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The method of NAIMA 3E plus simulation for selection of material insulation in removable thermal insulation cover

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Abstract. Heat loss occurs due to the temperature difference between the fluid flowing in the pipe and the temperature outside the pipe, it can also occur due to inappropriate material selection and insulation thickness. Insulation is a method for reducing the rate of heat transfer from inside a pipe to the outside of the pipe. Valve is an object that is often encountered in un-insulated conditions so that there is a lot of heat loss in this section. Therefore, an insulation method and the right insulation material are needed to prevent heat loss. The study was conducted to see the effect of two glass wool and rock wool insulation materials on heat loss. The study used a simulation method using NAIMA 3E Plus software. The output of the simulation is the value of heat loss on glass wool and rock wool material. Data analysis using two-way ANOVA method assisted by Minitab software. The results show that the higher the temperature, the greater the heat loss value and the thicker the insulation layer, the smaller the heat loss value. Insulation material is better to use rock wool.

1. Introduction

Removable thermal insulation cover is one of the new breakthroughs in heat insulation systems that can be disassembled and reassembled without damaging the design and the material inside. This component is made of special heat insulation material which is covered with fabric, plastic or rubber which is heat-resistant, the model used is to resemble a jacket, installed by means of a rope or hook. Conventional insulation is one of the heat insulation systems that is permanently installed, the insulation uses the main material glass wool which is wrapped with aluminium sheets and how to install it is bolted. This makes maintenance of insulated equipment difficult and time-consuming because they have to disassemble the conventional insulation [1]. Heat loss is the loss or loss of heat energy in the flow of fluid flowing in the pipe due to heat transfer from a fluid in the pipe to the outside air [2]. In the pipe there is a valve that is often encountered in an un-insulated condition so that a lot of heat is lost, in this case needed thermal insulation with the right material on the valve as a prevention of heat loss in the steam jetting process [3-5].

Conduction heat loss is stated by the formula:

$$qk = -K\,A\frac{T2 - T1}{\mathrm{L}} \tag{1}$$

Qk : Conduction heat transfer rate (Watt)
A : Cross-sectional area (mm^2)
K : Conductivity of material (W/ m.°C)
T2 : Steam temperature (°C)

T1 : Room temperature (°C)
L : Insulation Thickness (mm)

High thermal conductivity values indicate a large energy transfer rate and materials that have high thermal conductivity are called conductors while those that have a low k value are called insulators [6,7]. To minimize heat loss and losses due to heat loss on the surface of the steam pipeline, an insulator is used [8]. Rockwool insulation results in better heat loss values compared to glass wool insulation, this is because the conductivity value of rock wool is lower than the conductivity of glass wool [5,9,10].

2. Methods

The method used in this study is thermal insulation on a valve flowed by steam. Types of thermal insulation used are conventional insulation and removable thermal insulation cover, the material used in both insulation is glass wool and rock wool. The two materials were tested related to the resulting heat loss [11].

Figure 1. Cover design.

The valve cover is made removable to facilitate installation and is also able to adapt to the complicated valve shape.

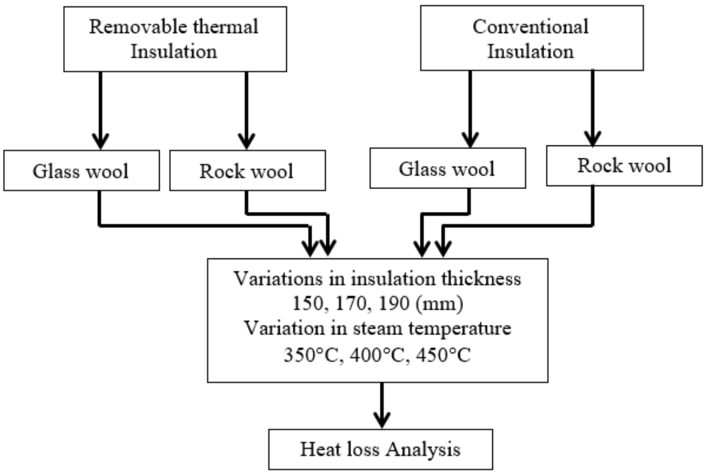

Figure 2. Research methods.

3. Discussion

The focus of this research is to determine the effect of the thickness of the steam temperature and the type of insulation material on the valve. The results displayed are data processing from heat loss simulation software and statistical software in graphical form [12].

3.1. Analysis of heat loss and insulation thickness in the valve

3.1.1. Heat loss value analysis for glass wool insulation. The graph of heat loss values for glass wool insulation with variations in steam temperature: 350°C, 400°C, 450°C in conventional insulation and removable thermal insulation cover is shown in Figure 2.

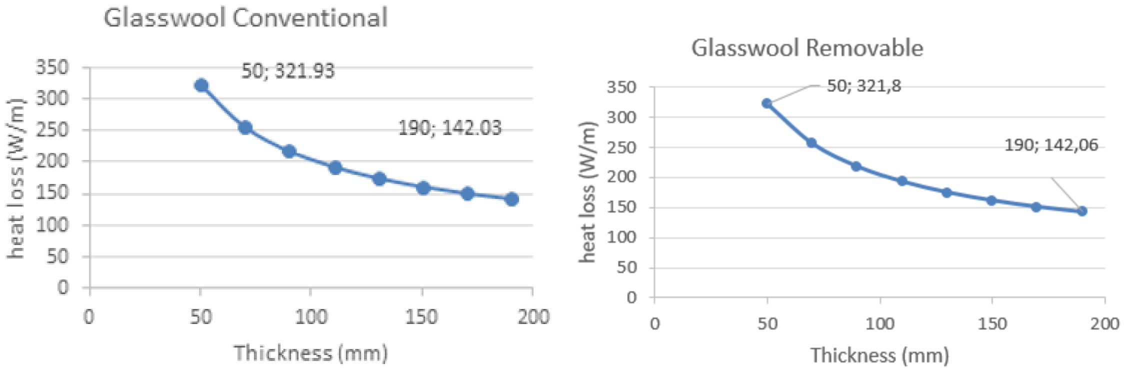

Figure 3. Insulation thickness vs. heat loss under conditions: Glass wool conventional insulation and glass wool removable thermal insulation cover.

From Figure 3 shows uniformity in each variation that the smallest value of heat loss occurs when the insulation layer is 190 mm and the greatest heat loss occurs when the insulation layer is 50 mm.

3.1.2. Heat loss value analysis for rockwool insulation

The graph of heat loss values for rock wool insulation with variations of temperature steam [13]: 350°C, 400°C, 450°C in conventional insulation and removable thermal insulation cover is shown in Figure 4.

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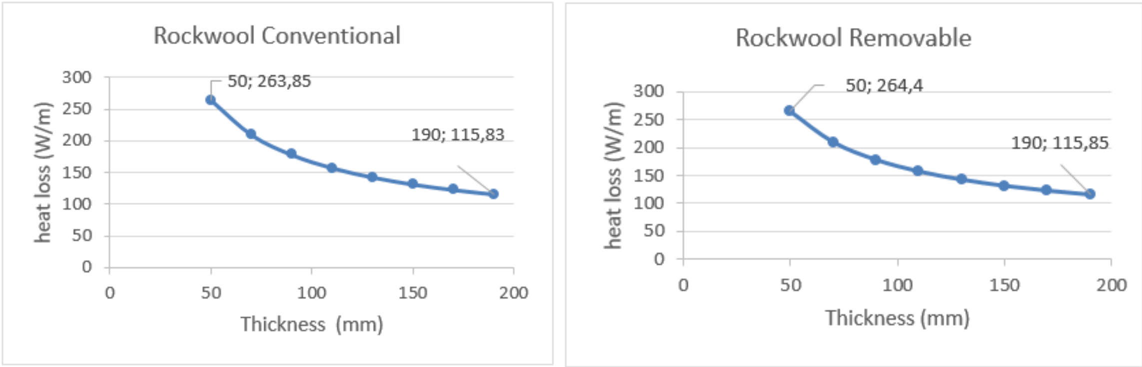

Figure 4. Insulation thickness vs. heat loss under conditions: Rockwool conventional insulation and rockwool removable thermal insulation cover.

From Figure 4 shows the uniformity in each variation that the smallest value of heat loss occurs when the insulation layer is 190 mm and the biggest heat loss occurs when the insulation layer is 50 mm.

3.2. Analysis of heat loss and temperature of steam insulation in the valve

3.2.1. Analysis of heat loss value for glass wool insulation
The graph of heat loss values for glass wool insulation with variations of temperature steam: 350°C, 400°C, 450°C in conventional insulation and removable thermal insulation cover is shown in Figure 5.

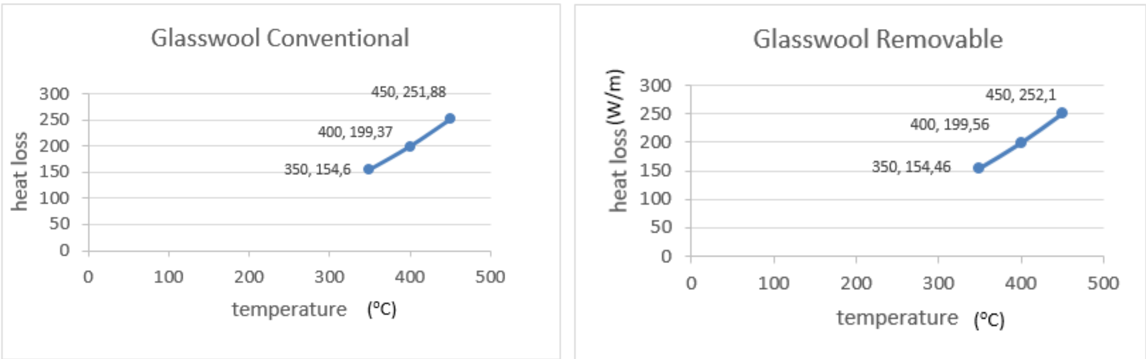

Figure 5. Steam vs. heat loss temperature under conditions: Glass wool conventional insulation and glass wool removable thermal insulation cover.

From Figure 5 shows uniformity in each variation that the smallest heat loss value occurs when the temperature is 350°C and the biggest heat loss occurs when the temperature is 450°C.

3.2.2. Heat loss value analysis for rock wool insulation
The graph of heat loss values for rock wool insulation with variations of temperature steam [14]: 350°C, 400°C, 450°C in conventional insulation and removable thermal insulation cover is shown in Figure 6.

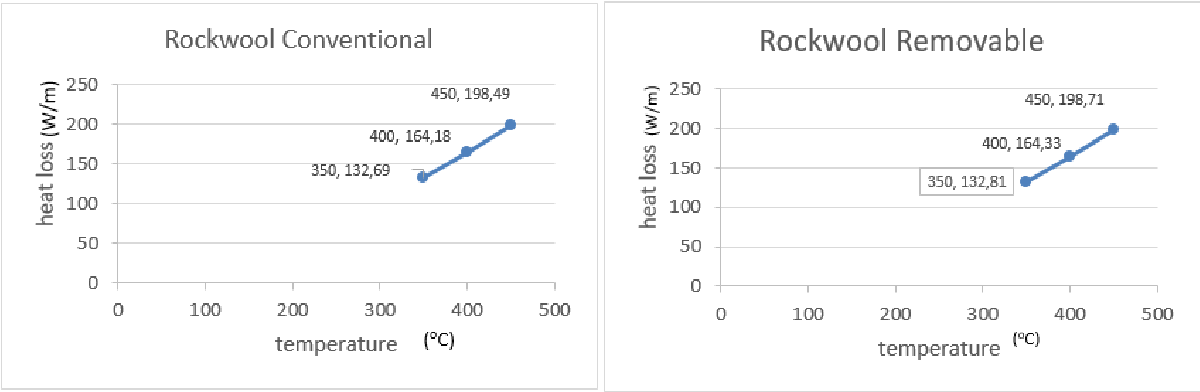

Figure 6. Steam vs. heat loss temperature under conditions: Rockwool conventional insulation and rockwool removable thermal insulation cover.

From figure 6 shows uniformity in each variation that the smallest value of heat loss occurs when temperature is 350°C and the biggest heat loss occurs when temperature is 350°C.

3.3. Analysis of glass wool and rock wool material against heat loss

3.3.1. Glass wool material

Heat loss value for glass wool insulation with thickness variations: 50mm, 70mm, 90mm, 110mm, 130mm, 150mm, 170mm, 190mm. And with variations of temperature steam: 350°C, 350°C, 350°C in both insulation shown in Figure 7.

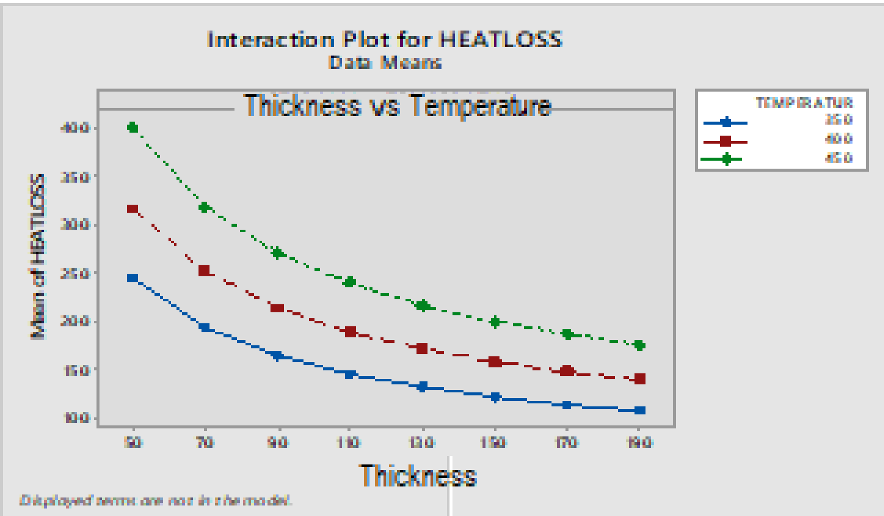

Figure 7. Graph of heat loss material glass wool value.

In Figure 7 shows the smallest value of heat loss in glass wool material is 108.60 W/m at a temperature of 350°C and insulation thickness of 190mm. Figure 6 also shows the thicker the insulation layer can reduce heat loss.

3.3.2. Rockwool material

Heat loss value for rock wool insulation with thickness variations: 50mm, 70mm, 90mm, 110mm, `130mm, 150mm, 170mm, 190mm. And with variations in T steam: 350°C, 400°C, 450°C in both insulation shown in Figure 8.

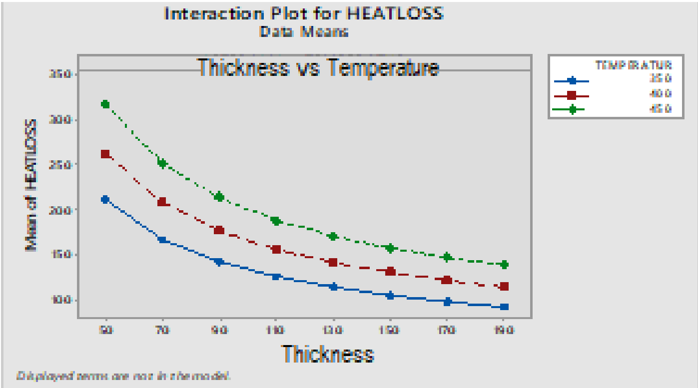

Figure 8. Graphs of heat loss material rock wool.

In Figure 8 shows the smallest heat loss value in rock wool material is 93.11 W/m at 350°C and insulation thickness of 190mm. Shows the thicker the insulation layer can reduce heat loss.

3.4. The relationship between thickness and temperature variables to the heat loss value

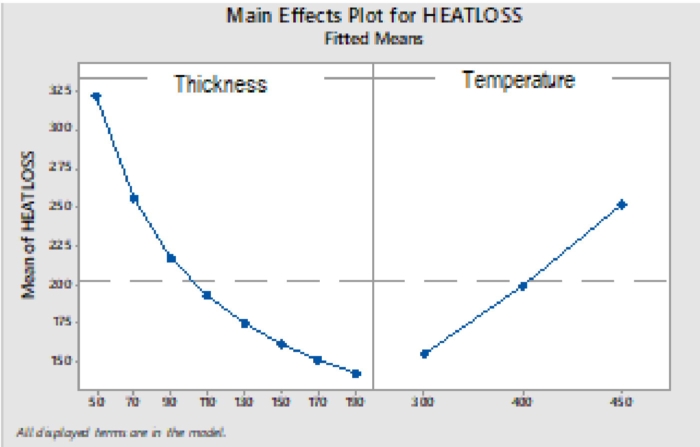

Figure 9. Relationship between insulation thickness and temperature steam on the heat loss value.

In Figure 9, the right hand graph shows the higher the temperature, the greater the heat loss value, and the lower the temperature the smaller the heat loss value. On the left graph shows the thicker the insulation material layer, the smaller the heat loss value, and the thinner the insulation material layer, the greater the heat loss value [10].

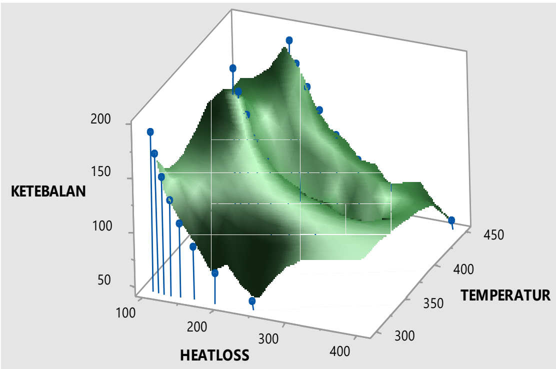

Figure 10. 3D plot diagram.

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In Figure 10 it can be seen that the lowest heat loss value is located at 350°C using 190 mm insulation material thickness. The value of the heat loss is 93.11 W / m.

4. Conclusion

The conclusions that can be drawn are the following:

- The use of glass wool material in conventional insulation produces a heat loss value of 108.60 W/m, the removable thermal insulation cover produces a heat loss value of 108.60 W/m. Both values are obtained from temperatures of 350°C with a material thickness of 190 mm.
- The use of rock wool material in conventional insulation produces a heat loss value of 93.11 W/m, the removable thermal insulation cover produces a heat loss value of 93.15 W/m. Both values are obtained from temperatures of 350°C with a material thickness of 190 mm.
- From the two insulation models, using rock wool material is better than glass wool material as insulation.

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