MAINTENANCE ACTIVITY AND SPARE PARTS OPTIMIZATION FOR CRITICAL SYSTEM ON MECHANICAL PLANT USING RELIABILITY CENTERED MAINTENANCE (RCM) AT PT. PERTAMINA GEOTHERMAL ENERGY KAMOJANG AREA

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Abstrak
The needs of the fuel energy in this world is increasing everytime.According to the projection of International Energy Agency –IEA, until 2030 world energy demand increased by 45% or an average point increase to 1.6% per year. The distribution of annual world energy consumption is 500 x 10 15 BTU/ year. The role of the renewable energy sources in electrical industry increasing continuesly. Projected from 2010, the rople of the renewable energy in electrical industry is sitting in the second position after the coal and hydro. In the other side the rising of the fossil fuel using is the trigger of the climate changes. That is why IEA is suggesting to use the clean and efficient energy to suppress the carbon emmision. The sources of renewable energy are solar energy, wind energy, water pump energy, geothermal energy, and biomass energy. Geothermal energy is an energy that is extracted from the heat that is kept in the earth. It is from the techtonical activities in the earth since the planet is made. The heat is also from the sun heat that is absorbed by the earth surface. Around 10 Gigawatt of geothermal electrical plant is placed around the world in 2007, and distributing around 0.3% of the total of electriocal energy in the world. Indonesia has 40% or 27.140 MW geothermal potential in the world. That is why geothermal energy is the best source of energy that is need to be invented in Indonesia. From the total of the potention, only 4.2% that is already used as the electrical energy. Pertamina Geothermal Energy (PGE),is a company of PT Pertamina (Persero),standing since 2006 and has already given an instruction from the governor to develop 15 Geothermal Companies in Indonesia. The new era of geothermal energy is started by the opening of Geothermal Kamojang field in 29th January 1983. PGE PLTP Kamojang Unit 4 has 1 PLTP unit installed with capacity 60 MW. PGE KMJ 4 maintenance task is mapped according ti the company's Key Performance Index target. There are come special critical equipments w hich are classified by PGE KMJ 4 maintenance division. The critical equipments are steam turbine, main condenser, and hotwell pump. All of those equipments have a vital role I the p roduction, so the maintenance task is needed in every critical equipment's parts. From the result of the research, those 3 equipments are in subsystem level 6 in the equipment hierarchy, it has 3 critical items. The critical components then processed using Reliability Cenetered Miantenance and RCM++ software for optimazing an effective and efficient maintenance activity in the time and cost side. Spare parts are divided into repairable and non - repairable spare parts. The spare parts availability is become a supporting role in this maintenance activity, so it can work simultaneously with RCM preventive task.According to the result of data processing in 3 critical subsystem components, it produces 47 tasks On Condition and 32 Failure Finding Tasks, with the va riation of interval. The proposed maintenance cost in 1 year is $17.242, it is reducing 13% from the existing maintenance cost. The non-repairable spare parts availability is 267 and the repairable spare parts availability is 8 In 1 year

Kata Kunci : Geot hermal, Reliability Centered Maintenance, Reliasoft, RCM++, Spare Parts

Abstract

The needs of the fuel energy in this world is increasing everytime.According to the projection of International Energy Agency –IEA, until 2030 world energy demand increased by 45% or an average point increase to 1.6% per year. The distribution of annual world energy consumption is 500 x 10 15 BTU/ year. The role of the renewable energy sources in electrical industry increasing continuesly. Projected from 2010, the rople of the renewable energy in electrical industry is sitting in the second position after the coal and hydro. In the other side the rising of the fossil fuel using is the trigger of the climate changes. That is why IEA is suggesting to use the clean and efficient energy to suppress the carbon emmision. The sources of renewable energy are solar energy, wind energy, water pump energy, geothermal energy, and biomass energy. Geothermal energy is an energy that is extracted from the heat that is kept in the earth. It is from the techtonical activities in the earth since the planet is made. The heat is also from the sun heat that is absorbed by the earth surface. Around 10 Gigawatt of geothermal electrical plant is placed around the world in 2007, and distributing around 0.3% of the total of electriocal energy in the world. Indonesia has 40% or 27.140 MW geothermal potential in the world. That is why geothermal energy is the best source of energy that is need to be invented in Indonesia. From the total of the potention, only 4.2% that is already used as the electrical energy. Pertamina Geothermal Energy (PGE),is a company of PT Pertamina (Persero),standing since 2006 and has already given an instruction from the governor to develop 15 Geothermal Companies in Indonesia. The new era of geothermal energy is started by the opening of Geothermal Kamojang field in 29th January 1983. PGE PLTP Kamojang Unit 4 has 1 PLTP unit installed with capacity 60 MW. PGE KMJ 4 maintenance task is mapped according ti the company's Key Performance Index target. There are come special critical equipments w hich are classified by PGE KMJ 4 maintenance division. The critical equipments are steam turbine, main condenser, and hotwell pump. All of those equipments have a vital role I the p roduction, so the maintenance task is needed in every critical equipment's parts. From the result of the research, those 3 equipments are in subsystem level 6 in the equipment hierarchy, it has 3 critical items. The critical components then processed using Reliability Cenetered Miantenance and RCM++ software for optimazing an effective and efficient maintenance activity in the time and cost side. Spare parts are divided into repairable and non - repairable spare parts. The spare parts availability is become a supporting role in this maintenance activity, so it can work simultaneously with RCM preventive task.According to the result of data processing in 3 critical subsystem components, it produces 47 tasks On Condition and 32 Failure Finding Tasks, with the va riation of interval. The proposed maintenance cost in 1 year is $17.242, it is reducing 13% from the existing maintenance cost. The non-repairable spare parts availability is 267 and the repairable spare parts availability is 8 In 1 year

Keywords : Geot hermal, Reliability Centered Maintenance, Reliasoft, RCM++, Spare Parts

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Chapter I Introduction

I.1 Background

The needs of the fuel energy in this world is increasing everytime.According to the projection of International Energy Agency – IEA, until 2030 the demands of fuel energy is increasing 45% or the average point is increasing to 1.6% each year. The distribution of using the fuel energy in the world is 500 x 10^{15} BTU/year.

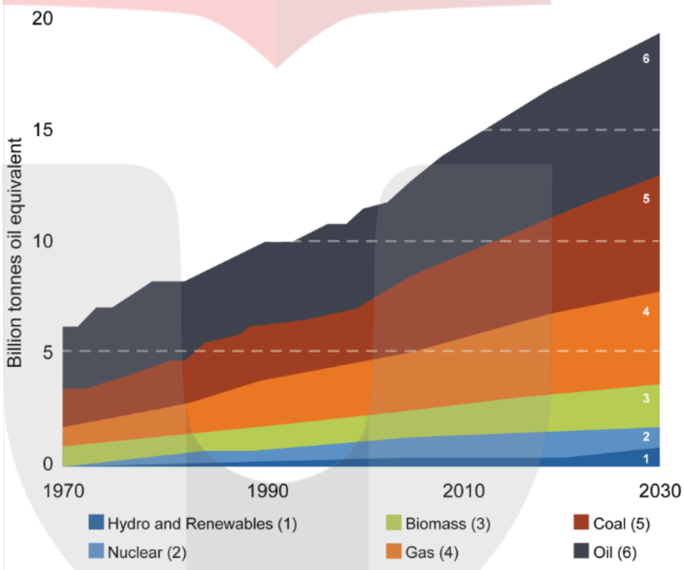

Figure I.1 Future Energy Needs
Source: International Energy Agency Outlook

After the Oil, the world energy is distributed by coal, gasoline, biomass, nuclear, hydro and renewables energy. The role of the renewable energy in electrical industry is increasing. Projected starting in 2010, the role of the renewable energy in electrical industry occupying the second position after the coal and hydro. On the other side the rising of the fossil fuel using is the trigger of the climate changes. That is why IEA recommends to using clean and efficient energy to reduce carbon emissions.

The sources of renewable energy are solar energy, wind energy, water pump energy, geothermal energy, and biomass energy.

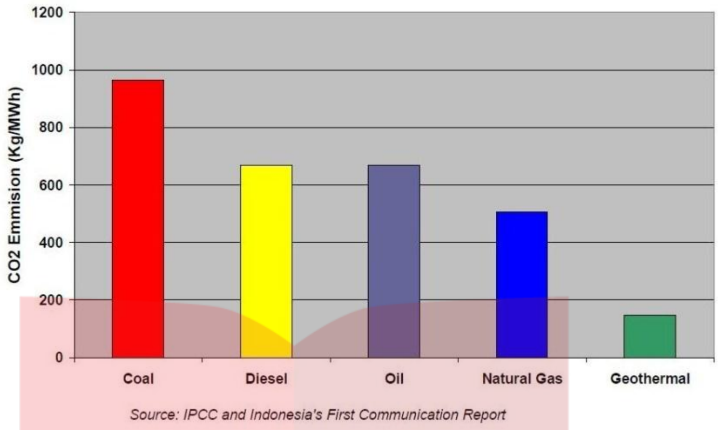

Figure I.2 The Content of Emission

Source: IPCC and Indonesia's First Communication Report 2009

Geothermal energy is an energy that is extracted from the heat that kept inside the Earth. It is from the techtonical activities in the earth since the planet was made. The heat is also from the sun heat that is absorbed by the earth surface.

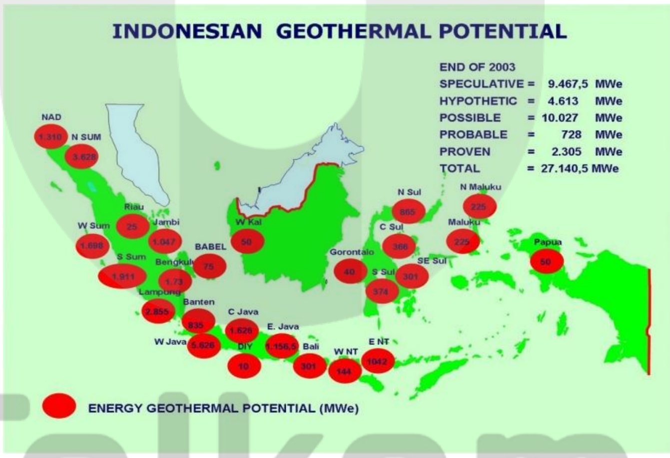

Figure I.3 Distribution of Potential Geothermal Indonesia
Source: Ministry of ESDM

About 10 Gigawatt of geothermal electrical plant have been installed around the world in 2007, and distributing about 0.3% of the total of electrical energy in the world. The geothermal energy is friendly to nature because the geothermal fluid, which is the heat energy changed into electrical energy, and the resiuade of the fluid will be returned to reservoir through injection well.

Indonesia has 40% or 27.140 MW geothermal potential in the world. That is why geothermal energy is the best source of energy that is need to be invented in Indonesia. From the total of the potention, only 4.2% that is already used as the electrical energy.

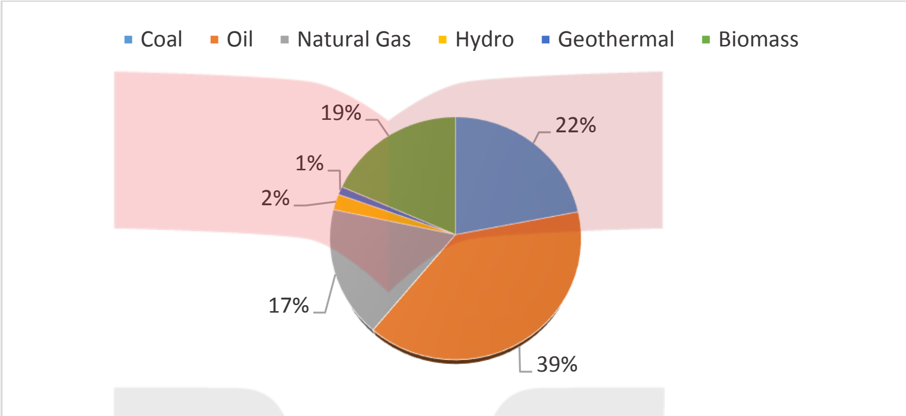

Figure I.4 Indonesian Electictry Production Type by Source
Source: Handbook of Energy & Economic Statistic Indonesia 2012

Pertamina Geothermal Energy (PGE), is a company of PT Pertamina (Persero), standing since 2006 and has already given an instruction from the government to develop 15 Geothermal Companys in Indonesia. The new era of geothermal energy is started by the opening of Geothermal Kamojang field in 29th January 1983. PLTP Kamojang unit 4 is one of the plant owned by PGE, the location of it is 41 kms south east of Bandung, where in Kecamatan Ibun, Kabupaten Bandung, West Java. PGE PLTP Kamojang Unit 4 has 1 PLTP unit installed with capacity 60 MW.

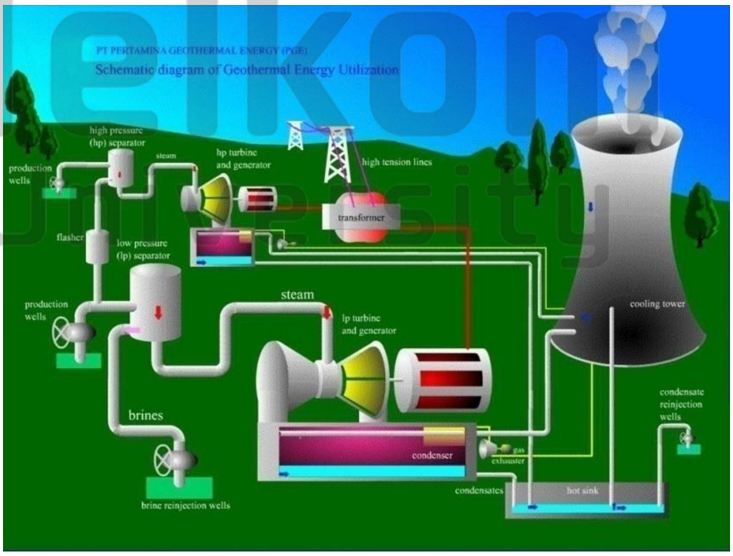

Figure I.5 The Flow of the Production Process
Source: Pertamina Geothermal Energy 2013

In figure I.5 can be seen the flow of electrical production process in PGE KMJ 4. Production began when the steam inside the earth running through the pipes in every wells, then head scrubber for separate the steam with other materials such as other gas or material which is brought along the steam from the earth that can make a corrosive. While the solid and liquid fluid will be injected back to the earth. After that, the steam will flow to the steam turbine to convert the heat of the steam into mechanical energy then distribute it to the plant to change it into the electrical energy. The steam pressure entering the steam tribune is 1.02 Mpa with temperature 181°C. Next the fluid from the steam tribune will be supplied to the condencer to be converted from the steam into water. And others than the water steam will go to the gas removal system to eliminate it. The water from the condencer will be injected to the earth and the others will be pumped using the hotwell pump to the cooling tower to be cooled. Then the water will flow back again to the condencer which is used to change the steam from the steam turbine into water. This production is working 24 hours every day.

A plant using continuously for 24 hours a day and 7 days a week, it must be in a good condition to produce the electric. This thing is based from the Key Priority Index (KPI) from PGE KMJ 4 as the minimum standard of electric production. So, the maintenance division and production division must have a standard operational procedure according to the company's KPI. One of the maintenance division strategys is classifying the critical equipments so it will get a special treatment. The critical equipment has a big role in the production in power plant, so it will need a special treatment and the right way, so the critical equipments can work properly.

Table I.1 MPI PGE Area Kamojang PLTP Unit 4

Rank	Equipment	Score MPI	Critical Index
242	Main Oil Tank	245,2987	3
243	LRVP	265,4376	
244	Cooling Tower	396,0519	

245	Hot Well Pump	514,0873	2
247	Condenser	665,2175	1
249	Steam Turbine	689,5133	

From all of the mean equipments on table above, the company have already classified the mean equipments according to the critical index. The company has the Maintenance Priority Index (MPI), by classifying the critical level into 5 parts. Which are Ring 1, 2, 3, 4, and 5. The Parameters that build the MPI are safety, maintenance cost, environment, the failure effect, ramp rate influence and the recovery time.

With this thing, the research will focus on the 3 critical equipments and the supporting equipments. These equipments will be classified in sub system according to the System Breakdown Structure in figure I.6.

That is why it needs an effective and efficient maintenance activities according to the failure charactertistic in every 3 sub system components by using Reliability Centered Maintenance method. To make the managing of the management assets easier is by using the software reliasoft RCM++.

In deciding the optimal machine maintenance policy, considering the reliability by using the RCM method supported by counting the needs of spare parts. Counting the spare parts is to know how many repairable spare parts and non-repairable spare parts to support the maintenance activities. To decide the right needed spare parts is by using Poisson Distribute as the accurate fortelling technique (Fukuda, 2008). Poisson distribute is same with the purpose of the research, which is deciding the total of the needed repairable and non-repairable spare parts.

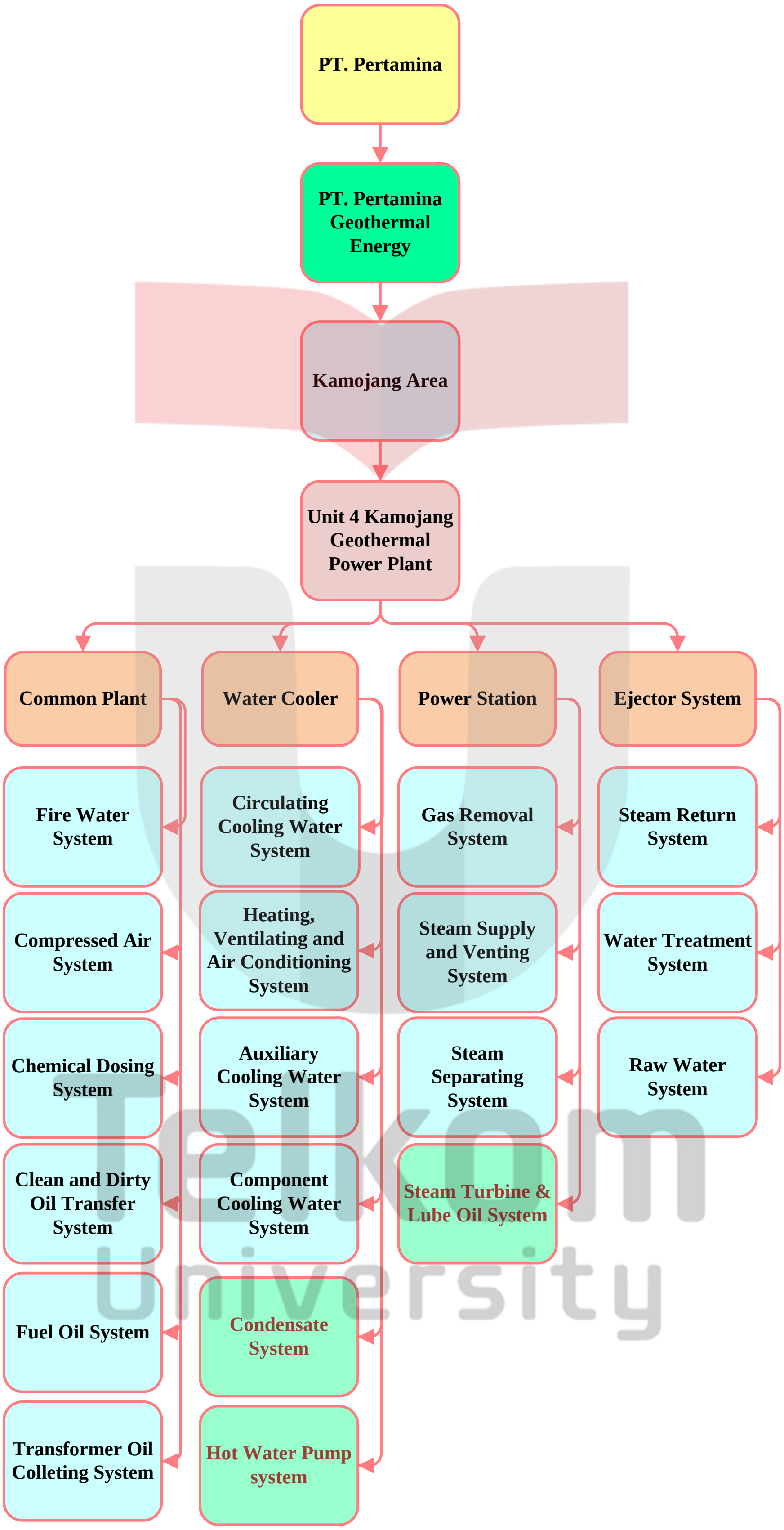

Figure I.6 System Breakdown Structure

I.2 Problem Formulation

The problem formulation in the final project research is :

1. How the equipment hierarchy in the PGE KMJ critical sub system by using the System Breakdown Structure (SBS)?
2. How the critical components in the PGE KMJ 4 critical sub system by using matrix risk?
3. How the optimal maintenance policy in PGE KMJ 4 critical sub system by using Reliability Cenetred Maintenance (RCM)?
4. How the maintenance policy using Reliasoft RCM++ in PGE KMJ 4 critical sub system?
5. How to deicide the optimal total of the spare parts from PGE KMJ 4 critical sub system based on the Reliability Centered Maintenance (RCM)?

I.3 Research Objective

Based on the problem formulations above, so it can be decided the purpose of the research, as follows :

1. Building a hierarchy of sub critical systems equipment the PGE KMJ 4 by using the System Breakdown Structure.
2. Determine the critical part of the PGE KMJ 4 critical sub system equipment by using risk matrix.
3. Make the optimal maintenance policy in PGE KMJ 4 critical sub system by using Reliability Centered Maintenance method.
4. Make the maintenance policy by using Reliasoft RCM++ in PGE KMJ 4 critical sub equipment.
5. Specifies the number of the component spare parts of PGE KMJ 4 critical sub system based on the output of Reliability Centered Maintenance (RCM).

I.4 Problem Boundaries

The problem limitations of this research are :

1. The technical aspect in maintenance activities such as repairing the components, attaching it, or reconstruct the machine, these all do not include in the discussion.

2. The research conducted only in the critical components from PGE KMJ 4 critical sub system.
3. The period of used data is from 2009 until 2013.
4. The data were not obtained using assumptions.

I.5 Research Advantage

The advantage of the research in this final project are :

1. Pertamina Geothermal Energy Kamojang area of policy evaluation can determine the treatment that was applied to the company.
2. Pertamina Geothermal Energy Kamojang area can determine optimal interval of PGE KMJ 4 critical sub system components maintenance based on the academic calculation by considering the factors of failure, reliability, and the maintenance cost.
3. Pertamina Geothermal Energy Kamojang area may know the optimal total number of the spare parts for the PGE KMJ 4 critical sub system components based on the academic calculation.
4. Pertamina Geothermal Energy Kamojang area can documented the management assets by using the Reliasoft RCM++.
5. Pertamina Geothermal Energy Kamojang area can determine the comparison cost ratio between existing maintenance policy and proposed maintenanance policy.

I.6 Writing Systematic

The research is described into these writing systematic :

Chapter I Introduction

In this chapter is containing about the explanation of the research background, the problem formulation, the purpose of the research, the research limitations, the results of the research, and the writing systematic.

Chapter II **Theoritical Basis**

In this chapter is containing about the relevant literate with the researched problem. The things that become the base of the research are maintenance management, Reliability Centered Maintenance, Rick Matrix, Reliability and Availability.

Chapter III **Research Methodology**

In this chapter is explaining detailed steps of the research, such as the step of making the problem formulation, improving the conceptual model and solving problem systematic.

Chapter IV **Data Collective and Data Processing**

In this chapter is containing of the processing data whether it is quantity or quality from the data obtained from the interview or historical, such as existing machine maintenance activities data and operating and maintenance cost data. Next is the making of the equipment hierarchy, deciding the critical equipment by using the risk matrix, processing RCM, the failure items data processing, maintenance interval time, cost control, and the optimal total of spare parts.

Chapter V **Analysis**

In this chapter is analyzing the results of the data processing from the previous chapter.

Chapter VI **Conclusion and Suggestion**

In this chapter is containing the conclusion and the suggestion of the research for the next research.

Chapter VI Conclusion and Suggestion

VI.1 Conclusion

1. After built the PGE KMJ 4 System Breakdown Structure, so it can be obtaine the 3 critical equipments, they are steam turbine, main condenser, and hotwell pump in level 7. In the next level were described that in level 8 there are 30 sub equipments. The next level is level 9, there are 24 components. Those sub equipments and components will be processed by using the risk matrix in the next process to obtain the critical components.
2. After some discussion with PGE KMJ 4 maintenance staffs, next is arranging the tools to choose the critical sub equipments and components for the research. Risk matrix is a tool that is used to choose the critical sub equipments and components. Below is the critical sub equipments and components :

Table VI.1 Critical Part

SUB EQUIPMENT	COMPONENT	EQUIPMENT	SUB EQUIPMENT
BEARING	MOP	OIL SUPPLY	MAIN OIL PUMP
	THRUST BEARING		AUXILIARY OIL PUMP
	JOURNAL BEARING		EMERGENCY OIL PUMP
ROTOR	STASIONARY BLADE		OIL PURIFIER
	MOVING BLADE	SAFETY VALVE	MAIN STOP VALVE
COUPLING	TURBINE GENERATOR COUPLING		MAIN CONTROL VALVE
	MOP COUPLING	VALVE (CND)	B'FLY VALVE
GLAND PACKING	FRONT GLAND PACKING		BALL VALVE
	REAR GLAND PACKING		VENT VALVE
CASING	CASING		DRAIN VALVE
	RUPTURE DISC	VALVE (HWP)	CHECK VALVE
CASE/BODY	SHELL		B'FLY VALVE
	HOTWELL		DRAIN VALVE
	WATER BOX		FLOW CONTROL VALVE
TUBE	TUBE SHEET		VENT VALVE

	TUBE		SUCTION VALVE
EXPANSION JOINT	EXP.JOINT TRB		
	EXP.JOINT HWP		
MOTOR	MECH OF MOTOR		
PUMP	HYDRAULIC		
	MECH OF PUMP		
	INLET		
	OUTLET		

3. Reliability Centered Maintenance (RCM) is used to decide the right preventive maintenance activity for the critical equipments. According to the result of RCM, there are some new maintenance policy. There are 47 scheduled on condition and 32 failure finding tasks. Here is Figure VI.1. which is containing of the description of proposed maintenance type for critical equipments.

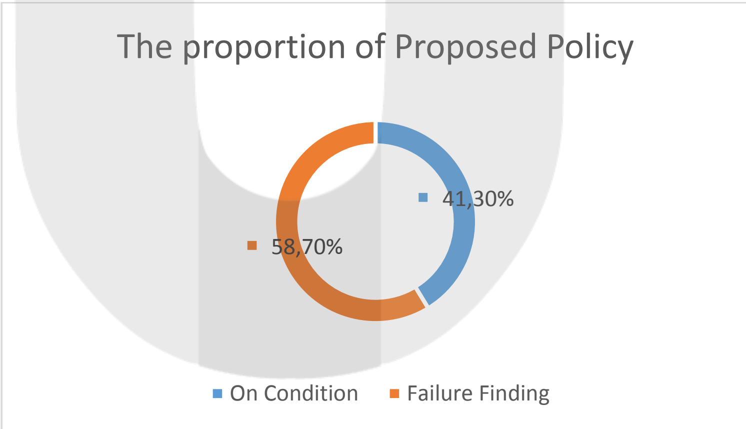

Figure VI.1 Conclusion Percentage Maintenance Task Proposed

Table VI.2 Conclusion Maintenance Task On Scheduled Proposed

Maintenance Type	Task Duration (1 Year)
On Condition 2W	8
On Condition 1M	17
On Condition 2M	11
On Condition 3M	11
TOTAL	47

Table VI.3 Conclusion Maintenance Task Failure Finding Proposed

MAINTENANCE TYPE	TOTAL TASK LIST
FAILURE FINDING (2Y)	4
FAILURE FINDING (3,7Y)	5
FAILURE FINDING (4,2Y)	2
FAILURE FINDING (4,7Y)	2
FAILURE FINDING (6,8Y)	14
FAILURE FINDING (7,6Y)	2
FAILURE FINDING (56,2Y)	2
TOTAL	31

4. Task classification according to the typical condition, it is in ON or not in the RCM++ output down condition. Below is the description :

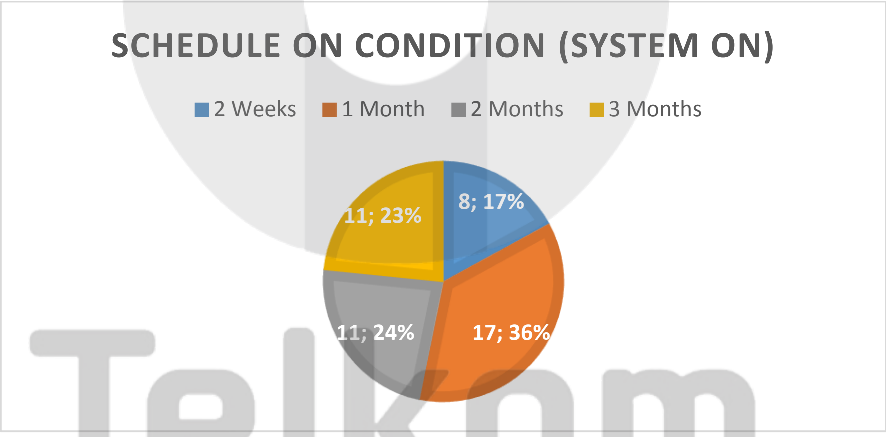

Figure VI.2 Conclusion Task On Condition of RCM ++

And the task list that make the system must be in the system condition and item down is described below :

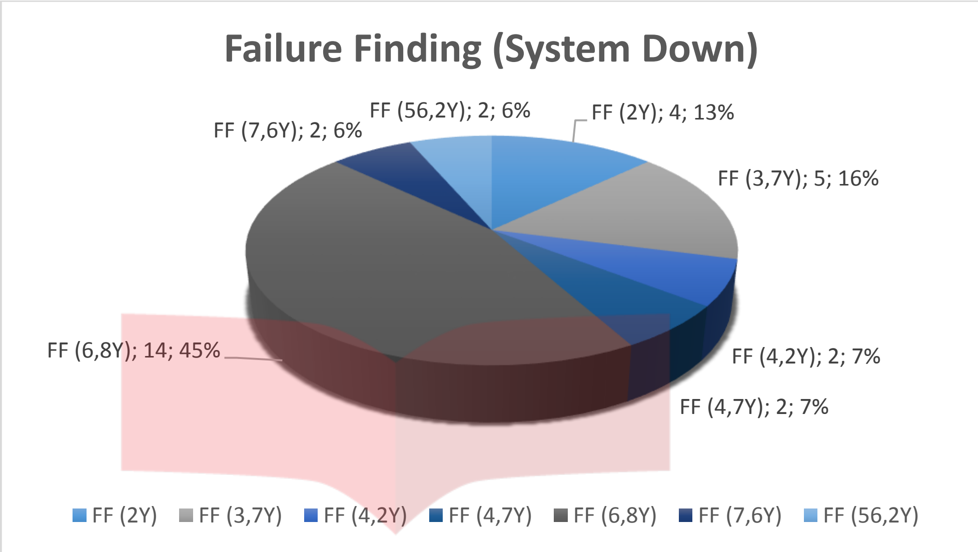

Figure VI.3 Conclusion Task Failure Finding of RCM ++

The comparison of the system down or not task can be seen below :

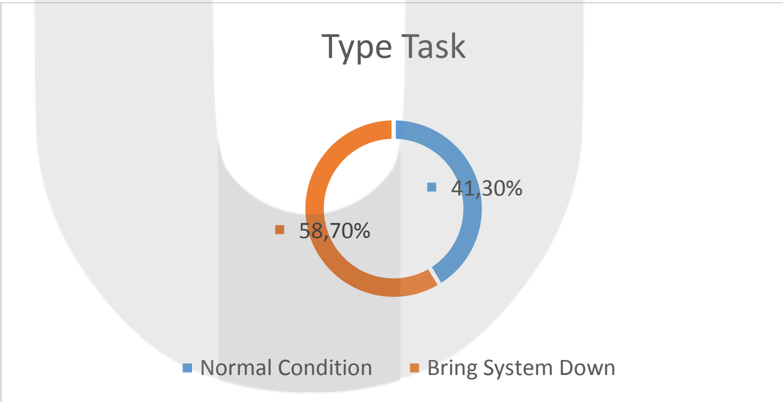

Figure VI.4 Conclusion Percentage Maintenance Task Proposed

5. The optimal number of repairable and non-repairable spare parts for PGE KMJ 4 critical equipments for a year is :

Table VI.4 Conclusion Require of Repairable Spare Parts

NO	COMPONENT	Stock
1	JOURNAL BEARING	2
2	MAIN STOP VALVE	2
3	MAIN CONTROL VALVE	2
4	MOTOR OF PUMP	2

Table VI.5 Conclusion Require of Repairable Spare Parts

	THRUST BEARING	Stock	30	OIL SEAL TB 50-95-14	2
1	FLUSHING STRAINER 200 MESH	2	31	RF GASKET 10K-150	3
2	FLUSHING STRAINER 250 MESH	2	32	TOUNGED WASHER M16	7
3	RTD (THRUST FRONT)	1	33	TOUNGED WASHER M10	9
4	THRUST BEARING 53407U	1	34	GASKET 10K-15	1
5	TONGUED WASHER M36	13	35	METAL GASKET 2*32*17	3
6	CLAW WASHER M30	4	36	METAL GASKET 2*32*9	2
	JOURNAL BEARING		37	GASKET 10K-15 JIS	2
7	FLUSHING STRAINER 200 MESH	3		MAIN CONTROL VALVE	
8	FLUSHING STRAINER 250 MESH	3	38	GASKET	2
9	RUPTURE DISC (NO.1 BEARING)	1	39	TONGUED WASHER M12, SUS	2
	COUPLING		40	TRUST WASHER	4
10	T/G SPANNER	5	41	GREASE NIPPLE R 1/4 FOR JIS	4
	GLAND PACKING		42	OIL SEAL TB 80-105-13 F ROTATING PISTON	2
11	PACKING ST786202C2	5	43	THRUST BALL BEARING 51205 JIS B 1532	2
12	LEAD PLATE ST758322	12	44	RUBBER PACKING D5 X 1290 KHS675-06C1	2
	MAIN OIL PUMP			CONDENSER	
13	JRNL BRNG W/ MCHNG ALWNC	0	45	30" RUPTURE DISC ASSEMBLY RD SP	1
14	CMBNTN BRNG W/ MCHNG ALWNC	0	46	GASKET ; FOR SHELL MANWAYS (C21)	1
	AUXILIARY OIL PUMP		47	GASKET : FOR HOTWELL MAN WAYS (C22)	0
15	BALL BEARING #7308BDB	0	48	30" RUPTURE DISC ASSEMBLIES W GASKETS	0
16	COUPLING RUBBER, NBR	12	49	GASKET 1/8" THK X 24" X 40" OUTSIDE 20" X 36"	1
17	DOUBLE WASHER M16	37	50	GASKET 30' X30"	1
18	DOUBLE WASHER M12	7	51	GASKETS 16"X20"	0
19	IMPELLER WASHER, SPCC	0		HOTWELL PUMP	
	EMERGENCY OIL PUMP		52	LOWER SHAFT	0
20	BALL BEARING #7308BDB,	1	53	INTERMEDIATE SHAFT	0
21	COUPLING RUBBER, NBR	12	54	IMPELLER DOUBLE ENTRY	0
22	DOUBLE WASHER M16	37	55	IMPELLER WEARING RING	0
23	DOUBLE WASHER M12	7	56	CADING WEARING RING	4
24	IMPELLER WASHER, SPCC	0	57	CUTLESS PUBBER BEARING 1	0
	MAIN STOP VALVE		58	CUTLESS PUBBER BEARING 2	1
25	GASKET 10K-15	2	59	RUBBER STRING PACKING	25
26	GREASE NIPPLE PT 1/4	3	60	MECHANICAL SEAL	0

27	GASKET	2	61	METAL SLEEVE	9
28	SPIRAL WOUND GASKET	2	62	RIGRID COUPLING	0
29	GREASE NIPPLE	3	63	SHELL COUPLING	0

IV.2.1 Suggestion for PGE KMJ 4

1. It should be better the PGE KMJ 4 in failure recording or operational failure has a detailed records and systematically record for every component and the system, and give the special attention for the recording. This will make the maintenance staffs easier in understanding the Failure components characteristic and in the next periode of maintenance activity.
2. In planning the maintenance activities such as the determining of the right maintenance intervals, it should be the company is coordinating with the production, administration, and maintenance division so it will make the type of maintenance easier. The first maintenance step is checking the characteristic of Failure components, so it can minimize the total of the Failure.

IV.2.2 Suggestion for The Next Research

1. Calculating the truly MTBF value and the interval when there is enough failure record from SEGWWL to be calculated using AVSIM+ software, because the result will be more accurate than using the OREDA data.
2. Updating the RCM++ software, so it can be more maximum in obtaining the RCM processing result using Reliasoft RCM++.
3. Try to using other software about RCM and spare parts optimization.

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