International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 34 No. 2 September 2022, pp. 366-375

Analysis Of Fuel Installation System Design At The Enviromental Of Naval Base

Sutrisno Sutrisno

Indonesian Naval Technology College, STTAL Surabaya, Indonesia

Abstract – The fuel installation system is necessary to support the Indonesian Naval ships to carry out operations. The current condition in the field is that Second Fleet Command does not yet have a fuel installation system. So far, to support Indonesian Naval Warship in carrying out operations using Pertamina's fuel installation pipes which are directly distributed from Pertamina's bunker. As a result, the Navy has become very dependent on Pertamina's performance and this is quite an obstacle. Therefore, the author has an idea to design a fuel installation system that must be owned by the Navy, especially in the Second Fleet Command work area. In this final project, the fuel pipe installation system planning is first carried out starting from the bunker, piping, fittings, and support as a support for the installation based on a standard pipe installation design with a flow capacity of 100 kL/hour. The next stage is the calculation of the head which includes the head loss along the pipe due to friction between the fuel and the surface along the pipe and the head loss due to fittings in the installation so that the total head value of the installation will be obtained. In addition to manual calculations, numerical calculations were also carried out using pipe flow expert v5.12 software. The next step is to determine the power required for both pumps and motors to overcome the installation head and flow capacity designed and select the appropriate pump.

Keywords – Indonesian Navy ship, Fuel Installation System, Environmental of Fleet Command.

I. INTRODUCTION

As an archipelagic country with a society consisting of various ethnic groups, Indonesia has elements of strengths and weaknesses at the same time. Its strength lies in its strategic geographical position and condition and is rich in natural resources. Meanwhile, the weakness lies in the shape of the archipelago and the diversity of people who must be united in one nation and one homeland, as the founders of the country have fought for. With 80% of its territory covering the ocean and only 20% of the territory in the form of land, the threat to Indonesia's sovereignty and territory lies at sea.

Second Fleet Command as a defense base against threats from the sea has a very important role in supporting every need for elements of the title of power at sea. The most important need is energy in the form of fossil fuels used as fuel for the Indonesian Naval Warship. The fuel commonly used is High-Speed Diesel (HSD), or so-called diesel. However, the need for solar has not been supported by the existence of piping installations has resulted in the dependence of the Indonesian Navy on Pertamina in the process of refueling for the Indonesian Naval Warship.

Against the background of the current conditions, an idea emerged to design a fuel pipe installation system that must be owned by Second Fleet Command to support Indonesian Naval Warship operations in defending the sovereignty of the Republic of Indonesia.

II. Material And Method

2.1 Design Methodology

The design methodology for the fuel installation begins with determining the flow capacity needed to support the needs of the Indonesian Naval Warship at Second Fleet Command. The design of the fuel pipe installation at Second Fleet Command is intended to serve the refueling of Indonesian Naval Warships with a contingent status where the Indonesian Naval Warships that are ordered to sail must be at sea within 4 hours. If it is assumed that the Indonesian Naval Warship must be in the operational area within 3 days with a speed of 18 knots and a distance of 1296 Nm, the Van Speijk class Indonesian Naval Warship is assumed to be operating with fuel consumption of 58 kL per day, then the HSD must be filled into the Van class Indonesian Naval Warship. Van Speijk class is about 200 kL.

Fuel support in the amount of 200 kL must be filled when the Indonesian Naval Warship carries out preparations. The time needed for Indonesian Naval Warship to carry out preparations for sailing and fighting both personnel and material is less than 4 hours, so the process *of loading* fuel is expected to be finished within 2 hours so that the required fuel flow capacity for the loading process is 100 kL/hour (0.0278 m3/s) (American Petroleum Institute, 1991)

Next is to determine the velocity of fluid flow in the pipe to comply with the permitted standards. Based on API RP 2003 and ISGOTT the maximum allowable fuel flow rate in the pipeline is 3 ft/s or 0.9144 m/s. So that further it can be determined the pipe diameter be used with the continuity formula (American Petroleum Institute, 1991) :

$$Q = A \times V$$

Where:

Q = flow capacity m3/s

V = flow velocity m/s

A = cross-sectional area of the pipe m2

The planned pipeline is on the ground surface and below the pier.

Figure 1. The Red Line Represents the Planned Pipeline

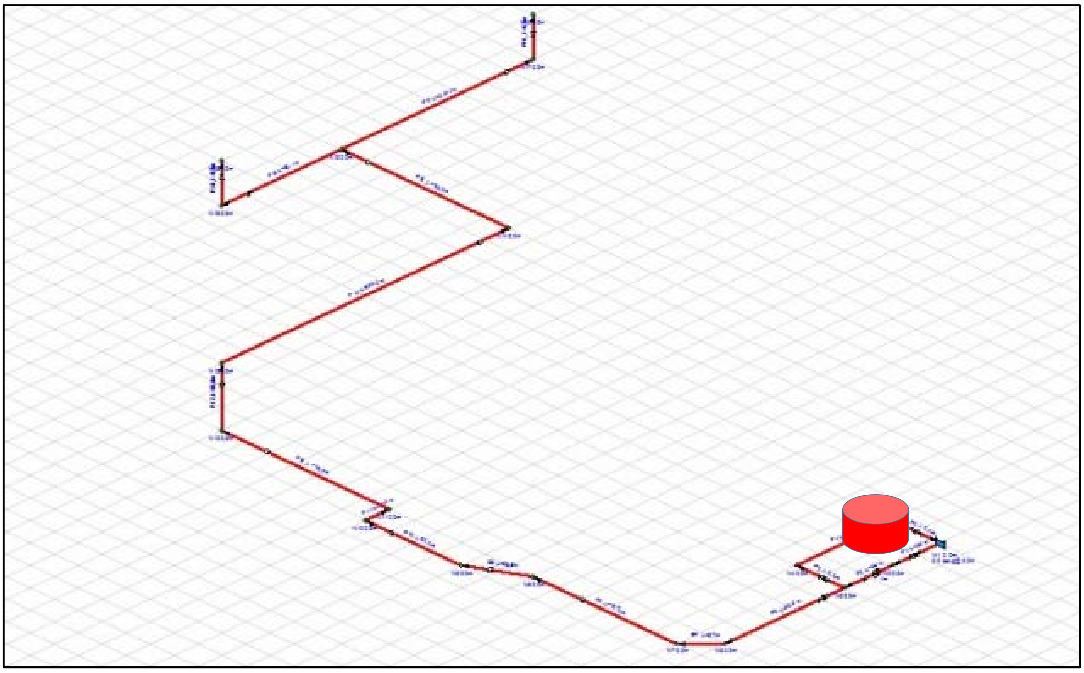

Figure 2. Pipe installation layout with Pipe Flow Expert v5.

For the calculation of determining the installation head using the equation

$$H_{inst} = \left(\frac{P_2 - P_1}{\rho . g}\right) + \left(\frac{\bar{V}_2^2 - \bar{V}_1^2}{2. g}\right) + (Z_2 - Z_1) + H_{LT}$$

To determine the head loss is divided into two, head loss due to friction and heat loss due to fitting (Ayodele & Ogunjuyigbe, 2014). The head loss due to friction is called the major head loss which can be determined by the formula

$$H_l = f \frac{L}{D} \frac{\bar{V}^2}{2g}$$

Where:

H_l = Head loss (m)

f = Friction factor

L = pipe length (m)

$\bar{V}$ = flow velocity (m/s)

D = Pipe diameter (m)

The friction factor value is known by the Colebrook formulation (Blair, 2010), namely:

$$\frac{1}{\sqrt{f}} = -2{,}01 log \left(\frac{e/D}{3{,}7} + \frac{2{,}51}{Re\sqrt{f}}\right)$$

With:

$$Re = \rho \frac{\bar{V}. D}{\mu}$$

Where:

e/D = Relative Roughness

Re = Reynolds Number

ρ = Density

μ = dynamic viscosity

Minor head loss is determined by Fox et al (2004):

$$h_{lm} = K\frac{\bar{V}^2}{2g}$$

Where:

h_{lm} = minor head loss (m)

K = Coefficient of losses

From the calculation value of the installation head, it can then be determined the pump power needed to overcome the installation head by formulating (Guida & Minutillo, 2017):

$$WHP = \rho \times g \times Q \times H$$

Where:

WHP= Hydrolic Power (watt)

H= head pump (m)

ρ = Density (kg/m^3)

g = gravity acceleration (9,8 m/s^2)

Q = pump capacity (m^3/s)

To get the shaft power (BHP) used the graph below

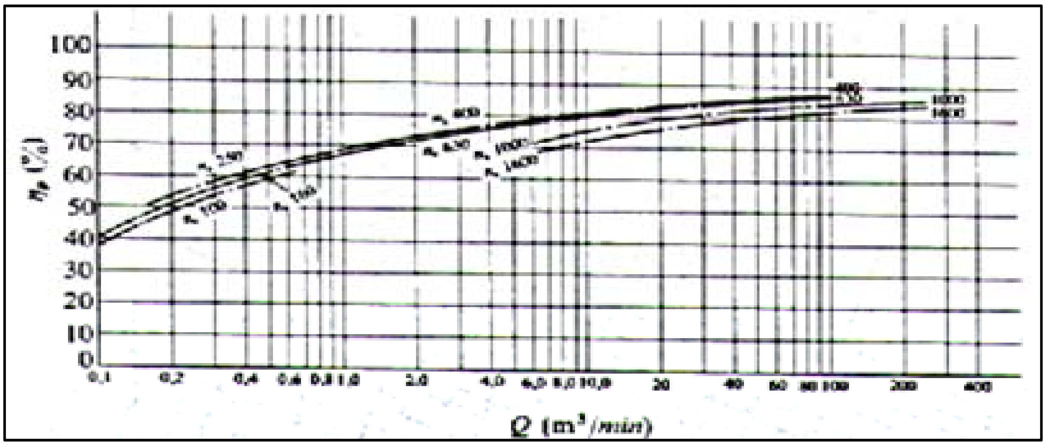

Figure 3. Efficiency-capacity graph based on specific speed

The available NPSH available calculation is used to determine the NPSH required by the pump (Jafarian et al, 2008). NPSHavailable is calculated by formulating positive suction, with the formula:

$$NPSH_{Available} = h_a - h_{vpa} + h_{st} - h_{fs}$$

Where:

h_a = Atmospheric Head (m)

$hvpa$ = Fluid Vapor Head (m)

hst = static suction head (m)

hfs = pipe friction loss (m)

$NPSH$ = Net Positive Suction Head (m)

In addition to calculating NPSH, a specific speed calculation is also carried out to determine the type of pump to be used with the following formulation (Kahraman et al, 2009):

$$n_s = \sqrt{\frac{\gamma}{75}} \times \frac{n \times \sqrt{Q}}{\sqrt[4]{H^3}}$$

Where:

n_s= pump rpm

Q = pump capacity (m^3/s)

γ = Density (kg/m^3)

H = Total head pump (m)

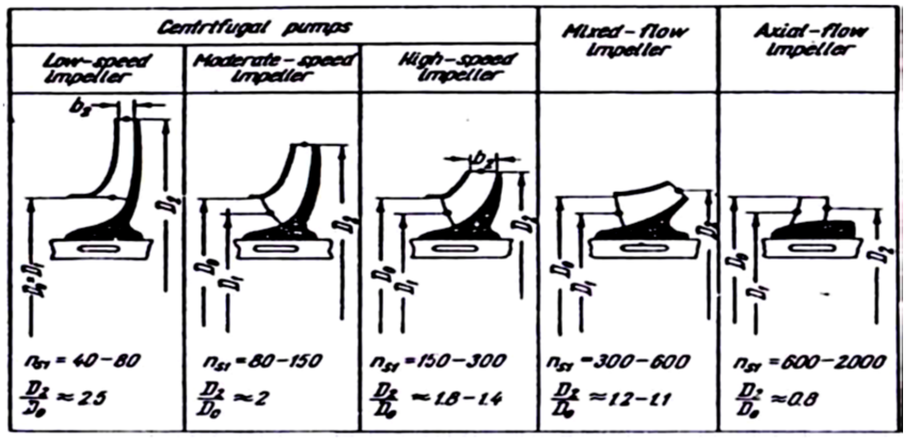

Figure 4. Classification of the pump impeller

The next step is to select the pump based on the manual calculation above and perform a performance correction to change the function of the water pump into a fuel pump (Katooli, 2017):

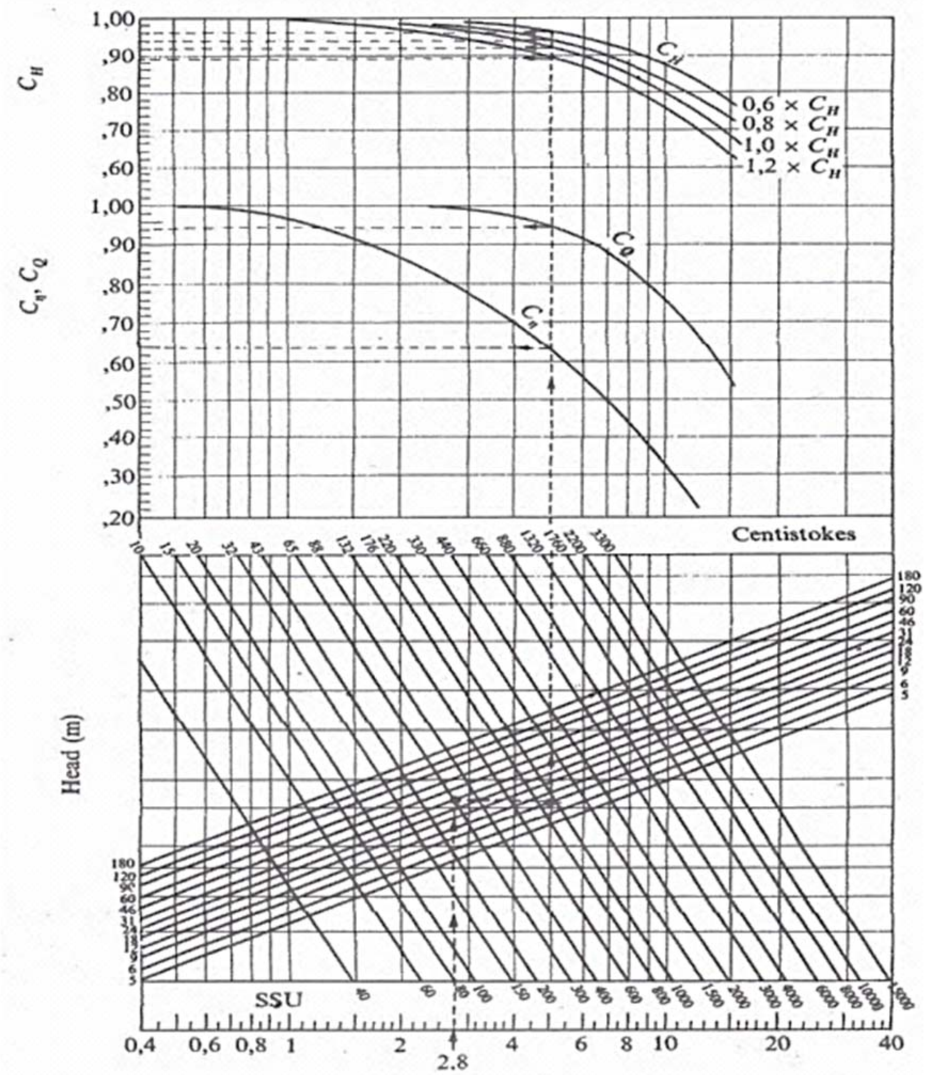

Figure 5. Performance correction table

The relationship between the oil pump and the water pump in the graph above is

$$Q_o = C_Q . Q_W$$

$$H_o = C_H . H_W$$

$$\eta_o = C_\eta . \eta_W$$

In addition to manual calculations, numerical calculations are also carried out using pipe flow expert software v.5.12 (Kays et al, 2014)

III. Results And Discussion

3.1 Data Collection

The flow velocity in pipes for hydrocarbon-type fluids in API RP 2003 concerning Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents, it is stated that planning for liquid flow must avoid generating static electricity in the flow because it can cause sparks and cause explosions (Martínez Díaz, 2013). The flow rate limit for HSD in pipes is 3 ft/s or 0.9144 m/s to avoid spraying and minimize surface turbulence. Pipeline flow and discharge velocity must be 3 ft/s (0.9144 m/s).

From the flow velocity limitation, it can be seen that the designed pipe diameter is:

- *Suction* = 10” 24 m long
- *Discharge* = 8” along 1163.99 m

By following the API RP 14E standard, pipe specifications can be determined based on the Maximum Allowable Working Pressure (Ritchie & Brouwer, 2018).

- Suction Pipe
- *nominal size* : 10 in
- Outside diameter : 10,750 in
- *Wall thickness* : 0.365 in
- *Class* : Standard
- *Schedule* : 40
- Max working pressure : 1023 Psig (-20–400 °F)
- Discharge Pipe
- *nominal size* : 8 in
- Outside diameter : 8,625 in
- *Wall thickness* : 0.322 in
- *Class* : Standard
- *Schedule* : 40
- Max working pressure : 1098 Psig (-20–400 °F)

The selection of installation support components such as valves, flanges, fittings, and supports is carried out by following the standards applied to a pipe installation design (O'Neil et al, 1993).

- *Valve: gate valve, globe valve*
- *flanges : welding neck flanges*
- *fittings: elbow 90°, elbow 45°, square edge inlet, exit, basket strainer, branch tee*
- *support*: *saddles, hangers* with rod value 3¾”

The result of manual calculation of pipe installation head is 14.09 m. The specific speed of flow is 93,155 so that the appropriate impeller for the pump is a moderate speed impeller. With an NPSHavailable of 18,766 m, the pump shaft power is 5.5 kW (Saman, 2016). The results of numerical calculations using pipe flow expert v5.12 software show results that are not much different, as shown in the image below:

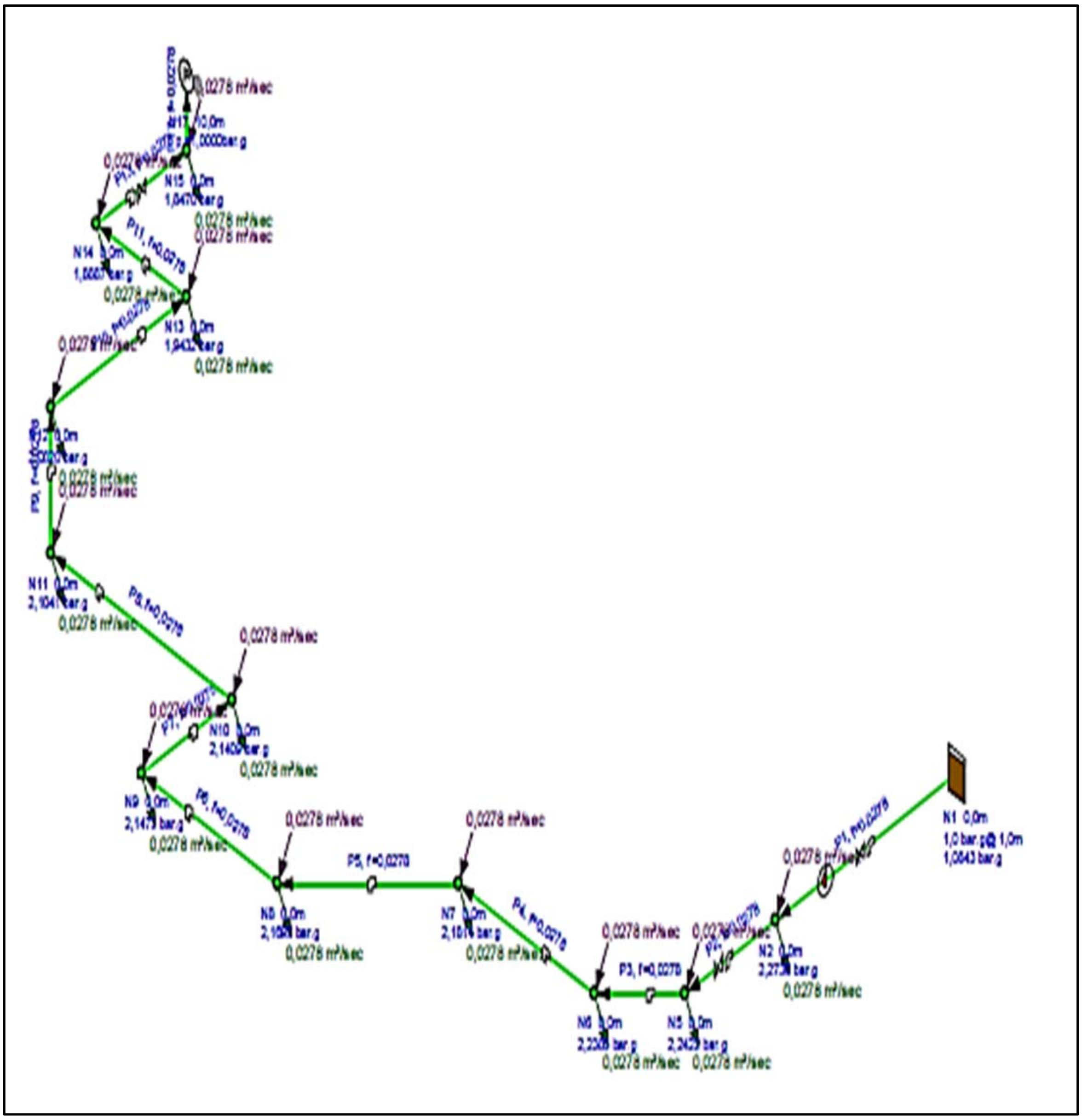

Figure 6. Numerical calculations using pipe flow expert v5.12 software

After getting the pump data from the calculation results, a pump selection is carried out following the data, an effort is made to select a pump with specifications slightly higher than the calculated data, so the 3-3L series Ebara pump is selected. 65-125/5.5 with specifications (Wilfert et al, 2005)

- pump head: 11.7 m of water
- Capacity: 108 m3/hour
- pump : 65%
- NPSHR: 7m water

After the performance correction is made, the pump specifications become:

- pump head: 14.1 m HSD
- Capacity: 108 m3/hour

- pump : 63%
- NPSHR: 7m water

IV. Conclusion

Based on the results of calculations that have been carried out both by manual calculation methods and using Pipe Flow Expert v5.12 software, several conclusions were obtained including:

a. The results of manual and numerical calculations are not much different.

b. Differences in the results of manual and numerical calculations can be caused by differences in input data such as viscosity, loss coefficient values between manual calculations and data in the pipe flow expert v5.12 software.

c. By taking into account the value of NPSHR<NPSHA pumps meet the requirements

V. Acknowledgement

The authors greatly acknowledge the support from Naval Technology College, STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

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