:

The hot waste water has to be changed from 80°C *to* 30°C .To fulfill the purpose,heat exchanger needs to be designed. And the pure water which receives this heat has to be stored in the reservoir and then pumped to hot water tank for use. A shell and tube heat exchanger can be selected for the above purpose. . The criteria for selection of heat exchanger are on basis of plant capacity, heat transfer rate etc… For increasing the temperature of pure water, hot waste water has to be used .pure water is available at cheap cost.Flow of fluids through the tube and shell is decided by the viscosity. High viscosity fluid is passed through tubes. While comparing the two fluids , the viscosity of hot waste water is low, so it has to be passed through the shell. Water may cause corrosion in the tubes, so it is necessary to pass fluid with high force for cleaning the tubes.

RESULTS AND CONCLUSION

From this paper, it is clear that proper utilisation of the condensate and hot water will make tremendous impact on the annual cost savings of the plant thereby steam system performance can be improved . The work also specified how thermal aspects can be applied to reduce the overall cost of plant.Proper utilization of such waste heat energy will provide us with huge cost savings. The need for a heat exchanger is depicted in the work which helps further improvement in the reducing the energy and savings

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References

[1] Allens, F. H. and R. P. Roe (1950) 'Performance characteristics of a volumetric condensate reservoir'' Trans AIME-189 (P83).

[2] Arps, J. J. and T. G. Roberts (1955) ''The Effects of Relative Permeability Ratio, Oil Gravity and solution Gas-Oil Ratio in Primary Recovery from a [3] Depletion Reservoir''. Trans, AIME-194 (121)

[3] Berryman, J. E. (1957) ''The Predicted Performance of gas condensate System''. Trans, AIME-210 (P102).

[4] Craft, B. C. and M. F. Hawkins (1958) ''Gas and Gas-Condensate Reservoir'' Text, Chapter-2&3. PP242-259

[5] Craze, R. C. and Buckley, S. E. (1945) ''A Factual Analysis of the Effect of Well Spacing on Oil Recovery'' Drill & Prod Prac, API 1945 PP144 – 159.

[6] Eilerts, C. K., (1957) ''Phase Relation of Gas-Condensate Fluids.'' Monogragh 10, Bureau of Mines, (New York): American Gas Association, Vol.I PP59-63.