BACHELOR THESIS – ME 141502

DESIGN OF GAS TURBINE WASTE HEAT RECOVERY SYSTEM USING ORGANIC RANKINE CYCLE WITH SILOXANE MIXTURES AS WORKING FLUIDS ON OFFSHORE PLATFORM POWER PLANT

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DOUBLE DEGREE PROGRAM OF
MARINE ENGINEERING DEPARTMENT
Faculty of Marine Technology
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Surabaya
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SKRIPSI – ME 141502

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APPROVAL FORM

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on

Marine Operation and Maintenance (MOM) Laboratory

Study Program Bachelor Double Degree of Marine Engineering Department Faculty of Marine Technology

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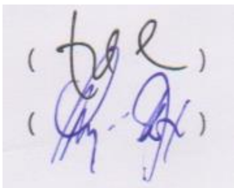

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July, 2017

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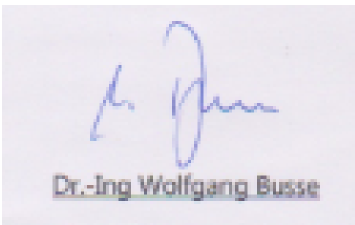

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Department : Double Degree Program in Marine Engineering

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DESIGN OF GAS TURBINE WASTE HEAT RECOVERY SYSTEM USING ORGANIC RANKINE CYCLE WITH SILOXANE MIXTURES AS WORKING FLUIDS ON OFFSHORE PLATFORM POWER PLANT

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ABSTRACT

Nowadays the urge to find alternative energy power generation is become more demanding due to many adding to regulation for emission. There are many ways to apply this, from using green fuel, alternative fuel, to adding some methods to increase efficiencies. One of the method is by installing a waste heat recovery unit, to use and utilize the unused heat that coming from any part of the main generator, and in this case is the heat coming from the exhaust gas. Gas Turbine heat are mainly still have 22% from its heat value that will be dumped in the exhaust gas. So in this bachelor thesis, it is used as the main heat source for Organic Rankine cycle, a close loop cycle of condensing and evaporating that use a organic fluid, and for this one, Hexamethyldisiloxane (MDM) is used. As said, the main equipments consists of evaporator, expander, generator, condenser, pumps, and the absorbant for heat of the exhaust gas, the exhaust gas heat exchanger. The main objectives are to find a calculated equipment to work in certain temperature and pressure that classified as supercritical organic rankine cycle due to its exhaust gas temperature range, the plotting and layout to be installed at a limited space on offshore platform, and find the estimated cost with adding the working hour that will take place. This system will also add 2%-3% of engine thermal electric efficiencies, and generate 120 kW of electric power with 0 gr/kWh Carbon emission. The main engine load for this system is 1,000 kW and exhaust gas temperature at 490 ^{o}C. for the cost is roughly on Rp 2,400,000,000 and needs 44 days and the total working hour is 352 hours, with assumed per day is 8 Hours of working hours.

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DESAIN SISTEM PEMANFAATAN PANAS GAS BUANG TURBIN GAS MENGGUNAKAN SIKLUS RANKINE ORGANIK DENGAN CAMPURAN SILOXANE SEBAGAI FLUIDA KERJA DI PLATFORM PEMBANGKIT TENAGA LISTRIK FASILITAS LEPAS PANTAI

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Ir. Hari Prastowo

ABSTRAK

Dewasa ini, kebutuhan untuk mencari pembangkit listrik bertenega alternative dirasa semakin mendesak dikarenakan banyaknya regulasi Internasional tentang emisi. Banyak cara untuk menyikapi hal ini,, mulai dari emnggunakan bahan bakar ramah lingkungan, bahan bakar alternative, hingga menambahkan metode untuk meningkatkan efisiensi. Salah satu metodenya adalah dengan memasang unit pemanfaatan panas terbuang, yang menggunakan dan memanfaatkan panas yang terbuang dari bagian manapun di pembangkit utama, dan dalam kasus ini yang dimanfaatkan adalah pans dari gas buang. Panas yang ihasilkan gas turbine dari pembakaran secara umum sebanyak 22% ikut terbuang dalam gas buang dan tidak termanfaatkan. Jadi, dalam thesis ini, panas tersebut digunakan sebagai sumber panas utama untuk sebuah siklus rankine organic, sebuah system siklus tertutup berulang yang terdiri dari proses kondensasi dan evaporasi yang menggunkan cairan organic dan untuk penelitian ini digunakanlah hexamethyldisiloxane (MDM). Seperti diterangkan sebelumnya, peralatan utama yang digunakan dalam sistem ini terdiri dari evaporator, condenser, expander, generator, pompa dan sebuah exhaust gas heat exchanger sebagai media penyerapan panas gas buang. Tujuan utama

dalam penelitian ini adalah untuk menghitung kapasitas yang cocok untuk tiap peralatan yang disesuaikan pada tekanan dan temperature tertentu, peletakan dan tata ruang untuk ditempatkan di platform fasilitas lepas pantai, dan mengestimasi biaya dan lama pengerjaan. System ini akan menambah efisiensi panas terhadap listik yang dihasilka sebesar 2% sampai 3%, dan menghasilkan energi listirk sebesar 120 kW dengan 0 gr/kWh emisi karbon. Pada permesinan utama untuk system ini berkapasitas konstan 1,000 kW dengan temperatur gas buang sebesar 490 ^{o}C.. Biaya yang dibutuhkan adalah Rp 2,300,000,000 dan membutuhkan 44 hari pengerjaan dengan total jam kerja 352 jam. Disini diasumsikan bahwa 1 hari kerja tersedia 8 jam kerja.

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PREFACE

Alhamdulillahirobbil 'alamin. Praise is merely to the Almighty Allah SWT for the gracious gifts to given the writer strength, capability, and passion to finally finish this thesis.This thesis reportis finished as a requirement to accomplished double degree study program. Also, writer would like to thank all of the people that have given help and support so this thesis can be completed:

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The author realizes that this thesis remains far away from perfect. Therefore, every constructive suggestion and idea from all parties is highly expected by author for this bachelor thesis correction and improvement in the future.

Finally, may Allah SWT bestow His grace, contentment and blessings to all of us. Hopefully, this bachelor can be advantageous for all of us particularly for the readers

Surabaya, July 2017

Author

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Chapter I

Introduction

1.1 Overview

Today's market conditions increasingly favor distributed generation fueled by natural gas and other gaseous fuels, and the addition of heat recovery from the generating source makes the economics all the more attractive. Developers of distributed generating systems have a choice between two primary power sources: gas reciprocating engines and gas turbines. Both are proven worldwide in thousands of installations. Over the years, both technologies have steadily improved in efficiency, reliability, emissions performance and operating costs – and they continue to do so(caterpillar,2010).

None of these technologies have absolute advantages over other technologies. Instead, each has attributes that make it the most suitable for specific conditions of fuel type and quality, electric and heat load profile, physical space, altitude, ambient conditions, and others. In fact, there are applications where reciprocating engines and turbines working in concert can provide the ideal levels of electrical reliability and efficiency, thermal output, load-following capability and, ultimately, return on investment.

Public policy and the push for sustainability are also driving adoption of gaseous fuels. Turbines and gas engines produce lower carbon dioxide emissions than coal-fired sources and also the conventional diesel engine.

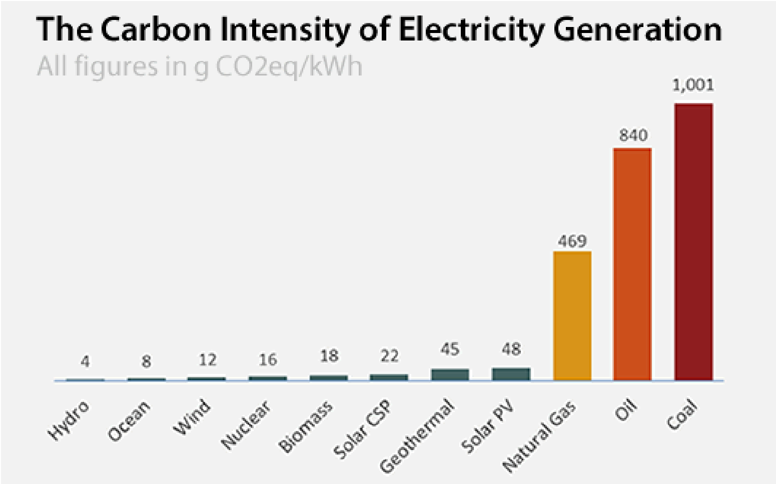

Figure 1Carbon emissions with Technologies
Source: IPCC Special Report

On PHE ONWJ Lima Flow station, the use KAWASAKI GPB 15 Gas Turbine Generator set to fulfill power demand in order to maintain the operation of the Flow Station. But, the same as many unused waste heat on exhaust gas turbine in other plant, on PHE ONWJ, the waste heat is left dumped to open air. The GPB 15 gas turbine has exhaust gas temperature that vary from 349˚C to maximum of 509˚C depends on the inlet temperature and Load of the gas turbine generator set. For this Thesis, the waste heat of the exhaust gas from gas turbine will be used to fulfill the non-essential load of the flow station facility.

On lima Flow-station the power requirements are:

Table 1List of power requirements(RFQ, PHE ONWJ)

Load Category	Max Of normal Load		Peak Load	
	kW	kVA	kW	kVA
Normal Load	702	815	740	858
Essential Load	594	668	632	724
Critical Load	108	147	108	134

Critical Loads : loads typically related to production, the loss of supply on critical load will not create unsafe condition for the personnel on board. Thus, will result in loss of production

Essential Loads : loads related to the safety of personnel and/or equipment. This loads are suitable for short breaks in the power supply without damaged.

Normal Loads :the overall load to maintain the running of facility and keeping the personnel in safe condition.

1.2 Problems Formulation

1. What was the power capacity that will be produced by the Organic Rankine Cycle?
2. How does the arrangement for the ORC system on the offshore Platform?
3. How does the Thermal Efficiencies after ORC is added?
4. What was the recommended working fluid of the ORC system?
5. How much estimated equipments cost and working hour will it be?

1.3 Limitation

1. This thesis only based on PHE ONWJ LIMA COMPLEX Offshore facility.
2. The system only from the coming of the Heat source Generator.
3. Limited to the waste heat of KAWASAKI GPB 15 gas turbine generator set running on inlet temperature of 38˚C and elevation 13m above sea level.
4. Focused on Arrangement of the system and Efficiencies after the ORC system is added.
5. Operational and maintenance cost are not considered.

1.4 Objectives

1. Determine the system can be generate the amount of electric power as demand and can select the proper equipment specification.
2. To make a specific arrangement, placement, and layout due to addition of ORC system.
3. To calculate the addition on thermal-electric efficiencies after the system is installed.
4. Define the proper working fluid of the system to be used.
5. To estimate the project's cost and the length of duration.

1.5 Benefits

The benefit of this thesis are to apply the current technologies on the waste of the gas turbine generator that left unused, and to know the arrangement so the ORC system can placed on the platform even the space is very limited.

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Chapter II
Literature Overview

2.1 Gas Turbine

Gas turbine is one of internal combustion engine that use expansion of hot gas to generate power using fan/blade. Approximately, 2/3 of generated power is used to turn shaft of the rotor and its own accessories, meanwhile 1/3 is used to turn other equipments such as compressor, generator, etc.

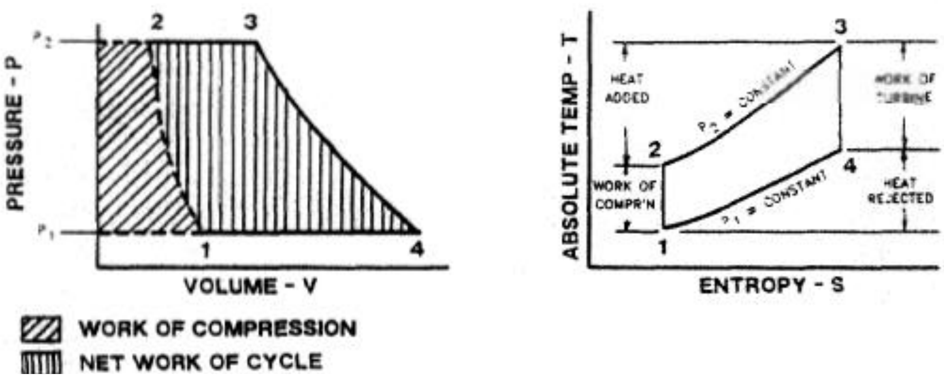


Figure 2 Diagram Of Gas Turbine Cycle
source : Surface Production Operations Vol.2 (Ken Arnold)

The basic gas turbine is described by the idealized brayton air cycle. In this cycle, air enters the compressor under normal atmospheric pressure and temperature, given P1 and T1. It is the isentropically compressed where the pressure and temperature are now P2 and T2. After that, the air flow to combustion chamber where fuel injected and burned at constant pressure, raising the temperature to T3 and expanding the volume to V3. From the combustion chamber, the heated gases enter the power turbine where they perform work by turning the output power shaft. These gases expand to near atmospheric pressure and exhausted at greater than atmospheric temperature to T4. Ideally it would be possible to have the same fluid going through this circuit all the time, and the step from end to beginning would be a cooling process. This step is accomplished by exhausting to atmosphere and taking a new charge of air.

2.2 Waste Heat Recovery System

Waste heat is a heat that coming from the after-product of a system that could be from combustion process or chemical reaction that straightly come to open air. This waste still can be reused. The strategy to recover this heat depends on the temperature of the waste heat gases. Usually, the higher the temperature, the higher the quality more cost effective to the heat recovery. In study of waste heat recovery, it was always necessary to waste recovery should be there.

The primary source of waste heat of amain engine for propulsion and power generation is the exhaust gas heat dissipation,which accounts for about halfof the total waste heat, i.e. about 25%of the total fuel energy(MAN B&W, 2011).

2.2.1 Range Of Waste Heat Recovery System

On the list that mentioned below are consist many examples of the waste heat that produced by a plant with various types and arranged by its temperature of the waste. The classification were separated to three classes, High Temperature, Medium Temperature and low temperature.

- High Temperature Waste Heat System

Types of Device	Temperature, °C
Nickel refining furnace	1370 –1650
Aluminium refining furnace	650-760
Zinc refining furnace	760-1100
Copper refining furnace	760- 815
Steel heating furnaces	925-1050
Copper reverberatory furnace	900-1100
Open hearth furnace	650-700
Cement kiln (Dry process)	620- 730
Glass melting furnace	1000-1550
Hydrogen plants	650-1000
Solid waste incinerators	650-1000
Fume incinerators	650-1450

Figure 3High Temperature Waste Heat System
Surface Production Operations Vol.2 (Ken Arnold)

- Medium Temperature Waste Heat System

Type of Device	Temperature, °C
Steam boiler exhausts	230-480
Gas turbine exhausts	370-540
Reciprocating engine exhausts	315-600
Reciprocating engine exhausts (turbo charged)	230- 370
Heat treating furnaces	425 - 650
Drying and baking ovens	230 - 600
Catalytic crackers	425 - 650
Annealing furnace cooling systems	425 - 650

Figure 4Medium Temperature Waste Heat System
Surface Production Operations Vol.2 (Ken Arnold)

- Low Temperature Waste Heat System

Source	Temperature, °C
Process steam condensate	55-88
Cooling water from: Furnace doors	32-55
Bearings	32-88
Welding machines	32-88
Injection molding machines	32-88
Annealing furnaces	66-230
Forming dies	27-88
Air compressors	27-50
Pumps	27-88
Internal combustion engines	66-120
Air conditioning and refrigeration condensers	32–43
Liquid still condensers	32-88
Drying, baking and curing ovens	93-230
Hot processed liquids	32-232
Hot processed solids	93-232

Figure 5Low Temperature Waste Heat System
Surface Production Operations Vol.2 (Ken Arnold)

2.3Rankine Cycle

Rankine cycle is roughly the fundamentals working cycle of all power plant where an operating fluid is continuously evaporated and condensed. The selection of the working fluid based on the available temperature range. The Rankine cycle work in following steps:

1. Isobaric heat Transfer
   High pressure liquid enters the boiler from feed pump and is heated to the saturation temperature. Further addition of energy, causes evaporation of the liquid until it's fully converted to saturated steams
2. Isentropic Expansion
   The vapor is expanded in the turbine, thus producing work which may be converted to electricity. In practice, the expansion is limited by the temperature of cooling medium. Exit vapor qualities must greater than 90%
3. Isobaric Heat Rejection
   The vapor liquid mixture leaving the turbine is condensed at low pressure, usually in a surface condenser using cooling water.
4. Isentropic Compression
   Pressure of the condensate is raised in the feed pump. Because of the low specific volume of liquids, the pump work is relatively small and often neglected in thermodynamic calculation

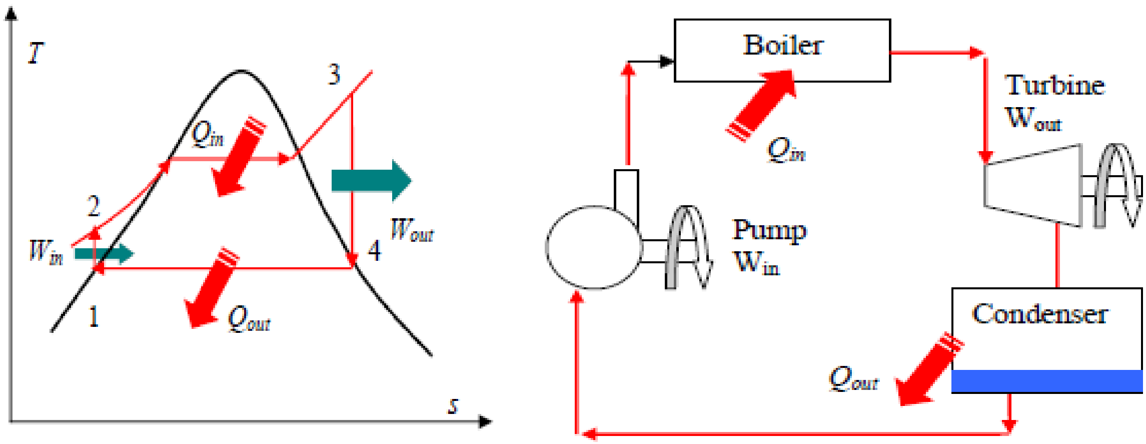


Figure 6*Ideal Rankine Cycle*

Source: Performance Analysis and Working Fluid Selection of Supercritical Organic Rankine Cycle for Low Grade Waste Heat Recovery

2.3.1 Energy Analysis of The Cycle

All of the components for the cycle are steady state, steady flow devices which the potential and kinetic energy are not to be considered. The first law per unit mass of steam can be written as:

Pump : $q = 0$, therefore $w_{pump,\, in} = h_2 - h_1$

Boiler : $w = 0$, therefore $q_{in} = h_3 - h_2$

Turbine : $q = 0$, therefore $w_{turbine,\, out} = h_3 - h_4$

Condenser : $w = 0$, therefore $q_{out} = h_4 - h_1$

The thermal efficiency for the cycle are determined on:

$$\square n_{th} = \frac{w_{net}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}}$$

In consideration:

$$w_{net} = q_{in} - q_{out} = w_{turbine,out} - w_{pump,in}$$

If the fluid assumed the fluid is incompressible, so the work input will be:

$$(h_2 - h_1) = v\,(P_2 - P_1)$$

Thus, to increase the efficiency one should increase the average temperature at whichheat is transferred to the working fluid in the boiler, and/or decrease the averagetemperature at which heat is rejected from the working fluid in the condenser.

2.4 Organic Rankine Cycle

Organic Rankine cycle is a Clausius – Rankine cycle which uses an organic fluid instead of water. The replacement of water with organic fluids brings a number of advantages over the classical steam process. Due to its thermophysical characteristics, that have low critical point, low boiling temperature and high molecular mass, the transformation of low temperature heat into useful electrical energy is iminent and can be effective (higher efficiency than other possibilities).Because of the low critical point relative to water and because the temperature level of the heat input is much lower than in the case of steam processes, the working pressures are lower and thus, they lead to a small-scale, low-cost installation which in most cases does not require permanent supervision.

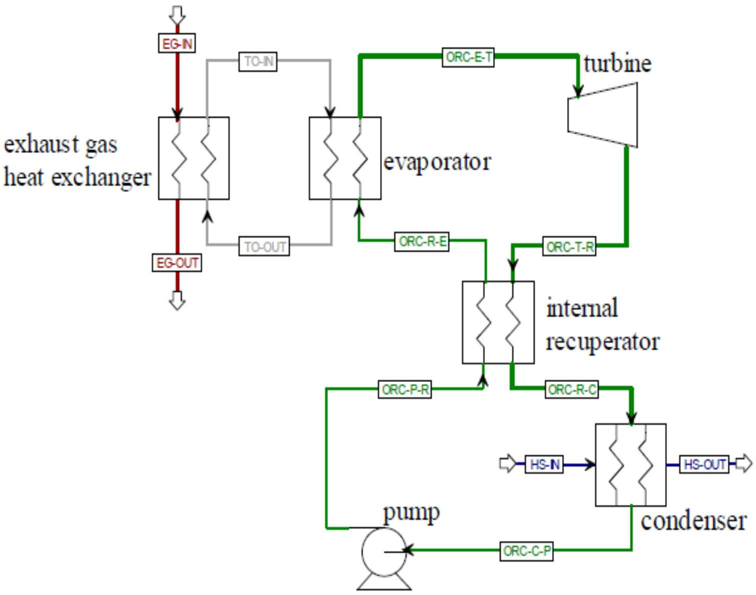


Figure 7 Illustration for Organic Rankine Cycle
Source: Performance Analysis and Working Fluid Selection of Supercritical Organic Rankine Cycle for Low Grade Waste Heat Recovery

2.4.1 The ORC- Turbine

The main use of a turbine in organic rankine cycle are to change the potential energy produced by the pressurized gas into a rotation kinetic energy and moving the generator shaft to produced electricity. Actually turbine for ORC system are the same with turbine from other power generation application. The classification for steam turbines are:

- By details of stage Design
    - Impulse
    - Reaction
- By steam supply and exhaust condition
    - Condensing
    - Back pressure
    - Automatic or controlled extraction
    - Mixed Pressure
    - Reheat
- By casing or shaft arrangement
    - Single casing
    - Tandem compound
    - Cross compound
- By steam flow
    - Axial flow
    - Radial flow
    - Tangential flow
- By the number of stage
    - Single stage
    - Multi stage
- By Steam Supply
    - Saturated
    - Superheated

2.4.1.2 Turbine Outlet Temperature and power Output

When gas adiabatically expanded from pressure P1 to pressure P2 the temperature ratio can be determined with formula:

$$\frac{T_2}{T_1} = (\frac{P_2}{P_1})^{1-\frac{1}{r}}$$

T2 = Temperature outlet
T1 = Temperature inlet

P2 = pressure outlet
P1 = pressure inlet
r = specific heat ratio (Cp/Cv)

2.4.2 Heat Exchanger

Heat exchangers are devices used to transfer heat energy from one fluid to another. Typical heat exchangers experienced by us in our daily lives include condensers and evaporators used in air conditioning units and refrigerators. Boilers and condensers in thermal power plants are examples of large industrialheat exchangers. A lot of methodology can be used to define many types of heat exchangers.

2.4.2.2Condenser

A condenser is a heat exchanger or unit used to condense a working fluid. In this organic Rankine cycle system, condenser is used to return refrigerant steam phase from turbine back to the liquid phase to be used again.

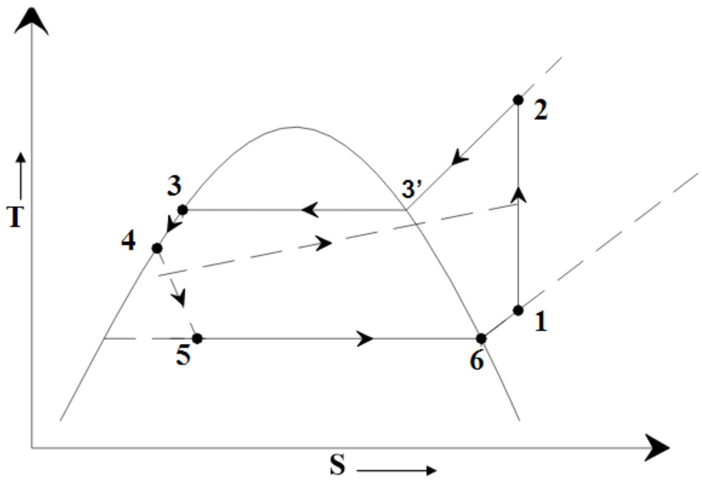


Figure 8Condenser
Source: google

In the figure, the heat rejection process is represented by 2-3’-3-4. The temperature profile of the external fluid, which is assumed to undergo only sensible heat transfer, is shownby dashed line. It can be seen that process 2-3’ is a de-superheating process, during which the refrigerant is cooled sensibly from a temperature T2to the saturation temperature corresponding condensing pressure, T3’. Process 3’-3 is the condensation process, during whichthe temperature of the refrigerant remains constant as it undergoes a phase change process.

Classification of condensers:

Based on the external fluid, condensers can be classified as:

a) Air cooled condensers

As the name implies, in air-cooled condensers air is the external fluid, i.e., the refrigerant rejects heat to air flowing over the condenser. Air-cooled condensers can be further classified into natural convection type or forced convection type.

b) Water cooled condensers

In water cooled condensers water is the external fluid. Depending upon the construction, water cooled condenserscan be further classified into:

- Double pipe or tube-in-tube type
- Shell-and-coil type
- Shell-and-tube type

c) Evaporative condensers

In these condensers, the water is sprayed from top part on abank of tubes carrying the refrigerant andair is induced upwards. There is a thinwater film around the condenser tubes from which evaporative cooling takes place. The heat transfer coefficient forevaporative cooling is very large. Hence, the refrigeration system can be operated at low condensingtemperatures

Formula for the changing phase in the condenser are:

Evaporated Condition

$$Q1 = \dot{m}.C_p.(T_{in} - T_{saturated})$$

Saturated Condition

$$Q2 = \dot{m}.L_v$$

Subcooled Condition

$$Q3 = \dot{m}.C_p.(T_{saturated} - T_{out})$$

$\dot{m}$	= mass flow rate (kg/s)
Cp	= Specific Heat (kJ/kg.^{o}C)
Tin	= Temperature inlet
Tsaturated	= temperature at satureated point
Tout	= temperature outlet
Lv	= Latent heat of vaporization (kJ/kg)

2.4.2.3Evaporator

The evaporator is a heat exchanger equipment to evaporate the phase from the liquid phase into steam phase. Evaporator has a basic function such as heat exchangers and for separating the vapor formed from the liquid.

A natural way of classifying evaporators is based on the state of the heat source: gas, liquid or solid. Evaporators utilizing gas as heat source are usually referred to as air coolersas air is the dominating gaseous heat source. Evaporators for liquid heat sources are called liquid coolers.Note that it is quite common to useindirect systems, both for refrigeration/freezing and for heat pumps. In these systems the primary heat source may be air, but the heat is transferred to the evaporator by a brineor secondary refrigerantwhich is a liquid.

Subcooled condition

$$Q1 = \dot{m}.C_p.(T_{saturated} - T_{in})$$

Saturated Condition

$$Q2 = \dot{m}.L_v$$

Subcooled Condition

$$Q3 = \dot{m}.C_p.(T_{out} - T_{saturated})$$

$\dot{m}$	= mass flow rate (kg/s)
Cp	= Specific Heat (kJ/kg.°C)
Tin	= Temperature inlet
Tsaturated	= temperature at satureated point
Tout	= temperature outlet
Lv	= Latent heat of vaporization (kJ/kg)

2.4.2.4 Pressure Drop

In designing a heat exchanger system one of the key element for the limitation are pressure drop. The design of heat exchanger must avoid unnecessary pressure to become more effective and have economic design. The pressure drop in heat exchanger that needs to be calculated can be classified in three, which are pressure drop for plate heat exchanger, tube side pressure drop and shell side pressure for shell and tube heat exchanger. Plate heat exchanger's pressure drop can be determined with equation follow:

$$\Delta P = \frac{1{,}5{G_p}^2 n_p}{2g_c\rho_i} + \frac{4fLG^2}{2g_cD_e}\left(\frac{1}{\rho}\right)_m \pm \frac{\rho_m gL}{g_c}$$

Gp = fluid mass velocity in port (kg/m^2s)
Np = number of plates
Gc = conversion factor ($kg . m / N . s^2$)
P = fluid density (kg / m^3)
f = friction factor
L = plate height (m)
G = mass velocity through the core ($kg / m^2 s$)
De = equivalent diameter (m)
g = gravity acceleration (m/s^2)

2.5 Pumps

A pump is a device used to raise, compress, or transfer fluids. The motors that power most pumps can be the focus of many best practices. It is commonto model the operation of pumps via pump and system curves. Pump curves offer the horsepower, head, and flowrate figures for a specific pump at a constant rpm. System curves describe the capacity and head required by a pump system. An example of both of these curves may be seen in Figure.

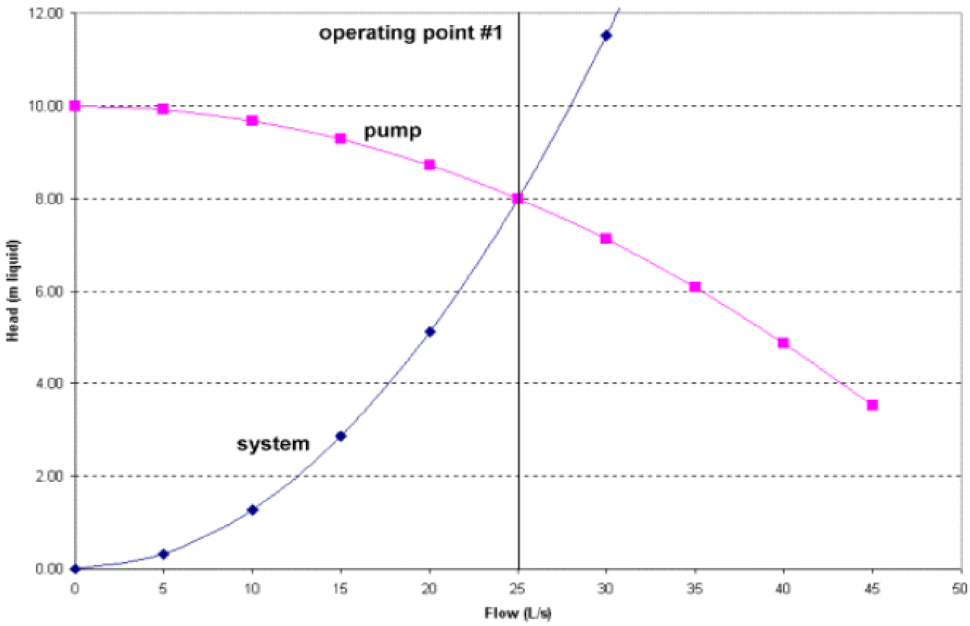


Figure 9Example of pumps system curve
Source: http://www.ciras.iastate.edu/publications/EnergyBP-ChemicalIndustry

Varioustypes of pumps are used in the chemical industry,for example like centrifugal, reciprocating,and helical rotor pumps. For the detailed types of pumps can be shown:

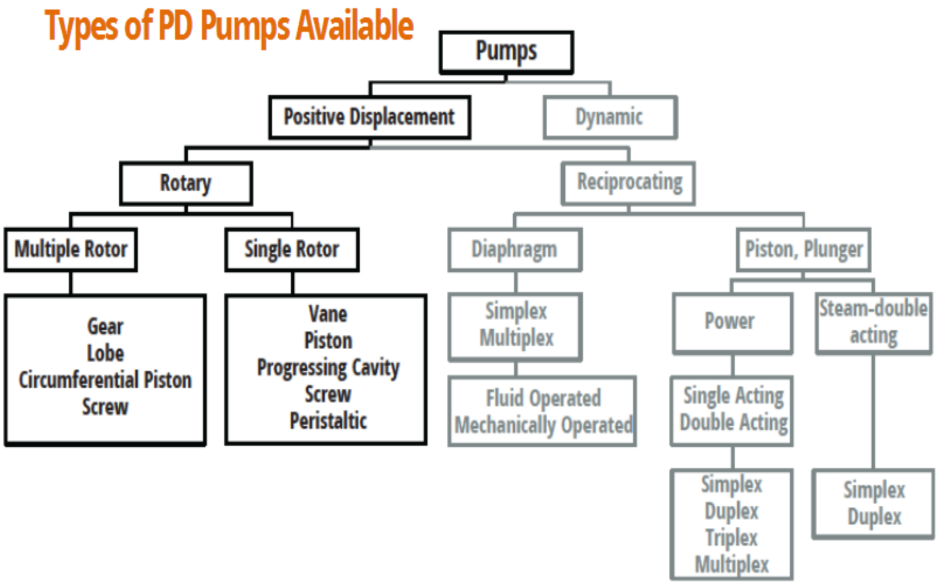


Figure 10Types of PD Pupms Available
Source: http://www.ciras.iastate.edu/publications/EnergyBP-ChemicalIndustry

Diaphragm pumps use a positive displacement design rather than centrifugal force to move water through the casing. This means that the pump will deliver a specific amount of flow per stroke, revolution or cycle.

Centrifugal pumps operate by applying a centrifugal force to fluids, many times with the assistance of impellers. These pumps are typically used in moderate to high flowapplicationswith low-pressure head, and are very common in chemical process industries. There are threetypes of centrifugal pumps, radial, mixed, and axial flowpumps.

2.5.1 Head of the pumps

In this system, the equipments are in the same deck, thus the head of the pump can be defined:

$$h = \frac{P2 - P1}{pg}$$

h = head of pump (m)
P = Pressure (bar)
P = density
G = Gravity acceleration

2.5.2 Temperature Rise

Because of the increasing pressure in the liquid, that also might increase the temperature in the pump. The increasing temperature can be determined as:

$$\Delta T = \frac{H(1-\eta)}{102(U.\eta)}$$

$\Delta T = Temperature\ Rise\ (C)$
H = total head (m)
n = Pump efficiency
U = Fluid specific Heat

2.5.3 Pump Capacity

The capacity of pump are the amount of liquid that pumped in a unit time. The capacity of pump can be defined as:

$$Q_s = \frac{\dot{m}}{\rho}$$

Qs = Pump Capacity (m^3/s)
M = mass flow rate (kg/s)

2.6 Thermal-Electric Efficiency

The electric power plant efficiency is defined as the ratio between useful electricity output from the generating unit in a specific time unit, and the energy value of the energy source supplied to the unit within the same time. The type of energy converted in a fuel-burning installation is variable. The output of the conversion process may either be electricity (power), heat or a mixture of both, which makes it difficult to define efficiency of the process (it is even more complex in a three-product system of electricity, heat and a high-quality syn-gas product, i.e. produced in gasification plants).

	GCV	NCV*
Heavy fuel-oil	42.6 MJ/kg (= 10,175 kcal/kg)	40.57 MJ/kg (= 9,690 kcal/kg)
Light fuel-oil	43.3 MJ/kg (= 10,342 kcal/kg)	41.2 MJ/kg (= 9,840 kcal/kg)
Burner-oil	44.1 MJ/kg (= 10,533 kcal/kg)	42.16 MJ/kg (= 10,070 kcal/kg)
Gas-oil	45.7 MJ/kg (= 10,915 kcal/kg)	43.75 MJ/kg (= 10,450 kcal/kg)
Natural gas	42.0 MJ/m^3 (=10,032 kcal/ m^3)	37.9 MJ/m^3 (= 9,052 kcal/m^3)
Hard coal	35.4 MJ/kg (=8,448 kcal/kg)	34.1 MJ/kg (=8,145 kcal/kg)
Lignite	24.0 MJ/kg (=5,732 kcal/kg)	23.0 MJ/kg (=5,493 kcal/kg)

Figure 11Fuel Heating Value

Source: PHE RFQ project File LIMA-LCOM-I-LPL-4004~3 AFC Instrument Location Plan

Thermo-electric efficiency Value:

(Fuel Calorific Value / Electricity-Fuel Ratio) x 100%

2.7 Working Fluids Selection

The working fluid in the ORC system have crucial role to the system. The working medium or in this case the fluids that is used for the system must have low freezing point and high temperature stability, high heat density and high heat vaporization . The fluid also must have low impact on environment, non-corrosive and non-toxic.

Pure working fluids used in organic Rankine cycles have been studied, such as HCFC123 (CHCl2CF3), PF5050 (CF3(CF2)3CF3), HFC-245fa (CH3CH2CHF2), HFC-245ca (CF3CHFCH2F), isobutene ((CH3)2C55CH2), n-pentane and aromatic hydrocarbons. Fluid mixtures were also proposed for organicRankine cycles. The organic working fluids have manydifferent characteristics from water.

The slope of the saturation curve of a working fluid in a T–s diagram can bepositive (e.g. isopentane), negative (e.g. R22) or vertical (e.g. R11),and the fluids are accordingly called ''wet'', ''dry'' and ''isentropic''fluids. Wet fluids like water usually need to be superheated, whilemany organic fluids, which may be dry or isentropic, do not need superheating.

2.8 Project Management

2.8.1 Bill Of Quantity

Bill of quantity is the schedule which categories, details, and quantifies the materials cost that will be used on a project (Basic Civil Engineering, 2015). It is important as the connector for parties that takes part in a project. There are several importance of a BOQ to be used mainly before the project and also after the project. The importance are:

1. Provides basic ideas to procurement department by giving the quantities.
2. Explain the extent of work, usually must followed by drawings and specification as well
3. Giving a view for the contract nominal.
4. It will provide a minimum basis of variation but it must be detailed for the variation.

For Bill of Quantity, many kinds, shapes, and details for each company policies that cause several differences and sometimes each project can be differ for other project because each of them may have each own necessity. Like the examples listed below.

BILL OF MATERIAL			Component Name				Project Name		: RBC BATCHING PLAN CAPACITY 3 M³			
			SUPPORT OF SILO (CEMENT SILO)				MF No.		: 1415 - 05			
			(1 OF 5)				Revision		: 4			
Line #	Rev.	Qty.	Description		OD (mm)	ID (mm)	Thickness (mm)		Width (mm)	Length (mm)	Material	App. Wt. (Kg.)
1	0		LEG SILO -1									
2	3	2	Pipe	Column (Pipe Sch. 40)	219.00		8.2	AWT		6000.0	CS	510.19
3	2	2	Plate - Ring	Connection Plate	400.00		16.0	Thk			CS	31.56
4	2	4	Plate - Rectangle	Stiffener Plate			10.0	Thk	80.00	200.0	CS	5.02
5	2	4	Plate - Rectangle	Gusset Plate			10.0	Thk	167.00	243.0	CS	12.74
6	2	12	Plate - Rectangle	Gusset Plate			10.0	Thk	135.00	630.0	CS	80.09
7	2	8	Plate - Rectangle	Stiffener Plate			10.0	Thk	35.00	200.0	CS	4.39
8	2	2	Plate - Rectangle	Base Plate			20.0	Thk	310.00	310.0	CS	30.17
9	0											
10	0		LEG SILO -2									
11	3	2	Pipe	Column (Pipe Sch. 40)	219.00		8.2	AWT		6000.0	CS	510.19
12	2	2	Plate - Ring	Connection Plate	400.00		16.0	Thk			CS	31.56
13	2	4	Plate - Rectangle	Stiffener Plate			10.0	Thk	80.00	200.0	CS	5.02
14	2	4	Plate - Rectangle	Gusset Plate			10.0	Thk	167.00	243.0	CS	12.74
15	2	12	Plate - Rectangle	Gusset Plate			10.0	Thk	135.00	630.0	CS	80.09
16	2	8	Plate - Rectangle	Stiffener Plate			10.0	Thk	35.00	200.0	CS	4.39
17	2	2	Plate - Rectangle	Base Plate			20.0	Thk	310.00	310.0	CS	30.17
18	0											
19	0		LEG SILO -3									
20	3	2	Pipe	Column (Pipe Sch. 40)	219.00		8.2	AWT		6000.0	CS	510.19
21	2	2	Plate - Ring	Connection Plate	400.00		16.0	Thk			CS	31.56
22	2	4	Plate - Rectangle	Stiffener Plate			10.0	Thk	80.00	200.0	CS	5.02

Figure 12Bill of Quantity

Source: Bahtera Samudera Kontruksi (1415-05) Cement Silo_Batching Plan_BoM (1 Of 2)

Some Bill of Quantity may differ from one another but commonly there are some major parts for BOQ to be considered as a BOQ. That major parts are:

1. Preliminaries

   In industry, preliminaries is known as the indirect cost for execution of project but these are the costs which is very much vital for the construction activities. The reason for these cost mentioned separately is it is very difficult to distribute these cost amongst with measured works.

2. Measured Works

   It is the actual or estimated work will be carried out to complete the project. The works have been measured in different units. They are liner meter, square meter, cubic meter, number, item & etc. Value of measured works will be calculated by multiplication of quantities and rate.

3. Provisional Sums

   The total amount of cost that will be carried out so the project owner can adjust the budget for tendering. It must be carried out as detail as possible so when the project is running, it will not overbudget. Some companies have its own policies about overwork.

2.9 LIMA Flow-station Offshore Facilities

Pertamina Hulu Energi ONWJ (PHE ONWJ) is currently the operator of the PSC, following the change of company ownership from BP to Pertamina in July 2009. PHE Offshore North West Java (ONWJ) production sharing contract in the Java Sea covers an area of approximately 8,300 square kilometres – stretching from the North of Cirebon to KepulauanSeribu. Facilities include 670 wells, 170 shallow water platforms, 40 processing and service facilities and some 1,600 kilometres of sub-sea pipelines. And one of the Offshore facilities is LIMA Complex. Lima Complex are located in Java sea, West Java Province with coordinates $05^{0}15'$ S and $107^{0}20'$E with distances about 50 Nmiles From Marunda Onshore Facilities. On LIMA Complex, the Power are generated from two platform that act as Power Source Facilities are LSER and LCOM.

After 30 years of running, the power generation are need to be replaced due to its age and lack of spare part availability and reducing the reliability and unable to continued the production on LIMA Complex. So, PHE-ONWJ want to ensure the continuity and keep a sustainable production by changing its power generation system.

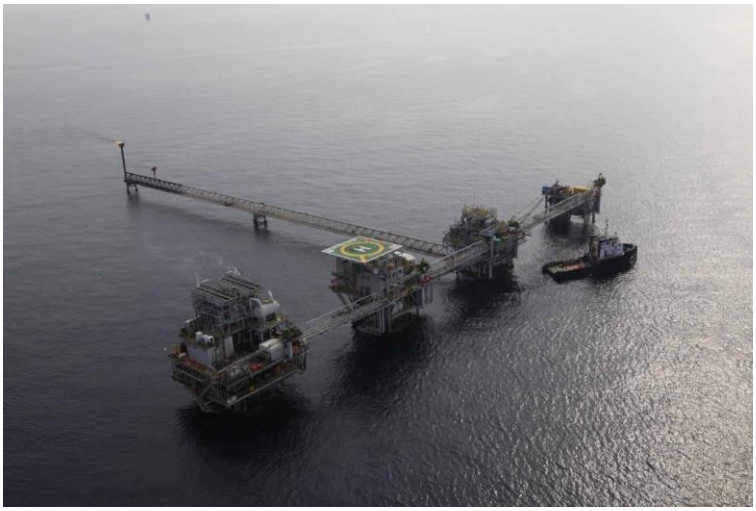


Figure 13LIMA Flowstation Complex
Source: http://skkmigas.go.id/wp-content/uploads/2013/09/lima-flow-station.jpg/

2.9.1 Power Generation Engine

The power generation that is used on platform are the new one that replace Caterpillar Gas Generator set G398 and currently use KAWASAKI GPB 15 with the followed specification:

Table 2 Power Generation Engine

Partial Load @ AIT 15 C	%	100	75	50
Electric output	kWe	1450	1090	730
Heat Rate	kJ/kWe-hr	15130	16500	19750
Exhaust gas temperature	Celcius	524	441	368
Exhaust gas mass flow	x10^3/hr	28.8	29.2	29.6

Table 2 Power Generation Engine

Inlet air temperature	Celcius	0	15	40
Electric output	kWe	1620	1450	1120
Heat Rate	kJ/kWe-hr	14690	15130	16880

Exhaust gas temperature	Celcius	516	524	547
Exhaust gas mass flow	$x10^3$/hr	30.9	28.8	25.2

Because of the changing from caterpillar to Kawasaki, so the arrangement will be changed because the capacity of caterpillar for each engine that relatively small so it must use 6 (31.692 M 2) units than the Kawasaki's capacity units than the Kawasaki's capacity that need only 2 units (19.574 M 22).

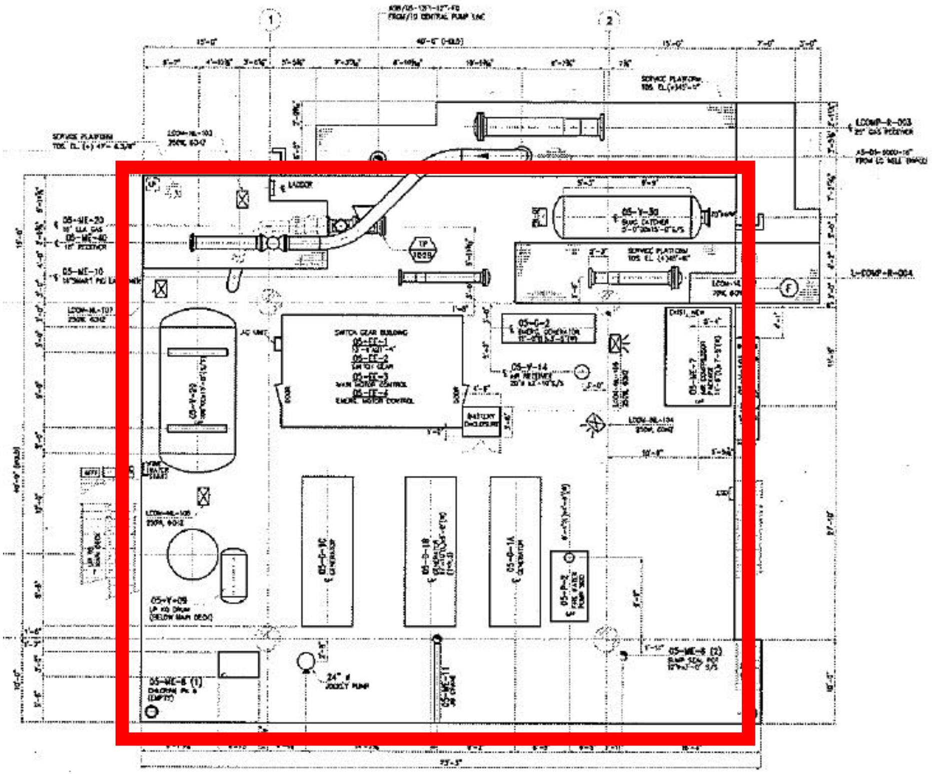
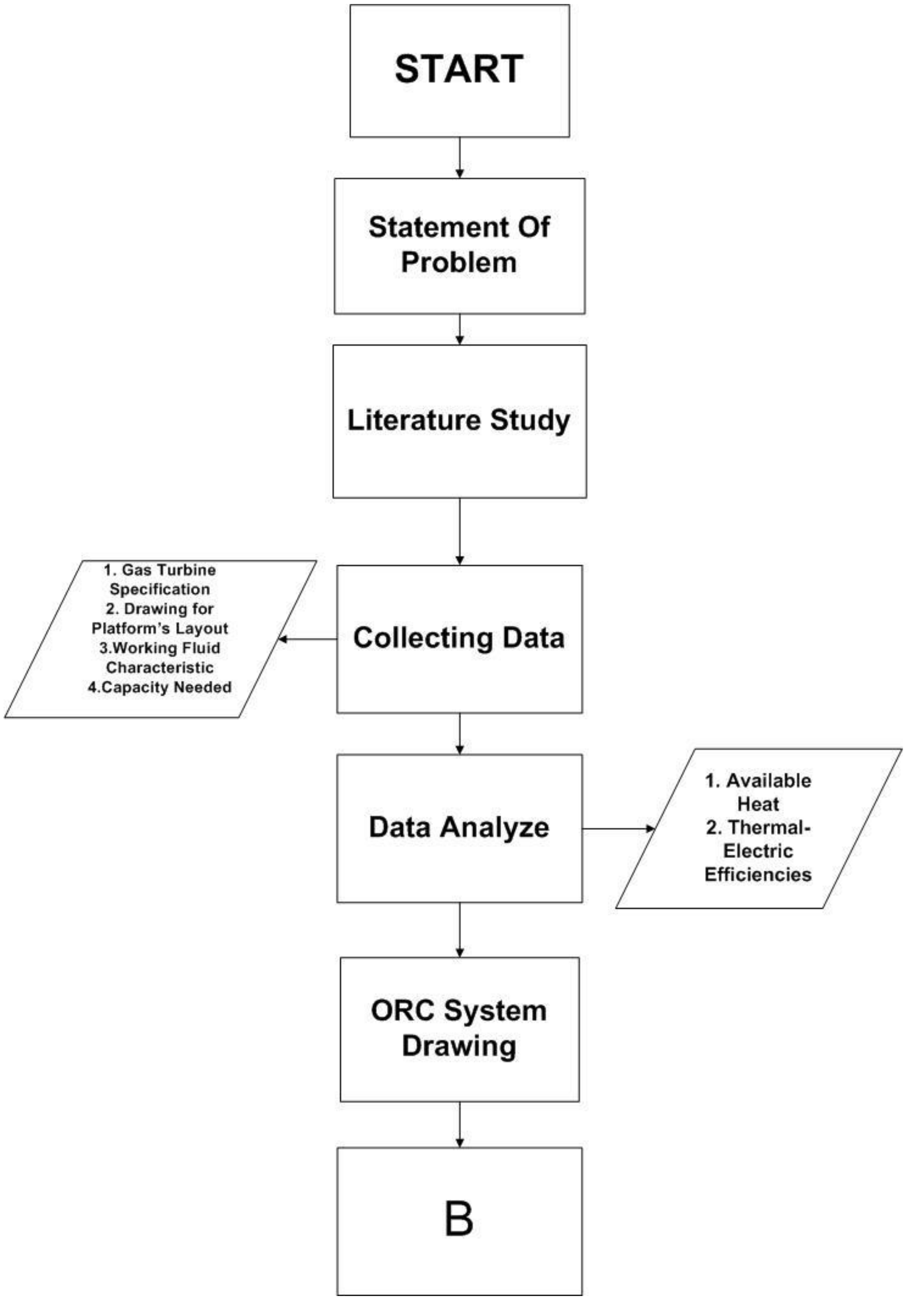


Figure 14 Ilustration for Arrangement on offshore platform
Source : **PHE RFQ project File LIMA-LCOM-I-LPL-4004~3 AFC Instrument Location Plan**

Chapter 3

Methodology



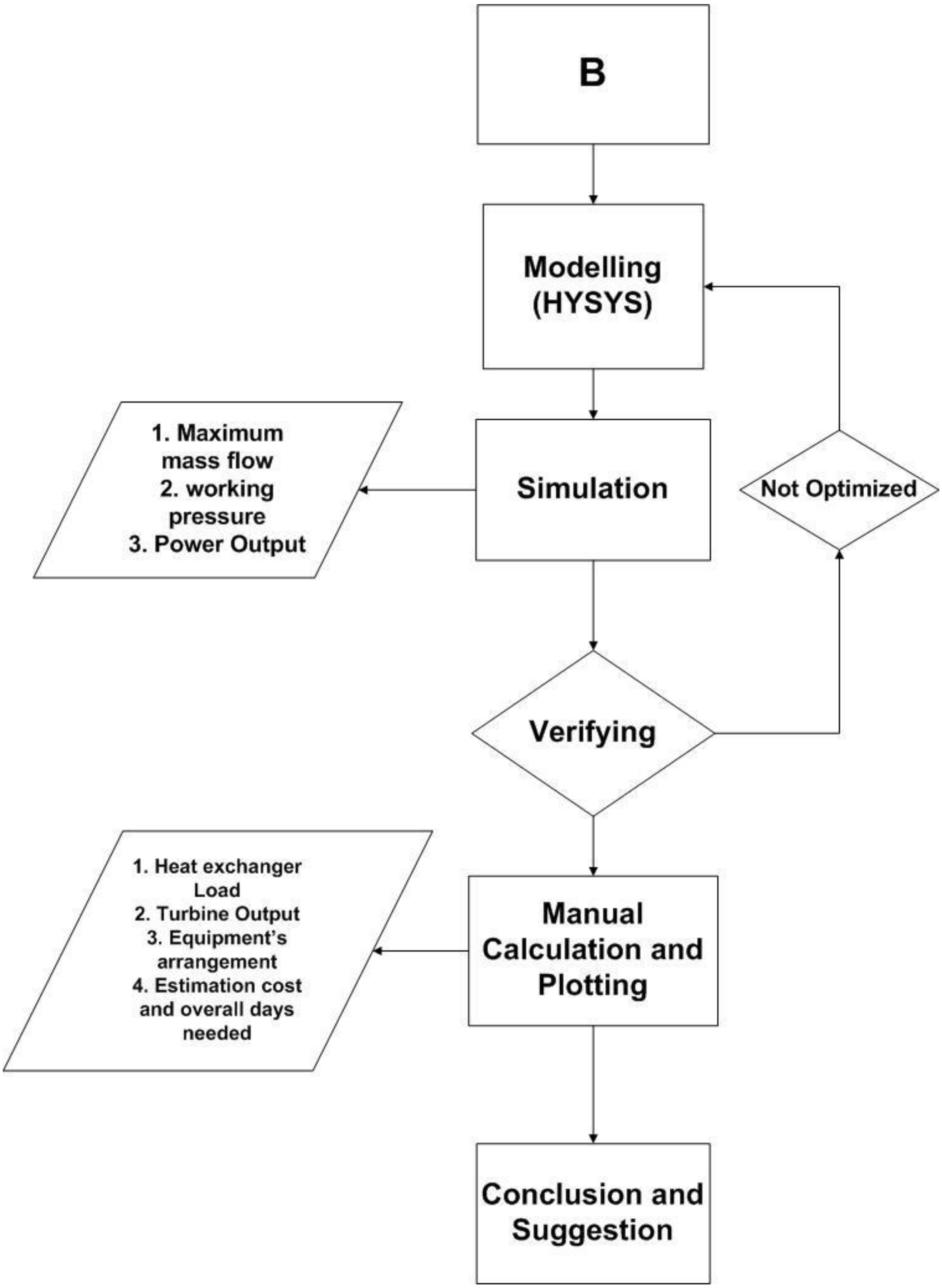


Figure 15Methodology

3.2 Methodology Definition

3.2.1 Problem Identification

The objective at this stage is to find out the problem that can be formulized and identified. The source to formulized and identify the problems is by curiosity from the writer and from various reference such as journal, paper and books.

3.2.2. Literature Study

In this research, literature study is an early stage for planning a process about the basic theories to be learned and a data for supporting the calculation and analysis to obtain the final result of this research. Some basic theories which may require as a fundamental to write and solve the problems in this research such as thermodynamic (heat transfer, properties of refrigerants, rankine cycle, energy balance), fluid machinery (pump, expander, heat exchanger), diesel engine and generator (sankey diagram, generated power to fuel consumption estimation), applied organic rankine cycle in maritime industry,

3.2.3 Collecting Data

The aim of this stage is to collect some data directly from PHE ONWJ platform that are required for the sake of this research such as the performance analysis of the

3.2.4 Data Analyze

After the process of collecting the data is completed, the next step is to analyze the collected data. There are some main data that are important to be analyze to obtain temperature inlet and outlet for jacket water cooling system at typical engine load condition, available heat which can utilized in organic Rankine cycle system, cooling system drawing and equipment of the ship and the refrigerant properties. The process of analyzing the data are concerning about jacket water cooling temperature & pressure at inlet and outlet condition to obtain the available heat and mass flow rate at typical load of the main engine from typical Gas Turbine Sankey diagram, properties of the refrigerants which is suitable for desired operating condition, the freshwater and seawater cooling system work from the drawing to determine in which part for installing the suitable ORC technology in the cooling system of the ship.

3.2.5 ORC System Design in heat recovery system used on platform

This stage aims to design in which suitable location at the ship cooling system that the process organic Rankine cycle system can be installed on the result from previous stage in modelling and simulation. Software that support for the design process at this stage is AutoCAD.

3.2.6 Modelling

Modeling steps is for preparing the system to a certain application of fluids application.

3.2.7 Simulation

Simulation is to detect whether the system is working properly and optimized.

3.2.8 Manual Calculation

The process of manual calculation has two purposes. First purpose is act as a comparison to show that the result from simulation stage can be use if the result from the manual calculation also show the same result with some tolerable error. The second is act as a tools to make sizing and selection for each organic Rankine cycle equipment (heat exchanger, pump, expander) that will be used. The aims at this stages is to show that the result from simulation stage can be use if the result from the manual calculation also show the same result with some tolerable error.

3.2.9 Conclusion And Suggestion

After all the stages have completed, the result from the research that obtained at the previous stage will be concluded. The conclusions are the answer for the problem that formularized from the earlier stage at Chapter 1 and it is a summary from the research and data analysis at the previous stage.

Chapter IV
Data Analysis and Discussion

4.1 General Description for the Platform and power plant

4.1.1 Platform's General Condition

For this research the platform that will be used are the LIMA Complex, the LCOM platform which there are the gas turbine has been installed to be exact. The platform general characteristics are:

Location : $05^0 15'$ S and $107^0 20'$E
Class 1, Division 2 area
No corrosive gas
Clean, Dust Free,
Salty air
Off shore, Platform
Elevation : 13 Meters Above sea Level
Temperature : (Outdoor) 26^o C to 35^o C
Wind : normal 8 m/s, maximum on 16 m/s

On this offshore platform the generator will have different performances based on the inlet temperature that affected by the ambient temperature on the platform.

4.1.2 Standard Performance Data

The performance references by the manufacturer of the Kawasaki Gas Turbine Generator set are provided and made into group based on the inlet temperature of the Gas Turbine. The data are:

Table 3 Standart Performance Data

Ambient Temp. (^oC)	Load Ratio (%)	Electric Output (kW)	Fuel Consumption (kW)	Electricity Electricity (%)	Inlet Air Weight (kg/s)	Exhaust Gas		
						Temp. (^oC)	Weight Kg/s	Volum M^3N/h
26	66.7	1000	4840	20.7	7.6	460	7.7	21600
26	58.0	870	4470	19.5	7.7	431	7.8	21700
26	29.0	430	3320	13.0	7.9	348	7.9	22100
30	66.7	1000	4870	20.5	7.4	475	7.6	21100
30	58.0	870	4490	19.4	7.5	445	7.6	21200
30	29.0	430	3330	12.9	7.7	358	7.7	21600
35	66.7	1000	4920	20.3	7.2	495	7.3	20500
35	58.0	870	4530	19.2	7.3	463	7.4	20600

35	29.0	430	3350	12.8	7.5	372	7.5	21000
38	66.7	1000	4950	20.2	7.1	507	7.2	20100
38	58.0	870	4560	19.1	7.1	475	7.2	20200
38	29.0	430	3370	12.8	7.3	381	7.4	20700

4.2 Data Analysis

Data analysis is crucial to obtain the particular data needed to continue the process of this research and to determine the power generated by the whole ORC-system at the end. The required data are:

- Engine Load based on ambient temperature
- Temperature of the exhaust gas
- Available heat to be utilized
- The ORC working fluid selection
- The layout of the platform plan

All of data above will be determined in the next sub-chapter.

4.2.1 Engine Load based on ambient temperature and the exhaust gas temperature

From the data that have been collected, we can define the engine load that will be used according to site condition and the most important are the exhaust gas temperature that have been dumped to open air because that will be utilized to generate additional electricity in this research. Thus, the summary of the data needed are:

Table 4 Engine load based on ambient temperature and the exhaust gas temperature

Ambient Temp. (°C)	Load Ratio (%)	Electric Output (kW)	Fuel Consumption (kW)	Inlet Air Weight (kg/s)	Exhaust Gas		
					Temp. (°C)	Weight Kg/s	Volum M^3N/h
35	66.7	1000	4920	7.2	495	7.3	20500
35	58.0	870	4530	7.3	463	7.4	20600
35	29.0	430	3350	7.5	372	7.5	21000

4.2.3 Available Heat

From the table of the engine load, we can conclude the available heat according to the particular sankey diagram for gas turbine:

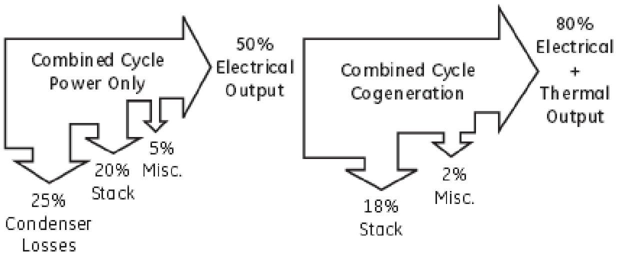


Figure 16Available Heat
Source: google

The available heat from the stack (exhaust) are approximately 18 to 20%. So using the formula:
Available heat (kW) = 20 % X b
Where:
b = 100% Fuel energy at typical engine load (kW)

Then the available heat for complete performances of the gas turbine are:

Table 5 Available Heat

Load (%)	kW	b (kW)	Available Heat (kW)
100	1495	14087.8251	2817.565021
95	1420.25	12714.26216	2542.852431
90	1350	11449.30268	2289.860535
85	1275	10212.49529	2042.499058
80	1200	9046.362608	1809.272522
75	1125	7950.904636	1590.180927
70	1050	6926.121372	1385.224274
66.7	1000	6285.337354	1257.067471
60	900	5088.578967	1017.715793
55	825	4275.819827	855.1639653
50	750	3533.735394	706.7470788
45	675	2862.325669	572.4651338
40	600	2261.590652	452.3181304
35	525	1731.530343	346.3060686

30	450	1272.144742	254.4289484
25	375	883.4338485	176.6867697
20	300	565.397663	113.0795326
15	225	318.0361855	63.60723709
10	150	141.3494158	28.26988315

4.2.4 Working Fluid Selection

The working fluid is used to generate electricity on the platform through the expander. In this research the working fluid that will be used are from the siloxane mixtures. The choices is Hexamethyldisiloxane (MDM). thechoosen one will be tested by simulation on HYSY. There are many possible working fluid but the mentioned is having the required flash point and auto-ignition temperature to be used in high temperature ORC-System.

The main characteristic from Hexamethyldisiloxane that are needed for the system are mentioned Below.

Table 6 Working Fluid Selection

Flash Point	150
Auto-ignition temperature	300
Boiling Point	110
Melting point	-90
Freezing Point	10

From the characteristic hexamethyldisiloxane are considered as the ideal working fluid from siloxane mixtures family for this organic rankine cycle system.

4.2.5 Proposed ORC system

The workflow of the ORC systems based on *energies* are:

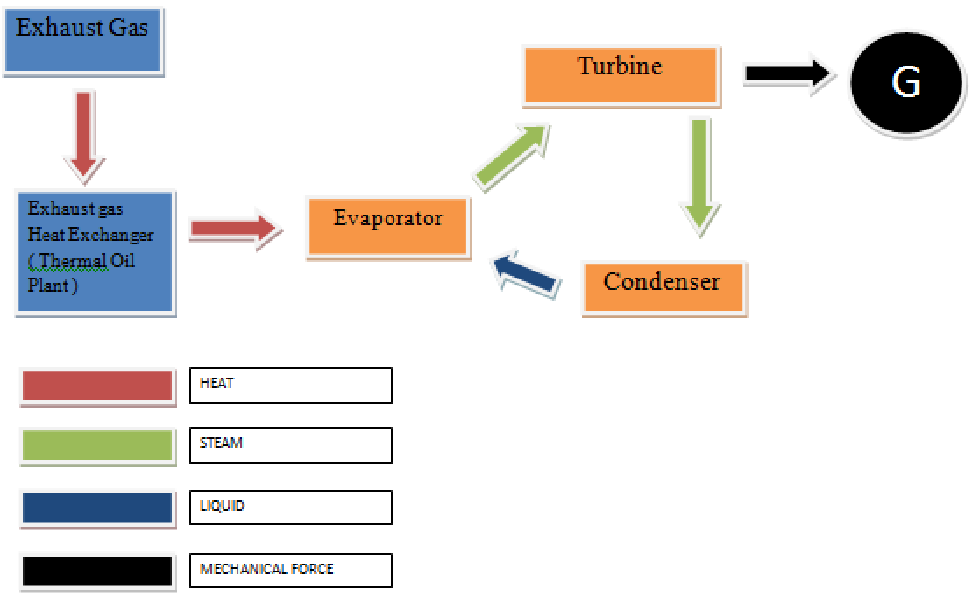


Figure 17 Proposed ORC system
Source: google

The piping and instrument diagram for the proposed system are attached.

4.2.5.1 Thermal Oil Plant

1. For this phase, the thermal oil are entering exhaust gas heat exchanger to obtained the specifical heat needed to be carried into the system. The heat that obtained must designed not to be exceed 250 ^oC that are the optimal working temperature for Hexamethyldisiloxane
2. From the Heat Exchanger, the fluid are brought to heat exchanger to heat up the Hexamethyldisiloxane for ORC-system. The heat up is not to be exceeded 200 ^oC
3. The Fluid pumped again to create close-loop system.

4.2.5.2 Organic Rankine Cycle

1. In the ORC phase the liquid first come to the evaporator to make contact with the heated Hexamethyldisiloxane. In this phase, the fluid must be heated up to 125 ^{o}C so it will become pressurized steam after leaving the evaporator.
2. From the evaporated the steam is brought to expander so the pressurized steam can move the expander's blade to turn generator shaft and can make electric power.
3. After the expander, the steam will come to condenser to be cooled down. For this phase the steam must be brought down to 110 ^{o}C so the fluid will become fluid.
4. After that, the fluid will pumped to evaporator again to repeat the system and making continous electric power.

4.3 Simulation Result

The simulation result from fluid simulation after entering the variable and through the try and error. The maximum mass flow for the system are 0.68 m/s. The complete product for the simulation using exhaust gas load on 66.7% on 1.000 kW rate is written on the table below:

Table 7 Simulation Result

Maximum mass flow rate	0.68 kg/s
Minimum mass flow rate	0.68 kg/s
Average mass flow rate	0.68 kg/s
Reference mass flow rate	0.67 kg/s
Power produced from simulation	135.77 kW
Maximum working temperature	300 ^{o}C
Ideal working temperature	250
Maximum working pressure	30 Bar

This simulation product is acquired using hexadimethyldisiloxane fluid and were simulated with margin error up to 5.65%

4.4 Manual Calculation

4.4.1 Exhaust Gas Heat Exchanger

The first to calculate for the system are the exhaust gas heat exchanger to acquired the heat from gas turbine's exhaust gas. The proposed condition for the heat exchanger are:

Table 8 Exhaust Gas Heat Exchanger

	Exhaust Gas (CO_2)		Thermal Oil	
Inlet Temperature	495	C	98	C
Outlet Temperature	477	C	X	C
Mass Flow Rate	7.4	Kg/s	2.48	Kg//s

The mass flow rate of the thermal oil are acquired from HYSYS simulation and the temperature of the thermail oil after leaving the exhaust gass heat exchanger are determined using heat balance formula:

$$Q_{EG} = \dot{m} . C_p . (T_{in} - T_{out})$$
$$Q_{EG} = 7.4 .3{,}74. (495 - 477)$$
$$Q_{EG} = 492\ KW$$
$$Q_{EG} = Q_{TO}$$
$$Q_{EG} = Q_1 + Q_2 + Q_3$$
$$Q_{EG} = 2{,}48.3{,}114. (\ 110.5 - 38) + \ 2{,}48.214 + 2{,}48.3{,}114\ (\ T_{out -}\ 110.5)$$
$$T_{Out} = \ 199\ \ ^oC$$

From the equation above we can determine the working condition for the exhaust gas heat exchanger, and determine the exhaust gas heat exchanger specification:

Table 9 Max Heat Load

Max Heat Load	416.176 kW
Maximum Flow Rate	0.68 kg/s
Maximum working temperature	199 ^oC
Maximum working pressure	8.76 Bar
Maximum Exhaust Gas Temperature	495 ^oC

According to the calculation above, the suitable exhaust heat exchanger are written below:

Table 10 Manufacturer

Manufacturer	BOWMAN
Type	5-60-3740-8
Maximum designed Pressure	30 Bar
Maximum designed Temperature (Exhaust Gas in/out)	1000 °C
Maximum designed temperature (ORC Fluids)	350 °C

4.4.2 Determining Fluid's Temperature after Leaving Evaporator

After determining the temperature coming from the outlet of the exhaust gas heat exchanger, the result of the heating in the evaporator can be determined using heat balance formula. The components' temperature taken from the temperature outlet of heat exchange where the power rating of the gas turbine are 66,7% (1,000 kW)with outlet temperature on 495 °C.

From the calculation are assumed that inlet temperature on the evaporator are 199 ^{o}C with mass flow rate on maximum 0.68 Kg/s based on HYSYS simulation. The temperature of the fluids after leaving the evaporator are written as follows:

$$Q_{EG} = \dot{m} . C_p . (T_{in} - T_{out})$$
$$Q_{EG} = 0.68.3{,}14.(198 - 38)$$
$$Q_{EG} = 339\ KW$$
$$Q_{EG} = Q_{TO}$$
$$Q_{EG} = Q_1 + Q_2 + Q_3$$
$$Q_{EG} = 2{,}48.3{,}114.(\,198 - 110.5) + 2{,}48.214 + 2{,}48.3{,}114\ (\,T_{out-}\ 88)$$
$$T_{Out} = 157\ ^{o}C$$

After calculating the temperature and the heat load needed for the evaporator, we can determine the requirements for evaporator as follows:

Table 11 requirements for evaporator

Max Heat Load	339 kW
Maximum Flow Rate	0.68 kg/s
Maximum working temperature	157 ^{o}C
Maximum working pressure	25 Bar

With the specification needed, we can select the proper evaporator to be used in the system as follows:

Table 12 Proper Evaporator to be used

Manufacturer	VunkeViFlow
Type	GPLK-95
Maximum designed Pressure	30 Bar
Maximum designed Temperature (Exhaust Gas in/out)	250 ^{o}C
Maximum designed temperature (ORC Fluids)	250 ^{o}C

4.4.3 Pressure Drop

For the pressure drop, it must be calculated to determine the working pressure for pumps and turbine so it can give the exact amount of electricity needed. Pressure drop calculation consist of some several steps. The steps and calculation are determined below:

$$\Delta P = \frac{1{,}5{G_p}^2 n_p}{2 g_c \rho_i} + \frac{4 f L G^2}{2 g_c D_e}\left(\frac{1}{\rho}\right)_m \pm \frac{\rho_m g L}{g_c}$$

np = 1
Np = 300
W = 0.608 m (width)
L = 1.23 m (height)
DP = 0.0704 m
B = 0.04 m
De = 0.008 m
Gc = 1
G = 9.78 m/s^2

M = 0.68 kg/s
U =0.0001367 kg/ms
p = 76.4 kg/m^3

To determine the pressure drop, first of all the specification for evaporator needs to be found to input the data. After the data is all complete it can be calculated as above. From the calculation the pressure drop after the fluid exit the evaporator are 0.1978 bar.

4.4.4 Electrical power generated by Turbine

After calculating the pressure drop from the fluids after leaving the evaporator that on approximate 0.2 bar or 0.189 bar to be exact and reducing the pressure from the pump that pumped ORC's fluid on 20 bar, so the pressure will become 19.817 bar when enters the expander.

The operating condition for the expander under 66.7% working load of the gas Turbine are written as follows:

Table 13 Electrical Power Generated by Turbine

Pressure inlet	19.817 Bar
Pressure outlet	7.5 Bar
Inlet Temperature	157 ^oC
r (Cp/Cv)	1.656
Mass flow rate	0.68 Kg/s

So after knewing the working condition for the turbine, we can conclude the output power, generated by the turbine.

$$T_2 = T_1 \frac{P2^{\frac{r-1}{r}}}{P1}$$

$$T_2 = 213.8392 \quad \frac{7.5^{\frac{1.789-1}{1.789}}}{19.817}$$

$$T_2 = 213.8392 \quad \frac{7.5^{\frac{1.789-1}{1.789}}}{19.817}$$

$$T_2 = 101\ ^oC$$

After we can determine the temperature after leaving the turbine we can conclude the power generated by the turbine with equation as follows:

$$Q = \dot{m}\,(T1 - T2)$$

$$Q = 0.68\,(213.8392 - 139.213)$$

$$Q = 120\ kW$$

4.4.5 Pumps Selection

4.4.5.1 Thermal Oil Plant's Pump

For the pump of thermal oil plant, the pump that will be used are calculated using pump capacity for there are only one pressure that working. So the capacity needed for the pumps are written as follows:

$$Q_s = \frac{\dot{m}}{\rho}$$

$$Q_s = \frac{0.68\ x\ 3{,}600}{764}$$

$$Q_s = 3.2\frac{m^3}{h}$$

So, the capacity needed for thermal oi plant's pump after calculated can be found written as follows:

Table 14 Thermal Oil Plant's Pump

Maximum Pressure	10 bar
Maximum temperature	250 °C
Maximum Head	20 m
Pump Capacity	4 m/h
Manufacturer	Iron Pump
Type	Gear pump

4.4.5.2. ORC-Plant System's Pump

For the ORC's pump, the calculation are set to work at pressure from expander that are 7,5 bar and need to be risen to 20 Bar to have a proper working condition so the output will be as expected. To get the expected result we can conclude the needed pump with equation Written below:

$$h = \frac{P2 - P1}{pg}$$

$$h = \frac{20000000 - 750000}{764\ x\ 9.78}$$

h = 167.92 m

After we can conclude the required head for the pumps, we can proceed to calculate the temperature rise after pump because the pressure increase, that will be increase on the temperature. To define the temperature rise, can be by the equation written as below:

$$\Delta T = \frac{H(\ 1 - \eta\ )}{102(U.\eta)}$$

$$\Delta T = \frac{168(\ 1 -\ 0.75\ )}{102(3{,}114\ x\ \ 0.75\ )}$$

$$\Delta T =\ 0.53\ \ ^{o}C$$

After calculation above, the proper type and capacity can be chosen for the ORC's liquid pump is:

Table 15ORC-Plant System's Pump

Maximum Pressure	25 bar
Maximum temperature	200
Maximum Head	170 m
Pump Capacity	70 m^3/h
Manufacturer	Iron Pump
Type	Gear Pump

4.4.6 Determining Condenser Heat Load

After determining the temperature coming from the outlet of the expander, in this case from turbine outlet. On this system, the fluid that come from expander, the temperature must be lowered down under 100 ^{o}C to get the fluid phase from hexamethyldisiloxane (MDM).

From the calculation of the expander, the outlet temperature can be determined 101.019 ^{o}C with mass flow rate on maximum 0.68 Kg/s based on HYSYS simulation. The temperature of the fluids after leaving the Condenser are written as follows:

$$Q_1 = \dot{m} \,.\, C_p .\, (T_{in} - T_{out})$$
$$Q_1 = 2{,}48.3{,}114. (110.05 - 101)$$
$$Q_1 = 19.923\ KW$$
$$Q_c = Q_1 + Q_2 + Q_3$$
$$Q_c = 19.923 + 2{,}48.214 + 2{,}48.3{,}114 (88 - 101.015)$$
$$Q_c = 638\ kW$$

After calculating the heat load needed for the condenser, we can determine the requirements for condenser with working conditions as follows:

Table 16Determining Condenser Heat Load

Max Heat Load	638 kW
Maximum Flow Rate	0.68 kg/s
Maximum working temperature	150 ^{o}C
Maximum working pressure	25 Bar

With the specification needed, we can select the proper evaporator to be used in the system as follows:

Table 17Proper evaporator to be used

Manufacturer	VunkeFivlow
Type	GPLK-90
Maximum designed Pressure	30 Bar
Maximum designed Temperature (Expander out)	150 ^{o}C
Maximum designed temperature (ORC Fluids)	150 ^{o}C

4.5 LayOut and Equipment Plotting

The system that have been calculated and the equipment had been selected, need to be assure that it will fit the offshore platform. The overall layout are:

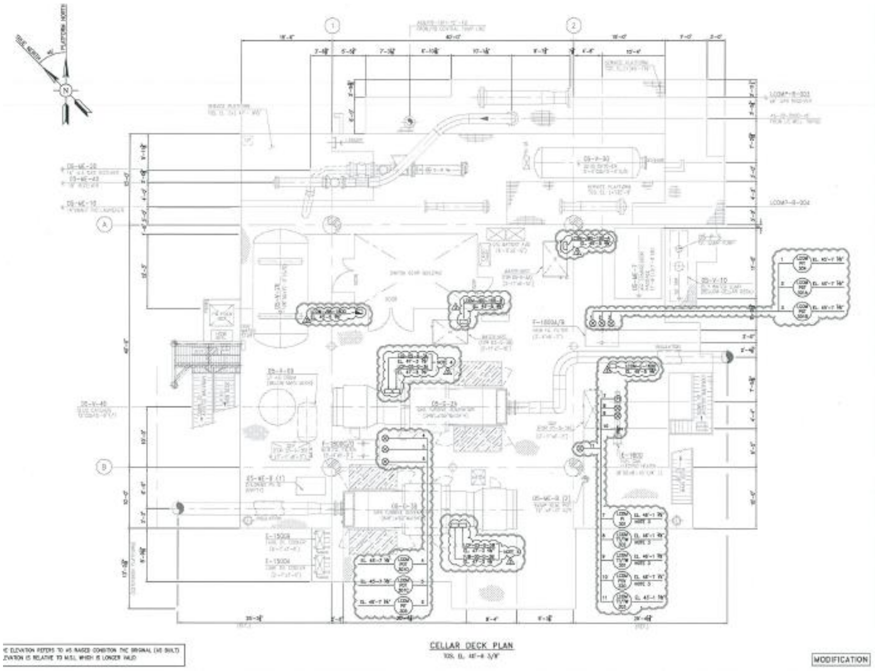


Figure 18Layout and Equipment Plotting
Source: LIMA-LCOM-I-LPL-4004~3 AFC Instrument Location Plan

The space that will be used are above the exhaust gas insulation that available about 4 x 5 meters. And the required space for the system are about 3 X 3.8 meters, the systems are:

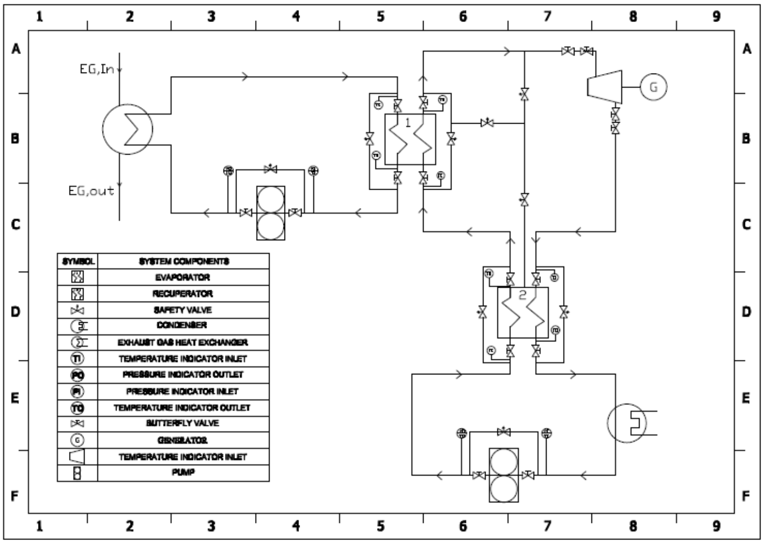


Figure 19 ORC system equipment plan

The detailed size and direction, also the placing of each equipments are detailed below:

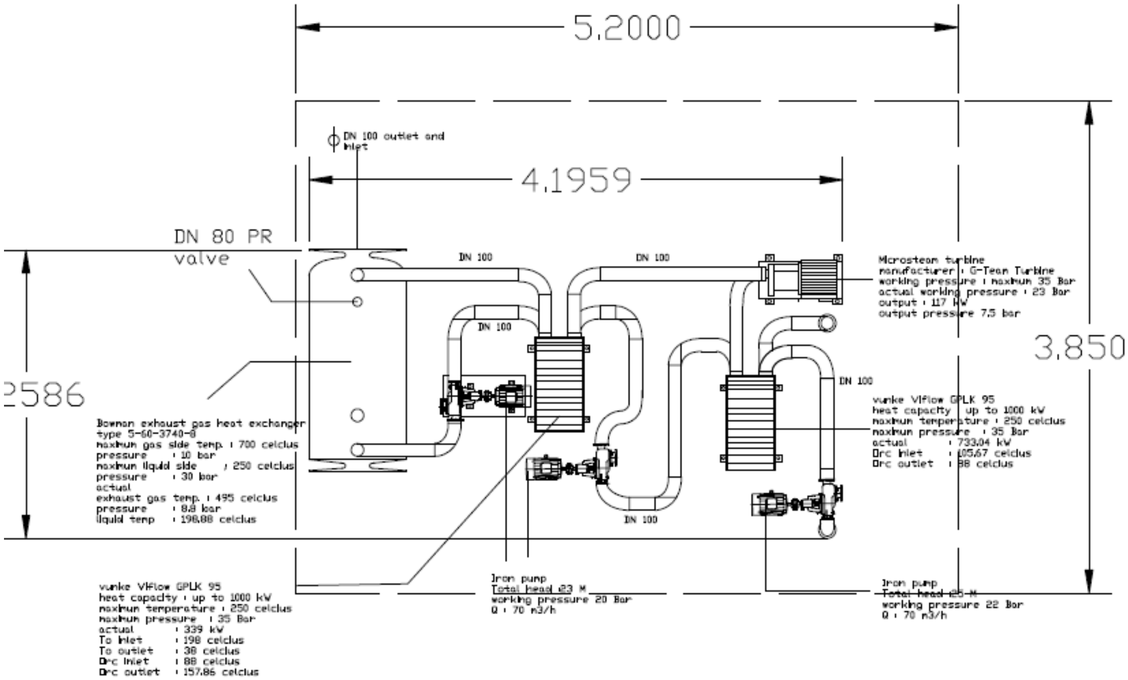


Figure 20 Plotting and Actual Size

Beside consist of each equipment type, the system plotting consist of the actual size of each equipments.

4.6 Thermal-Electric Efficiencies

For the Kawasaki GPB15 system are using the gas fuel directly from the well, so there are no economic value to its fuel consumption but only efficiencies that calculated using the ratio of fuel consumption and fuel heating value that will compared to generated power output. Thus, the thermal efficiencies before the system is added is written below:

Electric-fuel Ratio : 1195.15 kWh = 525.3244 M^3/Hr (at site condition rating)

: 2.2751 kWh = 1 M^3/Hr

Fuel Calorific value : = 37900 KJ/M^3(1 kJ = 2.8 x 10^{-4} kWh)

= 10.528 kWh/M^3

Thermo-Electric Efficiency

= (2.2751 / 10.528) x 100% = 21.61 %

After the ORC is added the calculation will changed because the output from same fuel energy consumed are added by 120 kW. The calculation after the ORC systemis added written below:

Electric-fuel Ratio : 1315.15 kWh = 525.3244 M^3/Hr(at site condition rating)

: 2.5035 kWh = 1 M^3/Hr

Thermo-Electric Efficiency

= (2.5035 / 10.528) x 100% = 23.78 %

4.7 Project Management

4.7.1 Bill Of Quantity

After the equipment have been determined, we can calculate the overall project cost by combining the price for each equipment from the system with the total manhour cost after calculate it with Labor cost. For the first part for the total project's cost, the total of equipment are written below.

For the cost below, the price information of each equipment are obtained from each website except for the piping, flange, and elbow are listed according to quotation from PT. BentengAnugrah Sejahtera. Please note that the price only as reference and may differ according to time and company's policies.

Table 18 Bill of Quantity

	Plant Name:			Project name:	ORC-WHRU	
BOQ	**Organic Rankine Cycle**			Student:	Datya A.F.	
	WHRU For Kawasaki GPB 15			NRP:	4213101008	
No	Description	Type	Qty	Price/unit		Price
	Material				**Rp**	**2,057,483,000**
1	G-Team Turbine	Microsteam	1	1,463,000,000	Rp	1,463,000,000
2	VunkeViflow evaporator	GPLK 95	1	82,460,000	Rp	82,460,000
3	VunkeViflow Condenser	GPLK 90	1	93,100,000	Rp	93,100,000
4	Gear Pump	IP-190	2	99,750,000	Rp	199,500,000
5	Centrifugal Pump	B100	1	106,400,000	Rp	106,400,000
6	Elbow 90	DN100	18	50,000	Rp	900,000
7	Bowman E/G H/E	5-60-3740-8	1	103,740,000	Rp	103,740,000
8	Pipe 4" x 6000 lg	DN100	10	520,000	Rp	5,200,000
9	Bolt & Nuts	CS	32	8,500	Rp	272,000
10	L X 4000 Lg	CS	4	323,000	Rp	1,292,000
11	4"-ANSI Flange	CS	35	45,000	Rp	1,575,000
12	Welding Electrode 15 kg		2	22,000	Rp	44,000
	Cost Of Design				**Rp**	**140,000,000**
13	Drawing and Layout		1	15,000,000	Rp	15,000,000
14	Equipment and capacity		1	25,000,000	Rp	25,000,000
15	Project Management		1	100,000,000	Rp	100,000,000
	Cost Of Comissioning				Rp	30,000,000
16	Comissioning		1	30,000,000	Rp	30,000,000
	Taxes				**Rp**	**133,133,000**
17	Customs	4%	1	81,928,000	Rp	81,928,000
18	PPn	2.50%	1	51,205,000	Rp	51,205,000
	Cost Of Transport					

19	Tug Boat	200 HP	4	14,440,000	Rp	57,760,000
	TOTAL				**Rp**	**2,418,376,000**

Cost of Material

This cost are consist of all material needed for this project including each equipment from heat exchanger to expander, also supporting for each equipments. This cost on project commonly minimum 70% from project's provisional sum.

Cost of Design

Cost of design is cost for engineering, calculating and drawing for the project, usually occurred when the project is EPC (Engineering, Procurement, Construction). This cost can be more expensive if owner or appointed contratctor use consultant for the project. The amount of design cost is about 7% to 8% from provisional sum.

Cost of commissioning

Cost of commissioning are cost for testing the equipment to know whether it will fulifill the required specification or not. It have to attended by the contractor and project owner. Roughly cost of commissioning will cost about 1% to 2%.

Taxes

This cost are mainly for cost that affected from government regulation and legals. For customs, it depends on the regional and treaty from government, as example if the equipment is coming from China, it will custom free to CAFTA treaty. But commonly, it is around 4% up to 7.5% each equipments and added local taxes 2.5%.

4.7.2 Project Scheduling

After the equipment have been plotted to fit into the platform, and the cost overall for this project have been estimated,to complete the project management, iti is necessary to calculate estimation of working hour needed for each step to be done.

For this project the required hours to be done are written as below on the table, estimating one day has 8 working hours. With Saturday are set to be working day. Please note that these schedule can be longer due to national holiday or religion based holiday.

Table 19Project Scheduling

WBS	Task Name	Duration (Days)
1	**Event**	**2**
1.1	Sign Up Contract	1
1.2	kick Off meeting	1
1.3	administration Check	1
2	**Design**	**7**
2.1	Capacity Calculation	3
2.2	Layout redraw	3
2.3	Material Listing	2
2.4	P&ID Drawing	3
2.5	Cost estimating and RFQ	2
2.6	Evaluation and Revision	7
3	**Installation (On shore)**	**24**
3.1	Major equipment shipping	14
3.2	Support and Piping Fabrication	14
3.3	Worker administration and permit	14
3.4	Quality Control and Repair	12
3.5	Piping Pressure and Liquid Test	5
3.6	Packaging and Containment	2
4	**Installation (Offshore)**	**9**
4.1	Shipping for each equipments	5
4.2	Condenser pipe arranging	3
4.3	Turbine,Condenser,Evaporator plotting	2
4.4	Support and Pipe Welding	1
4.5	Running test	1
5	**Comissioning**	**2**

5.1	Load test and Finishing	1
5.2	Final Check before Hand Over	1
	TOTAL DAYS	**44**
	TOTAL WORKING HOUR(s)	**352**

For the gantt-chart that show which can be done simultaneously and which work order that needs to wait other order are attached as appendix. For each steps, it will affected if the shipment of main equipment are delayed.

On event, there will be no any problem since the step are only to validate and confirmed the actual contract and project requirement and value so the project can be started.

On designing phase usually, if the requirement had clearly stated there are no obstacle, especially when the contractor have a reliable consultant to overview or subbing the drawing, calculating, and material listing.

For installation steps, it will be divided to 2 (two) groups, the process that have to be finished onshore before taken to platform, and process that can only be done on offshore platform. Due to the production that needs to be shutted because this system installation will interrupted the power generation on the facilities, so the less the work on platform the better.

Chapter V

Conclusion

5.1 Conslusion

Based on data analysis and result of calculation that have been completed we can conclude these following:

1) The electricity power that will be generated from ORC-system is set on the gas turbine daily rate on 1,000 kW on 66.7% with exhaust temperature at 490 ^{O}C with inlet air temperature on 38 ^{o}C it will generated 120 kW on power generation. The available heat from exhaust gas are 1257 kW with fuel calorific value on 37,000 kJ/kg. The maximum mass flow for the system are 0.68 kg/s with working pressure 22 bar on maximum rate in the expander and with maximum working temperature on evaporator 197 ^{o}C.

2) The arrangement for the system are maintained to be as efficient as possible. To cut cost from each link of the pipe, it all use elbow 90 degree with same radius, leaving 0.5 m minimum space for each equipments as working space. The overall available space on the platform are roughly 5.2 m x 3.85 m and the overall space needed for system to attached are 3.2 m x 4.19 m with maximum clearance 2.25 m and the highest equipment, which is the exhaust gas temperature on 1.58 m including the outlet and inlet line.

3) The thermal efficiencies before the system is added are on 21.61% rate. After the adding of this ORC-system, the overall efficiencies are climbed up 2.17% to 23.78%. These result acquired from a process that need no combustion, but pureheat processing, with 0 kg/kwh carbon emission produced.

4) The working fulid that is used are hexamethyldisiloxane (MDM) due to its durability to be use in high temperature or supercritical cycle and its low range from boiling point on 85 ^{o}C to flash point at 101.5 ^{O}C. the maximum temperature for the liquid are 300^{o}C for its auto ignition

temperature but it is advised to be use no more than 250°C and 25 Bar working pressure.

5) The estimated overall for this system are on Rp 2,360,616,000 with detail are Rp 2,057,483,000 are for materials and equipment cost; Rp 140,000,000 for cost of design; Rp 30,000,000 for commissioning cost; and Rp 133,133,000 for tax and customs. The needed working hour are 44 days with total 352 working hours that included from kick-off meeting until commissioning.

5.2 Suggestion

These suggestion are added due to many improvement still can be done for further use and research. The suggestion that potentially can be useful in the future are listed below:

1) The ORC system needs to calculated for each decreasing amount of the fluid so it can be more accurate on acquiring the exact provisional sum.
2) The maintenance cost and maintenance plan for overall and individual equipments.
3) The exact duration of allowed off-producing time on platform to create window for real installation.
4) The comparison with other waste heat recovery technologies.

References

Akram Faisal, TFNSTMS,D-IWB 2016, 'Technical and Economic Analysis of Organic Rankine Cycle System Using Low-Temperature Source and Refrigerant Liquid as Working Fluid to Generate Electricity in Ship'.

Bronicki, LY 2013, 'Organic Rankine Cycle Power Plant for Waste Heat Recovery'.

D. C. Bândean, SSJTC 2011, 'Working fluid selection for Organic Rankine Cycle applied to heat recovery systems', *Energy End-Use Efficiency Issues (EEE)*.

David Meyer, CWFEADSK 2013, 'DESIGN AND BUILD OF A 1 KILOWATT ORGANIC RANKINE CYCLE', *35th New Zealand Geothermal Workshop: 2013 Proceedings*.

Durmaz, A 2010, 'Waste Heat Recovery Generator', TMEIC, Houston.

group, EPRW 2003, 'Efficiency in Electric Generation', EURELECTRIC, Brussels.

Hamid, EMKA 2010, *HYSYS : An Introduction to Chemical Engineering Simulation*, Universiti Teknologi Malaysia, Johor.

Hong Gao, CLCHXXSWAYL 2012, 'Performance Analysis and Working Fluid Selection of a Supercritical Organic Rankine Cycle for Low Grade Waste Heat Recovery', *energies open access*.

Huijuan Chen, DYEKS 2010, 'A review of thermodynamic cycles and working fluids for the conversion of', *Renewable and Sustainable Energy Reviews*.

Ken Arnold, MS 1999, *Surface Production Volume 2*, Gulf Publishing Company, Houston.

Lyons, C 2010, 'Choosing Power for CHP project'.

Markus Preißinger, DB 2016, 'Thermal Stability of Hexamethyldisiloxane (MM) for High-Temperature Organic Rankine Cycle (ORC)', *energies*.

MUN Engineering 2011, 'Heat Exchangers', in *Mechanical Equipment and Systems*, www.engr.mun.ca, California.

Ngoc Anh Lai, MWJF 2010, 'Working fluids for high-temperature organic Rankine cycles', *Energy*.

PHE ONWJ 2013, 'RFQ For LPSU Project', Jakarta.

PHE ONWJ 2014, 'LIMA-LCOM-I-LPL-4004~3 AFC Instrument Location Plan', PHE ONWJ, Jakarta.

PHE ONWJ 2014, 'LIMA-M-EVT-0001~6 AFC TBE Gas Turbine Generator(05-G-3 AB)', PHE ONWJ, Jakarta.

reay, DA 1979, 'Heat Recovery System', *Bureau of Energy Efficiency*.

SIEMENS 2014, 'Power Generations with SIEMENS ORC-module', *Power Generation*.

Thulukkanam, K 2013, *Heat Exchanger Design Handbook Second Edition*, CRC Press, New York.

Weith, T 2014, 'Performance of Siloxane Mixtures in a High-Temperature Organic Rankine Cycle Considering the Heat Transfer Characteristic During Evaporation', *energies*.

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ATTACHMENTS A

EQUIPMENT CALCULATION
FOR EACH ENGINE LOAD

EXHAUST GAS HEAT EXCHANGER

LOAD	66.7
temperature	495
Power	1,000 kW
mass flow	7.4

Thermal oil stream	
Inlet	495
outlet	477
m	7.4
c	3.7

hexamehtyl	
inlet	38
out	x
m	0.68
c	3.1

qhot = q cold

qTO	492.84	kW	Tout	198.8128	C
q1	151.8814	kW			
q2	145.52	kW			
q3	80.104	kW			

LOAD	58
temperature	463
Power	1,000 kW
mass flow	7.46

Thermal oil stream	
Inlet	463
outlet	445
m	7.46
c	3.7

hexamehtyl	
inlet	38
out	x
m	0.68
c	3.1

qhot = q cold

qTO	496.836	kW	Tout	200.7084	C

q1	151.8814	kW
q2	145.52	kW
q3	80.104	kW

LOAD	66.7
temperature	495
Power	1,000 kW
mass flow	7.53

Thermal oil stream	
Inlet	360
outlet	342
m	7.5
c	3.7

hexamehtyl	
inlet	38
out	x
m	0.68
c	3.1

qhot = q cold

qTO	499.5	kW	Tout	201.9722	C
q1	151.8814	kW			
q2	145.52	kW			
q3	80.104	kW			

EVAPORATOR

LOAD	66.7
temperature	495
Power	1,000 kW
mass flow	7.4

evaporator TO side	
Inlet	198.8128083
outlet	38
m	0.68
c	3.1

ORC side	
inlet	88
out	x
m	0.68
c	3.1

qhot = q cold

qTO	338.9934	kW	Tout	157.2806	C
q1	47.43				
q2	145.52				
q3	185.504				

LOAD	58
temperature	463
Power	1,000 kW
mass flow	7.4

evaporator TO side	
Inlet	200.708444
outlet	38
m	0.68
c	3.1

ORC side	
inlet	88
out	x
m	0.68
c	3.1

qhot = q cold

qTO	342.9894	kW	Tout	159.1762	C
q1	47.43				

q2	145.52	
q3	185.504	

LOAD	29
temperature	372
Power	1,000 kW
mass flow	7.5

evaporator TO side	
Inlet	201.9722011
outlet	38
m	0.68
c	3.1

ORC side	
inlet	88
out	x
m	0.68
c	3.1

qhot = q cold

qTO	345.6534	kW	Tout	160.4399	C
q1	47.43				
q2	145.52				
q3	185.504				

TURBINE OUTPUT

LOAD	66.7
temperature	495
Power	1,000 kW
mass flow	7.4

pressure inlet	22.897	bar
pressure outlet	7.5	bar
Temperature inlet	157.2806	C
r (Cp/Cv)	1.656	
m	0.68	
T2	101.0791067	C

kW	118.8548128

LOAD	58
temperature	463
Power	1,000 kW
mass flow	7.4

pressure inlet	22.897	bar
pressure outlet	7.5	bar
Temperature inlet	159.1762	C
r (Cp/Cv)	1.656	
m	0.68	
T2	102.2973703	C

kW	120.2873194	

LOAD	29
temperature	372
Power	1,000 kW
mass flow	7.5

pressure inlet	22.897	bar
pressure outlet	7.5	bar
Temperature inlet	160.4399	C

r (Cp/Cv)	1.656	
m	0.68	

T2	103.109546	C

kW	121.2423238

Heat Load For the condenser

LOAD	66.7
temperature	495
Power	1,000 kW
mass flow	7.4

T in	101.0791067
T sat	110.5
Latent	214

m	0.68
C	3.11
Tout	88

q1	19.92330505	
q2	665.54	
q3	-47.583	
q	637.8803051	kW

LOAD	58
temperature	463
Power	1,000 kW
mass flow	7.4

T in	102.2973703
T sat	110.5
Latent	214

m	0.68
C	3.11
Tout	0

q1	17.34692131

q2	665.54
q3	-233.6854
q	449.2015213	kW

LOAD	29
temperature	372
Power	1,000 kW
mass flow	7.5

T in	103.109546
T sat	110.5
Latent	214

m	0.68
C	3.11
Tout	88

q1	15.62933215	
q2	665.54	
q3	-47.583	
q	633.5863321	kW

Pressure drop calculation

Inlet 35 Load 66.67 %

exhaust gas temperature	495	C
	768	k

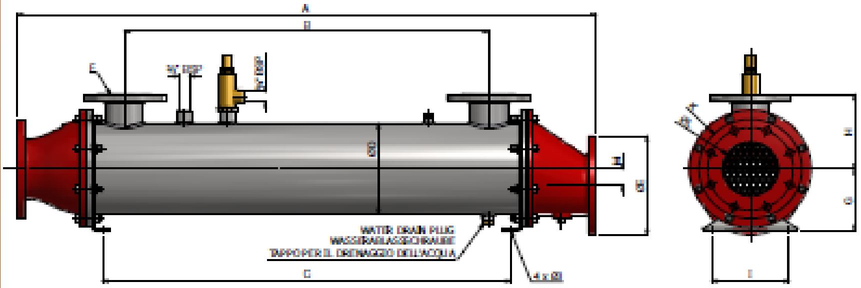
Gp	0.6
np	1
Np	300
w	0.363
Dp	0.095
L	1.4
b	0.0021
De	0.004
gc	1
g	9.78
m	0.68
u	0.000511
p	764

Gp	0.095982497	
A0	0.0007623	
G	892.0372557	
Re	6982.679105	
f	0.087515397	
Ap	11095.16999	
	0.1978517	BAR

ATTACHMENTS B

EQUIPMENT SELECTION

Exhaust Gas Heat Exchanger



Type	A	B	C	D	E	F	G	H	I	J	K	L	M	kg
	mm	mm	mm	mm	mm		mm	mm	mm	mm		mm	mm	
6-32-3741-5	1080	668	760	168.3	210	DN65	120	140	130	11	DN100	104	28	48
6-40-3741-6	1282	870	962	168.3	210	DN65	120	140	130	11	DN100	104	28	55
6-60-3741-8	1790	1378	1470	168.3	210	DN65	120	140	130	11	DN100	104	28	72
8-32-3742-5	1150	648	750	219	240	DN80	150	180	180	14	DN125	130	40	89
8-40-3742-6	1352	850	952	219	240	DN80	150	180	180	14	DN125	130	40	98
8-60-3742-8	1860	1358	1460	219	240	DN80	150	180	180	14	DN125	130	40	125
10-32-3743-5	1230	608	750	273	265	DN100	180	220	250	14	DN150	154	55	132
10-40-3743-6	1432	810	952	273	265	DN100	180	220	250	14	DN150	154	55	146
10-60-3743-8	1940	1318	1460	273	265	DN100	180	220	250	14	DN150	154	55	185
12-32-3744-5	1330	538	736	324	320	DN125	220	260	300	18	DN200	204	55	190
12-40-3744-6	1532	740	938	324	320	DN125	220	260	300	18	DN200	204	55	208
12-60-3744-8	2040	1248	1446	324	320	DN125	220	260	300	18	DN200	204	55	268
15-40-5745-6	1670	740	912	406.4	375	DN150	280	320	350	18	DN250	254	70	319
15-60-5745-8	2180	1248	1420	406.4	375	DN150	280	320	350	18	DN250	254	70	404

Flange 'F' to BS EN 1092-1:2007 - PN6.
Flange 'K' to BS EN 1092-1:2007 - PN6.

EVAPORATOR/CONDENSER

VI|FLOW

GPLK/NPLK

Heat transfer plates with V-corrugation for applications with media of low viscosity.

Main feature of the GPL series is a balance relation between heat transfer rate and low pressure drops. Even in case of low mass flows the thermally optimized plate corrugation generates a highly turbulent flow, very effective utilisation of the available heat-exchanging surface and a very strong self-cleaning effect.

Media:
- oil and oil containing fluids
- glycol mixtures
- alcohols
- refrigerants
- gas/air
- water
- specific media on request

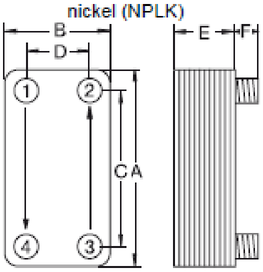
Limit conditions:
- operating pressure max. 30 bar
- special models max. 45 bar
- operating temperature -160°C up to +200°C
- heat capacity 2.0 to 4000 kW

Materials

Plates: 1.4401 / AISI 316

Solder: copper

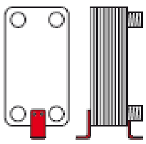
nickel (NPLK)



Applications:

Heating, cooling, condensating
- system separation
- heat extraction and heat recovery in domestic and process technology
- refrigeration engineering
- mechanical engineering
- oil cooling
- hot water/process water
- heating (solar-, central- and floorheating
- cooling of machines and motors
- evaporating/condensing in cooling systems
- air drying
- mold machine temperature control

Position of the connections :
- standard on front plate
- optional on front plate and end plate



Optional:
- angular feet
- wall brackets
- transport hooks
- insulation (hot/cold)

Type		Dimensions/ mm					Connection (standard)	Max. no. of plates	Empty weight kg	Volume/ channel liter
Copper	Nickel	A	B	C	D	E				
GPLK 10	NPLK 10	206	73	172	42	8+2,27*(N-1)	G 1/2"	60	0,81+0,04*(N-1)	0,025
GPLK 20	NPLK 20	194	80	154	40	10+2,25*N	G 3/4"	60	0,8+0,05*N	0,025
GPLK 30	NPLK 30	311	73	278	40	10+2,3*N	G 3/4"	60	0,84+0,07*N	0,04
GPLK 40	NPLK 40	306	106	250	50	10+2,4*N	G 3/4"	100	1,5+0,135*N	0,055
GPLK 55	NPLK 55	522	106	466	50	10+2,4*N	G 3/4"	120	3,1+0,22*N	0,095
GPLK 50	NPLK 50	304	124	250	70	10+2,4*N	G 1"	100	1,6+0,15*N	0,065
GPLK 60	NPLK 60	504	124	444	64	10+2,4*N	G 1"	120	3,5+0,24*N	0,107
GPLK 70	NPLK 70	528	246	456	174	11,5+2,4*N	G 2"	160	7,2+0,52*N	0,232
GPLK 80		527	245	430	148	11+2,85*N	G 2 1/2"	140	8,5+0,49*N	0,289
GPLK 90		798	269	690	161	14+2,4*N	G 2 1/2"	260	11,5+0,8*N	0,400
GPLK 95		870	383	723	237	23+2,4*N	DN 100	300	39,5+1,25*N	0,600

N = number of plates

Quality and certificates

Quality means safety. Each unit is costruction and pressure tested.

Additional testing may also be available in accordance with such quality organisations as:

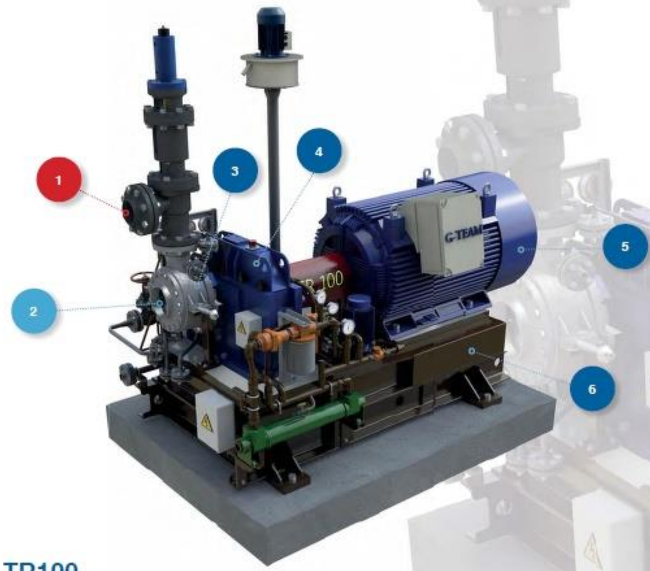
- American Bureau of Shipping (ABS)
- Bureau Veritas (BV)
- Det Norske Veritas (DNV)
- EU Pressure Equipment Directive 97/23/EG
- Germanischer Lloyd
- Lloyds Register of Shipping
- Schweizerische Verein für technische Inspektionen
- Technischer Überwachungsverein (TÜV)

- as well as customer´s test and inspection regulations

FUNKE has been certified according to DIN EN ISO 9001/2000 and is an approved manufacturer according to:

- ASME U-Stamp
- China Certificate
- GOST R
- HP0 in connection with DIN EN 729-2

EXPANDER



- Microturbine TR100 is particularly designed to drive generators with following power generation.
- Gearbox with fixed-on stator of TR100 reduces the speed of impeller to comply with the electric asynchronous generator speed. Base frame including entire oil system and gearbox connected to propelled machine by means of flexible coupling. Mechanical face seals provided reduce steam leaks effectively.
- Microturbine is used for automatic steam reduction to required value in connection with steam extraction which determines electric output of generator.

TR100

1/ Steam inlet	Power output	up to 150 kW
2/ Steam outlet	Generator speed	3 000 rpm
3/ Turbine casing	Inlet steam pressure	up to 4,0 MPa (a)
4/ Gearbox	Exhaust steam pressure	up to 0,6 MPa (a)
5/ Asynchronous generator	Inlet steam temperature	up to 420 °C
6/ Base frame	Partial admission of impeller	

ATTACHMENTS C

LAYOUT

ATTACHMENTS D

GANTT-CHART FOR PROJECT SCHEDULING

ATTACHMENTS E

PO LIST FOR THE EQUIPMENTS

RBC

SURAT PEMBELIAN BARANG

Kepada Yth :

PT. Benteng Anugerah Sejahtera

Alamat : Jl. Tanjungsari No.44B, RT 001 RW 016
Simomulyo, Surabaya

Telephone : 031 7480101 ; 081-332440321 ; 0888-05147725

Fax : 031 7480777

Up. : Ibu Irene

Nomor S.P.B	431 /BAS/DOP-PO/7-2016
Tanggal S.P.B	19-Jul-16
Srt. Permintaan Pnwrn	
Srt. Penawaran	PT.Benteng Anugerah S.
No. Surat Pnwrn	
Tanggal Pnwrn	

Alamat Pengiriman : Jl. Raden Patah no.99 Pungging Mojosari, Mojokerto

Waktu pengiriman : Segera, setelah melakukan konfirmasi ke PT. Benteng Anugerah Sejahtera via telephone.

Syarat-syarat Pembayaran sebagai berikut :

- DP 20%, BG Mundur 30 Hari Setelah invoice diterima

Transfer ke PT Benteng Anugerah S.

Keterangan :
- Nomor ini harus terlihat pada surat tagihan dan catatan - pengiriman barang;
- Penjual setuju untuk mengadakan, menjual sesuai dengan uraian dan syarat-syarat seperti yang telah ditentukan.
- Harga include Ppn

Kebutuhan Pemakaian untuk :

Batching Plant 3m

Kontak Person : Yunaini / Andre
Telephone : 0321-3717464 /
Fax :

No.	Jumlah	Satuan	Berat (Kg)	Jenis Barang	Harga / Kg	Harga Satuan	Jumlah
1	1	pcs	35.5	L 65 x 65 x6	6,642	Rp 235,800	Rp 235,800
2	4	pcs	104	CNP 100 x 50 x 3.2	8,692	Rp 226,000	Rp 904,000
3	4	pcs	1752	Plate 6 x 5' x 20'	6,700	Rp 2,934,600	Rp 11,738,400
4	2	pcs	103.5	Pipe, 2 1/2" x 4.2mm x 6000 Lg	7,923	Rp 410,000	Rp 820,000
5	6	pcs	87.84	Pipe, 1" x 2.8mm x 6000 Lg	8,933	Rp 142,000	Rp 852,000
			2082.84	* Harga Include PPN			
						Total	Rp. 14,550,200

Terbilang : **Empat Belas Juta Lima Ratus Lima Puluh Ribu Dua Ratus Rupiah**

PT. RIDLATAMA BAHTERA CONSTRUCTION

(Ir. Feri Sismianto)

Disetujui Distributor / Penjual
PT. Benteng Anugerah Sejahtera

(..................)

Setelah disetujui, harap ditanda-tangani, di cap perusahaan, selanjutnya di kirim kembali via fax ke nomor fax. tersebut diatas.

PT. RIDLATAMA BAHTERA CONSTRUCTION
Kantor Operasional : PERUM YKP PANDUGO I Jl. Penjaringan Timur VI/6 Surabaya Tlp. 031-8705232, Fax. 031-8795636
Kantor Pusat Workshop : JL. Raya Gunungmalang RT. 02 RW. 02 Kec. Suboh Kab. Situbondo Jawa Timur
Kantor Pemasaran : Grand Bintaro Blok C-5 Jl. Bintaro Permai Raya no.1 telp : 021-7372136 Fax : 021-7372163
Email : bahtera@rbc.co.id ; NPWP : 02.784.718.5-656.000

RBC

SURAT PEMBELIAN BARANG

Kepada Yth :

PT. Benteng Anugerah Sejahtera

Alamat : Jl. Tanjungsari No.44B, RT 001 RW 016
Simomulyo, Surabaya

Telephone : 031 7480101 ; 081-332440321 ; 0888-05147725

Fax : 031 7480777

Up. : Ibu Irene

Nomor S.P.B	: 427 /BAS/DOP-PO/7-2016
Tanggal S.P.B	: 19-Jul-16
Srt. Permintaan Pnwrn	:
Srt. Penawaran	: PT.Benteng Anugerah S.
No. Surat Pnwrn	:
Tanggal Pnwrn	:

Alamat Pengiriman : Jl. Raden Patah no.99 Pungging Mojosari, Mojokerto

Waktu pengiriman : Segera, setelah melakukan konfirmasi ke PT. Benteng Anugerah Sejahtera via telephone.

Syarat-syarat Pembayaran sebagai berikut :
- DP 20%, sisanya BG depan 30 hari
- Transfer : PT Benteng Anugerah Sejahtera

Keterangan :
- Nomor ini harus terlihat pada surat tagihan dan catatan - pengiriman barang;
- Penjual setuju untuk mengadakan, menjual sesuai dengan uraian dan syarat-syarat seperti yang telah ditentukan.
- Harga include Ppn

Kebutuhan Pemakaian untuk :

Workshop Tulunagung

Kontak Person : Yunaini / Andre
Telephone : 0321-3717464 /
Fax :

No.	Jumlah	Satuan	Berat (Kg)	Jenis Barang	Harga / Kg	Harga Satuan	Jumlah
1	220	pcs	8316	CNP 150 x 65 x 20 x 3	8,278	Rp 298,000	Rp 65,560,000
2	38	pcs	1483.92	L 75 x 75 x 6	6,752	Rp 278,200	Rp 10,571,600
3	4	pcs	468	Plate 5 x 4' x 8'	7,075	Rp 807,500	Rp 3,230,000
4	35	pcs	726.4	L 50 x 50 x 5	6,643	Rp 150,800	Rp 5,278,000
5	68	pcs	599.7	RB 16	8,271	Rp 77,500	Rp 5,270,000
6	90	pcs	516	RB 12	7,383	Rp 44,300	Rp 3,987,000
7	2	pcs	1026	Plate 22 mm x 4' x 8'	6,600	Rp 3,385,800	Rp 6,771,600
8	2	pcs	560	Plate 12 mm x 4' x 8'	6,450	Rp 1,806,000	Rp 3,612,000
9	2	pcs	466	Plate 10 mm x 4' x 8'	6,450	Rp 1,502,850	Rp 3,005,700
10	4	pcs	748	Plate 8 mm x 4' x 8'	6,450	Rp 1,206,150	Rp 4,824,600
11	2	pcs	140	Plate 3mm x 4' x 8'	7,100	Rp 497,000	Rp 994,000
			15050.02	* Harga Include PPN			
						Total	Rp. 113,104,500

Terbilang : **Seratus Tiga Belas Juta Seratus Empat Ribu Lima Ratus Rupiah**

PT. RIDLATAMA BAHTERA CONSTRUCTION

(Ir. Feri Sismianto)

Disetujui Distributor / Penjual
PT. Benteng Anugerah Sejahtera

(..................)

Setelah disetujui, harap ditanda-tangani, di cap perusahaan, selanjutnya di kirim kembali via fax ke nomor fax. tersebut diatas.

PT. RIDLATAMA BAHTERA CONSTRUCTION
Kantor Operasional : PERUM YKP PANDUGO I Jl. Penjaringan Timur VI/6 Surabaya Tlp. 031-8705232, Fax. 031-8795636
Kantor Pusat Workshop : JL. Raya Gunungmalang RT. 02 RW. 02 Kec. Suboh Kab. Situbondo Jawa Timur
Kantor Pemasaran : Grand Bintaro Blok C-5 Jl. Bintaro Permai Raya no.1 telp : 021-7372136 Fax : 021-7372163
Email : bahtera@rbc.co.id ; NPWP : 02.784.718.5-656.000

RBC

SURAT PEMBELIAN BARANG

Kepada Yth :

PT. Benteng Anugerah Sejahtera

Alamat : Jl. Tanjungsari No.44B, RT 001 RW 016
Simomulyo, Surabaya

Telephone : 031 7480101 ; 081-332440321 ; 0888-05147725

Fax : 031 7480777

Up. : Ibu Irene

Nomor S.P.B	432 /BAS/DOP-PO/7-2016
Tanggal S.P.B	20-Jul-16
Srt. Permintaan Pnwrn	
Srt. Penawaran	PT.Benteng Anugerah S.
No. Surat Pnwrn	
Tanggal Pnwrn	

Alamat Pengiriman : Jl. Raden Patah no.99 Pungging Mojosari, Mojokerto

Waktu pengiriman : Segera, setelah melakukan konfirmasi ke PT. Benteng Anugerah Sejahtera via telephone.

Syarat-syarat Pembayaran sebagai berikut :

- DP 20%, BG Mundur 30 Hari Setelah invoice diterima

Transfer ke PT Benteng Anugerah S.

Keterangan :
- Nomor ini harus terlihat pada surat tagihan dan catatan - pengiriman barang;
- Penjual setuju untuk mengadakan, menjual sesuai dengan uraian dan syarat-syarat seperti yang telah ditentukan.
- Harga include Ppn

Kebutuhan Pemakaian untuk :

Showroom Tulungagung

Kontak Person : Yunaini / Andre

Telephone : 0321-3717464 /

Fax :

No.	Jumlah	Satuan	Berat (Kg)	Jenis Barang	Harga / Kg	Harga Satuan	Jumlah
1	88	pcs	4297.74	Pipe 2 1/2"	8,014	Rp 410,000	Rp 36,080,000
2	105	pcs	2405.7	Pipe 1 1/2"	8,395	Rp 199,500	Rp 20,947,500
3	210	pcs	6528	C 125x50x20x3	7,531	Rp 241,000	Rp 50,610,000
4	105	pcs	529.65	RB Ø12mm	8,333	Rp 44,300	Rp 4,651,500
5	54	pcs	895.72	RB Ø22mm	8,052	Rp 147,200	Rp 7,948,800
6	2	pcs	730	Plate 5 mm x 5 x 20	6,850	Rp 2,500,250	Rp 5,000,500
7	4	pcs	2625	Plate 12 mm x 5 x 20	6,500	Rp 5,687,500	Rp 22,750,000
8	2	pcs	3208	Plate 22 mm x 5 x 20	6,649	Rp 10,666,000	Rp 21,332,000
9	2	pcs	466	Plate 10 mm x 4 x 8	6,550	Rp 1,502,850	Rp 3,005,700
10	3	pcs	1166	Plate 8 mm x 5 x 20	6,550	Rp 3,789,500	Rp 11,368,500
11	3	pcs	192	pipe 2"	7,904	Rp 258,000	Rp 774,000
			23043.81	* Harga Include PPN			
						Total	Rp. 184,468,500

Terbilang : Seratus Juta Delapan Puluh Empat Ribu Empat Ratus Enam Puluh Delapan Ribu Lima Ratus Rupiah

PT. RIDLATAMA BAHTERA CONSTRUCTION

(Ir. Feri Sismianto)

Disetujui Distributor / Penjual
PT. Benteng Anugerah Sejahtera

(..................)

Setelah disetujui, harap ditanda-tangani, di cap perusahaan, selanjutnya di kirim kembali via fax ke nomor fax. tersebut diatas.

PT. RIDLATAMA BAHTERA CONSTRUCTION

Kantor Operasional : PERUM YKP PANDUGO I Jl. Penjaringan Timur VI/6 Surabaya Tlp. 031-8705232, Fax. 031-8795636
Kantor Pusat Workshop : JL. Raya Gunungmalang RT. 02 RW. 02 Kec. Suboh Kab. Situbondo Jawa Timur
Kantor Pemasaran : Grand Bintaro Blok C-5 Jl. Bintaro Permai Raya no.1 telp : 021-7372136 Fax : 021-7372163
Email : bahtera@rbc.co.id ; NPWP : 02.784.718.5-656.000

RBC

SURAT PEMBELIAN BARANG

Kepada Yth :

PT. Benteng Anugerah Sejahtera

Alamat : Jl. Tanjungsari No.44B, RT 001 RW 016
Simomulyo, Surabaya

Telephone : 031 7480101 ; 081-332440321 ; 0888-05147725

Fax : 031 7480777

Up. : Ibu Irene

Nomor S.P.B	:	426 /BAS/DOP-PO/7-2016
Tanggal S.P.B	:	19-Jul-16
Srt. Permintaan Pnwrn	:	
Srt. Penawaran	:	PT.Benteng Anugerah S.
No. Surat Pnwrn	:	
Tanggal Pnwrn	:	

Alamat Pengiriman : Jl. Raden Patah no.99 Pungging Mojosari, Mojokerto

Waktu pengiriman : Segera, setelah melakukan konfirmasi ke PT. Benteng Anugerah Sejahtera via telephone.

Syarat-syarat Pembayaran sebagai berikut :
- DP 20%, sisanya BG depan 30 hari
- Transfer : PT Benteng Anugerah Sejahtera

Keterangan :
- Nomor ini harus terlihat pada surat tagihan dan catatan - pengiriman barang;
- Penjual setuju untuk mengadakan, menjual sesuai dengan uraian dan syarat-syarat seperti yang telah ditentukan.
- Harga include Ppn

Kebutuhan Pemakaian untuk :

Sillo AMP RBC

Kontak Person : Yunaini / Andre
Telephone : 0321-3717464 /
Fax :

No.	Jumlah	Satuan	Berat (Kg)	Jenis Barang	Harga / Kg	Harga Satuan	Jumlah
1	1	pcs	75	Plate 3,2 x 4'x 8'	6,900	Rp 517,500	Rp 517,500
2	10	pcs	3650	Plate 5 x 5' x 20'	6,850	Rp 2,500,250	Rp 25,002,500
3	1	pcs	117	Plate 5 x 4' x 8'	6,901	Rp 807,500	Rp 807,500
4	1	pcs	438	Plate 6 x 5' x 20'	6,700	Rp 2,934,600	Rp 2,934,600
5	1	pcs	729	Plate 10 x 5' x 20'	6,500	Rp 4,738,500	Rp 4,738,500
6	1	pcs	280	Plate 12 x 4' x8'	6,450	Rp 1,806,000	Rp 1,806,000
7	1	pcs	373	Plate 16 x 4' x 8'	6,550	Rp 2,443,150	Rp 2,443,150
8	2	pcs	160	Checkered Plate 3,2 x 4' x 8'	7,700	Rp 616,000	Rp 1,232,000
9	1	pcs	11	L 40 x 40 x 4	5,818	Rp 64,000	Rp 64,000
10	6	pcs	136.08	L 50 x 50 x5	6,649	Rp 150,800	Rp 904,800
11	11	pcs	390.5	L 65 x 65 x6	6,642	Rp 235,800	Rp 2,593,800
12	1	pcs	90.6	L 100 x 100 x 10	6,849	Rp 620,600	Rp 620,600
13	9	pcs	68.85	Pipe 1/2", thick 2.8 mm	11,373	Rp 87,000	Rp 783,000
14	9	pcs	135	Pipe 1", thick 3.2 mm	8,933	Rp 134,000	Rp 1,206,000
15	1	pcs	24.3	Pipe 1 1/2", Thick 3.5 mm	8,210	Rp 199,500	Rp 199,500
16	3	pcs	203.22	Pipe 3" , Thick 4.2 mm	7,603	Rp 515,000	Rp 1,545,000
17	3	pcs	216	Pipe 4", Thick 4.5 mm	10,583	Rp 762,000	Rp 2,286,000
18	1	pcs	158.4	Pipe 8", Thick 5.8mm	10,417	Rp 1,650,000	Rp 1,650,000
19	4	pcs	272	UNP 125x65x6	7,941	Rp 540,000	Rp 2,160,000
20	7	pcs	136.5	Hollow 60 x 30 x 2.3	8.410	Rp 164,000	Rp 1.148,000
21	5	pcs	47.5	RB Dia 16	8,158	Rp 77,500	Rp 387,500
22	1	pcs	1.35	RB Dia 6	8,667	Rp 11,700	Rp 11,700
			7713.3	* Harga Include PPN			
						Total	Rp. 55,041,650

Terbilang : **Lima Puluh Lima Juta Empat Puluh Satu Ribu Enam Ratus Lima Puluh Rupiah**

PT. RIDLATAMA BAHTERA CONSTRUCTION

(Ir. Feri Sismianto)

Disetujui Distributor / Penjual
PT. Benteng Anugerah Sejahtera

(..................)

Setelah disetujui, harap ditanda-tangani, di cap perusahaan, selanjutnya di kirim kembali via fax ke nomor fax. tersebut diatas.

PT. RIDLATAMA BAHTERA CONSTRUCTION

Kantor Operasional : PERUM YKP PANDUGO I Jl. Penjaringan Timur VI/6 Surabaya Tlp. 031-8705232, Fax. 031-8795636
Kantor Pusat Workshop : JL. Raya Gunungmalang RT. 02 RW. 02 Kec. Suboh Kab. Situbondo Jawa Timur
Kantor Pemasaran : Grand Bintaro Blok C-5 Jl. Bintaro Permai Raya no.1 telp : 021-7372136 Fax : 021-7372163
Email : bahtera@rbc.co.id ; NPWP : 02.784.718.5-656.000

AUTHOR BIOGRAPHY

The Author was born in Surabaya, August 24th, 1995 as the first oldest brother for two younger brothers, and held family name of Fiantara, and son from Ir. Hari Mujiantoro and Dra. Suci Alfiani. Started Formal education at Kebraon II state Elementary School, proceed to Surabaya 16 state Junior high school, and then continued to Surabaya 15 State Senior High School, and recently pursue bachelor degree in Marine Engineering at ITS-Hochschule Wismar Double Degree Program, based on Faculty of Marine Technology, ITS, Surabaya and specialized in Marine Operation and Maintenance field. Beside academic skill, author also have an experience on softskill and managerial capability. The author was the Head of ITS student photography association (2015-2016) and Internal Deputy Head of LMB ITS (2016-2017), also the chief of FANTASI (2015) and also General Manager Of PEKSIMINAL on Photography section (2016).

Datya Adyata Fiantara

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motto:

"Expect for the best, Prepare for the worst, and let God do the rest."

With us this is possible. With God everything is possible.