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Risk Assessment on Liquefied Petroleum Gas (LPG) Handling Facility, Case Study: Terminal LPG Semarang

T A Akbar[1,2,a], A A B Dinariyana[1,2] , A Baheramsyah[1] , F I Prastyasari[1,2] and P D Setyorini[2,3]

[1] Department of Marine Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia, 60111
[2] Centre of Excellences of Maritime Safety and Marine Installation (PUI-KEKAL) Institut Teknologi Sepuluh Nopember Surabaya
[3] Department of Marine Engineering, Faculty of Engineering and Marine Sciences, Hang Tuah University Surabaya, Indonesia

[a] thariqakb@gmail.com

Abstract. LPG plays important role in Indonesia as household fuel. With the rapid growth of LPG usage, its handling facility is built across the country. The handling of LPG requires various activity prior to supporting its supply chain. One of the vital facility is Terminal LPG (or on this case Terminal LPG Semarang) which serve as a hub in LPG distribution because it handles a relatively huge amount of LPG. It is exposed to operational risk especially fire risk. This paper is intended to assess the risk of LPG Terminal by using combined both qualitative and quantitative methods. The initial step is to identify the hazard by using HAZOP Study. The next step is to determine the likelihood of the risk by using FTA and ETA resulted in event frequency. The severity level is determined using consequences analysis which involved fire modeling of the intended scenarios. The result from both frequency and consequences will be presented in the risk matrix to determine the unacceptable risk scenario to develop a mitigation plan by using Fire Risk Card to assess the capability of the Terminal firefighting equipment.

1. Introduction

1.1. Background

Solar radiation energy was one form of alternative energy that could be used for various purposes to replace the energy produced by petroleum. For a long time, solar energy had become a source of lighting during the day, and was also widely used to dry agricultural produce, clothing, wood, heating water and others. An Indonesian gift located in the equator, where solar energy was available at all times.

As one alternative energy source, solar energy had become increasingly widespread. One of its uses was to use a device called a solar collector. At present, flat plate or wave shape solar collectors for water heaters had been developed. This collector, using wave shaped plate that serves to absorb the incoming solar energy and move the heat received to the working fluid, namely water. At the top of the collector, a transparent cover was used to cause a greenhouse effect. In order to avoid heat loss to the environment at the bottom and side of the solar collector, an insulator was provided (Made et al., 2010).

1.2. Identification of the problem
The problem of this research was to identify the influence of the variation of the time period of the collector shift at a short interval of 20 minutes, 40 minutes, 60 minutes to the efficiency of solar water heater.

1.3. The purpose of the study
The purpose of the study was knowing the effect of variations in the period of time the collector shifts to the efficiency of solar water heater.

1.4. Benefits of research
The benefits of the research was could find out the process of designing and manufacturing solar collectors with tracker. Could be used for further research with various variations so as to get better efficiency. Could be used as one of the utilization of environmentally friendly energy sources and never runs out.

1.5. Scope of problem
The scope of problem was : the testing process uses a solar water collector with a wave plate heater with a tracker. Variation in the time period of the collector shift time 20 minutes, 40 minutes, 60 minutes. Measurement results was taken for each time interval 15 minutes. Fluid capacity was set 30 liters. Flow rate was set at 0.011 liters/second. Volume of fluid inside the collector was 15 liters. Collector's tilt position was 15º facing north.

2. Literature Review

Previous research

Mustofa (2008), an experimental study of the comparison of double plate collectors and conventional collectors on the performance of solar water heater. The research resulted, the heat absorption efficiency of solar double plate heater was higher than the efficiency of conventional solar heater heat absorption.
Farid and Ismail (2010), tested the double absorber plate of wave models which produced an average heat absorption efficiency value in the double wave solar heater model with an average of 19.81%, while the value of the average heat absorption efficiency in solar absorbent plate heater flat at 12.43%.
Most solar collectors were permanently installed with fixed elevating angles. This causes the solar collector to be unable to absorb solar radiation optimally because the sun was always moving, namely in the east-west direction (called the sun's pseudo-daily motion) and north-south (called the annual pseudo-motion of the sun). Absorption of solar radiation will be optimal if the direction of solar radiation was perpendicular to the surface of the field of the solar collector. Therefore, efforts were needed to direct the surface of the solar collector to be perpendicular to sunlight. The method for directing solar collectors to always follow the direction of the sun's motion was known as the method of tracking the sun (Huang et al, 2009).

Determine efficiency

The efficiency of the collector panel was the ratio between the useful heat level (QU) transferred to the liquid divided by solar radiation in the cover plate. Efficiency could be shown at equation Duffie JA and Beckman W.A. (1980), as follows:

$$\eta = \frac{q_u}{A_C G_T} \tag{1}$$

From the above equation could also use the efficiency of the collector efficiency as follows:

$$\eta = F_R(\tau\alpha) - F_R U_L \frac{(Ti - Ta)}{G_T}$$

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$$\eta = \frac{\dot{m}\ C_p(T_0 - T_i)}{G_t . A_c} \qquad (2)$$

where :

Qu = The energy absorbed by collector, (W/m^2)
Ac = Collector Size (m^2)
FR = Collector heat loss factor
UL = Overall heat loss (W/m^2. ° C)
Gt = Total intensity of solar radiation (W/m^2)
Ta = ambient temperature (° C)
Tin = Entering water temperature (° C)
T_{out} = water temperature out (° C)
Cp = saturated water/liquid properties (kJ/(kg.°C))
τ = Transmissivity cover glass
α = Absorbtivity of the absorbent plate
$m^{\cdot}$ = Fluid flow rate (liters/second)

Fluid mass flow rate

The fluid mass flow rate was the amount of fluid mass that flows per unit of time and could be stated as follows:

$$\dot{m} = \frac{m}{t_u} = \frac{V\rho}{t_u} \qquad (3)$$

where :

m = fluid mass
tu = Time of fluid movement from one end to the other solar heat collector (liter/second)
Vρ = Volume of fluid flowing from collector exit pipe (liters).

3. ResearchMethod

The research starts from 10.00 WIB until 14.00 WIB in March 2018 until completion. Testing the variation of the time period of the collector shift was carried out in Madiun City, East Java, Indonesia A subsection

Equipment and Materials

From testing requires the following tools and materials: 3 mm thick zinc absorbent plate, 10 mm thick PVC plate, 3 mm thick glass, 25 liters water tank, framework for solar tracker collectors, circulation pipe with 25.4 mm in diameter, 3 mm thick insulator (stereofoam), aquarium pump, 1/2 " stop faucet, water hose, precision pyranometer, computer/laptop, programmable peripeal interface (PPI), analog digital converter (ADC), measuring glasses, roll cable and LM35 temperature measuring instrument.

Research Procedure

The steps taken in researching the performance of solar water heater were:

- Data collection was done by placing the collector in the sun.
- The collector was tilted at a fixed angle of 15˚ north.
- Install a series of measuring instruments to measure the temperature of the inlet water, absorbent plate temperature, glass temperature 1, glass temperature 2, temperature of the outgoing water, ambient temperature and solar radiation.
- Record the measurement results in accordance with the shift variation of the collector angle at 20 minutes, 40 minutes and 60 minutes.
- Direct the collector with the direction of falling sun radiation by 90 degrees by following the axis perpendicular to the shadow of the direction of the sun.
- Collect the data in table.
- Analyze the results of testing.

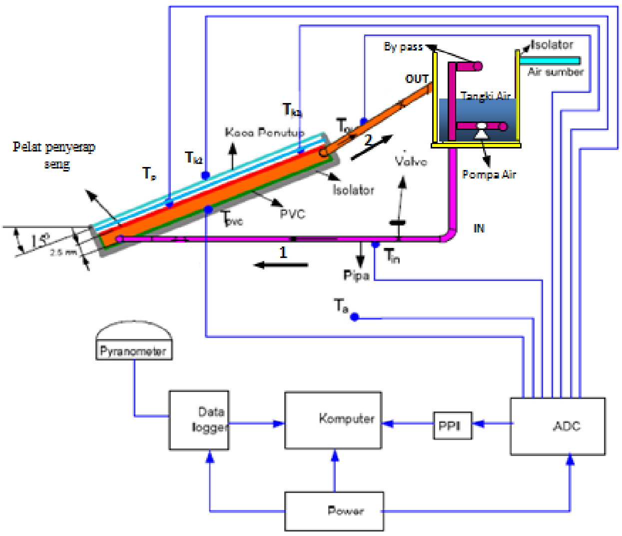

Figure 1. Scheme of solar water heating test equipment

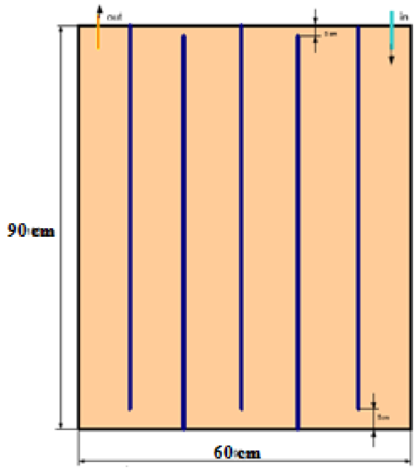

Figure 2. Scheme of collector absorber with zig zag grooves

4. Result and Discussion

From the research results obtained data and graphs could be made as follows:

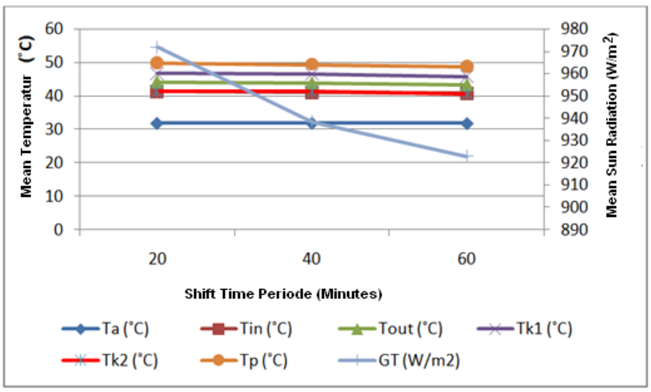

Figure 3. Relationship between the average temperature and the intensity of solar radiation

At the inlet temperature, glass temperature 1, glass temperature 2, absorbent plate temperature, and the exit temperature at each test the price was the same as the range 30˚C to 50 .C. While at the ambient temperature the price was the same as the time variation of 20 minutes, 40 minutes, 60 minutes the price was lower than the inlet temperature, glass temperature 1, glass temperature 2, the temperature of the absorber plate, and the exit temperature range at 30˚C. In solar radiation there was a significant decrease with a price range of 1000 W/m^2 to 800 W/m^2. This was due to the time of the same collector shift. At 20 minutes the shift time was shorter so that the displacement of the sun's upright position to the collector was faster.

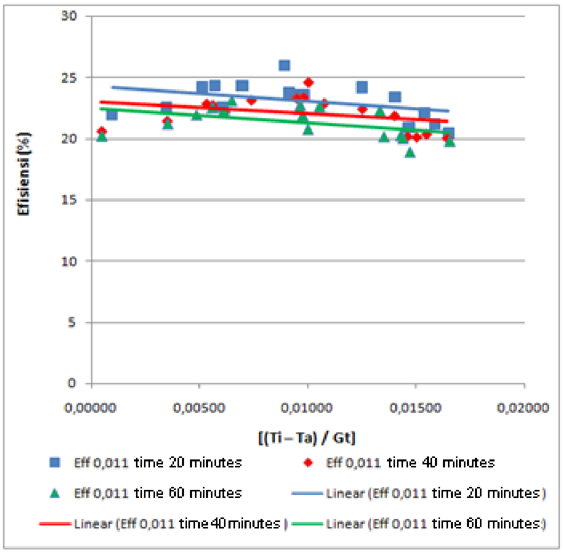

Figure 4. Graph of the relationship between the three efficiencies with (Ti-Ta / Gt)

In the test graph above it could be concluded that on the three tests the time period of the collector shift every 20 minutes, 40 minutes and 60 minutes at the same flow rate of 0.011 liters / second shows that the period of time the collector shifts greatly affects the intensity of solar radiation falling on the collector. the faster the collector's shift time toward the direction of falling solar radiation, the greater the solar radiation intensity, and the greater the temperature, the higher the efficiency obtained. From the three tests get results that show that the test using the shortest period of time the collector shift obtained the best efficiency in a period of 20 minutes while the longer the time period used, the radiation that falls to the collector and the absorption of heat gets smaller. So that the shift time affects the absorption of solar radiation in the collector which causes an increase in efficiency.

5. Conclusion
In small time interval, the collector shift was used, the greater the efficiency obtained. The best efficiency results for a time interval of 20 minutes with an average efficiency of 23.07%.

6. Ackowledgement
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