BAB III

METODE PENELITIAN

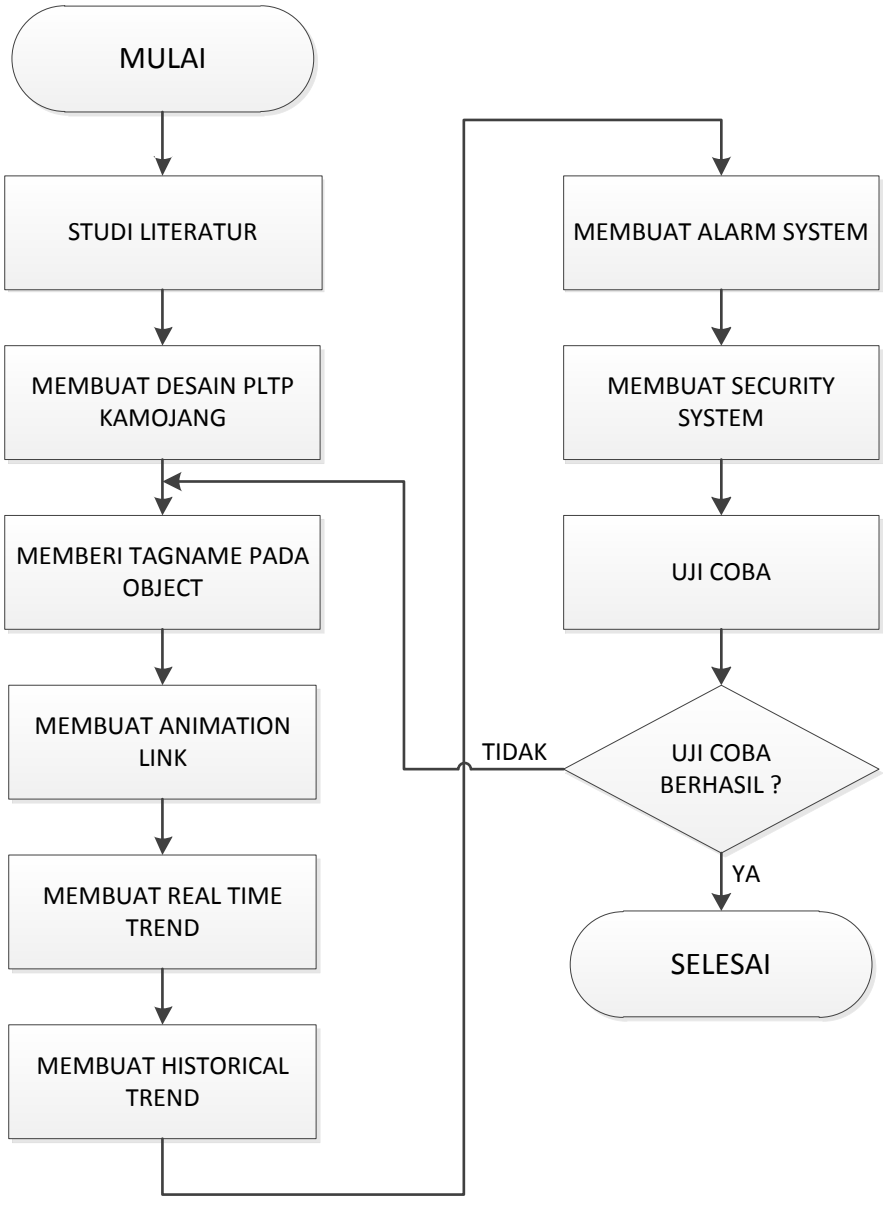
1.1 Prosedur penelitian

Prosedur dalam melakukan penelitian terdiri dalam beberapa langkah, yaitu langkah *pertama* melakukan studi literatur dari berbagai sumber terpercaya seperti jurnal internasional, data teknis perusahaan, laporan teknik perusahaan, dll. Langkah *kedua* yaitu setelah mendapatkan data yang cukup mengenai PLTP Kamojang maka selanjutnya membuat desain *SCADA* virtual PLTP Kamojang dari flow diagram yang telah ada di PT. Indonesia Power UBP Kamojang dengan menggunakan software Wonderware Intouch 10.0. Langkah *ketiga*, memberikan *tagname* kepada masing-masing object di desain *SCADA* tersebut. Langkah *keempat* yaitu membuat *animation link* pada setiap object agar ketika di *run time* akan terlihat hidup sepertii dengan keadaan real dilapangan.

Setelah membuat *animation link*, langkah *kelima* membuat *sript real time trend* yang menampilkan grafik secara *real time*. Kemudian langkah *keenam* membuat *historical trend* yang menampilkan grafik peristiwa yang terjadi di masa lampau dalam waktu tertentu. Langkah *ketujuh* membuat *alarm system* yang akan menunjukan indikasi adanya perubahan keadaan yang tidak aman pada sistem. Langkah *kedelapan* membuat *security system*. *Security system* bertujuan untuk menjaga sistem dari kesalahan kerja operator yang tidak sesuai dengan *set point system* yang telah dibuat. Langkah selanjutnya yaitu melakukan uji coba pada system mulai dari *historical trend, real time trend, alarm system* dan *security system* apakah bekerja sesuai yang diinginkan atau tidak. Apabila ada fungsi yang tidak berkerja, maka kembali ke langkah ketiga yaitu memberi tagname dan mengikuti langkah selanjutnya hingga sistem bekerja sesuai yang dinginkan.

1.2 Flowchart Penelitian

Untuk memudahkan dalam memahami langkah-langkah yang dilakukan penelitian, maka prosedur penelitian tersebut ditunjukkan dalam sebuah flowchart sebagai berikut :



Gambar 1.1 Flowchart Penelitian

1.3 Data Teknis

Adapun spesifikasi teknis peralatan yang digunakan PLTP kamojang sebagai berikut :

Tabel 1.1 Spesifikasi teknis peralatan PLTP Kamojang

No.	Data	Keterangan
1.	***Steam Receiving Header***	
	Quantity	1 *Set*
	Type	*Cylindrical Shell*
	Size	1800 A Dia. X 19 M
	Material	
	Main Header & Nozzle	API-5L, *Grade* B
	Reinforcing Plate	JIS SB42
	Pressure	
	Maximum	10.15 Barg
	Normal	6.00 Barg
	Temperature	
	Maximum	205 ˚C
	Normal	170 ˚C
2.	***Separator***	
	Quantity	2 Set
	Type	*Cyclone. Vertical Type*
	Manufacturer & Model No.	Burgess-Miura Co. LTD.
	Material	ASTM A516-70
	Design Pressure	1 Mpa
	Design Temperature	205 ˚C
	Design Steam Flow Rate	120 Kg/Sec
3.	***Demister***	
	Type	*Vertical Type*
	Quantity	One (1)/UNIT
	Design Steam Flow	408.0 T/H (899,485 1b/H)
	Inside Diameter Of Shell	2200 mm (86.61")
	Height	5990 mm (235.82")
	Thickness Of Shell	22 mm (0.87")
	Materials	
	Shell & Head	JIS SB42
	Separator Element	JIS SUS304

	Nozzle Neck	JIS STPT38/SB42
	Internal	JIS SUS304, JIS SB42
	Design Pressure	11 bar.a (11.2 kg/cm^{2}a)
	Design Temperature	205 ˚C (401 ˚F)
	Normal Operating Pressure	6.5 bar.a (6.6 kg/cm^{2}a)
	Normal Operating Temperature	161.9 ˚C (323 ˚F)
	Capacity	*Approx.* 19.5 m^3
4.	***Steam Turbine***	
	Type of Turbine	*Impulse and reaction double flow condensing turbine*
	Number of set	*Two* (2)
	Maximum continuous rated output (at generator terminal)	55,000 kW
	Maximum capability (at generator terminal)	57,750 kW
	Rated speed at turbine	3,000 rpm
	Rotating Direction	clockwise
	Rated steam pressure at emergency stop valve inlet	6.5 bar abs
	Rated steam temperature at emergency stop valve inlet	161.9 ^{o}C (Sat.)
	Design Pressure for MSV and main steam piping upto MSV	10.15 bar g
	Design pressure for GV and steam pipng upto MSV	7 bar g
	Design pressure for steam pipng after GV	6.86 bar g
	Design temperature for main steam piping	205 ^{o}C
	Rated condenser vacum	0.10 bar abs
	Number of stages	*Double flow of* 5 *stages*
	Stage inlet pressure	
	1st stage	6.31 bar abs
	2nd stage	2.53 bar abs
	3rd stage	0.90 bar abs
	4th stage	0.46 bar abs
	5th stage	0.24 bar abs
	Last stages dimension	
	Blade height	584.2 mm
	Mean diameter	1955.8 mm
	Critical speed	

	1st	1,700 rpm	
	2nd	3,600 rpm	
	Inertia moment GD2 including generator	26,700 kg-m2	
	Barring gear data		
	Turbin rotor revolution	3 rpm	
	Driving motor capacity and revolution	5.5 kW x 1,500 rpm	
	Lifting weight		
	Upper casing	34,000 kg (*including lifting gear*)	
	Rotor	22,000 kg (*including lifting gear*)	
	Steam consumption		
	Output	55,000 kW	
	Main steam flow	388,300 kg/H	
	Geothermal gas flow	1,942 kg/H	
	Steam pressure at main stop valve inlet	6.5 bar abs.	
	Steam temperature at main stop valve inlet	161.9 °C	
	Back pressure at exhaust flange	0.10 bar abs.	
	Power factor	0.80	
	Max capability		
	Output	57,750 kW	
	Power factor	0.84	
	Steam pressure at main stop valve inlet	6.82 bar abs.	
	Steam temperature at main stop valve inlet	163.9 °C	
	Back pressure at exhaust flange	0.104 bar abs	
5.	***Generator***		
	Continuous output at 0.8 pf lagging	68750 kVA	
	Terminal voltage	11800 kV	
	Excitation voltage at 0.8 pf lagging	194 V	
	Excitation current at 0.8 pf lagging	999 A	
	Excitation voltage on open circuit	54 V	
	Excitation current on open circuit	344 A	
	Open circuit transient time constant	7.10 s	
	Short circuit transient time constant	1.07 s	
	Efficiency at :	*Unity* p.f	*Rated* p.f
	(a) Overloud capability condition (57,75 MW)	98.83%	-
	(b) Nominal Rating (55 MW)	98.82%	98.47%
	(c) 80% (44 MW)	98.70%	98.41%

(d) 60% (33 MW)	98.45%	98.21%
(e) 40% (22 MW)	97.90%	97.70%
(f) 20% (11 MW)	96.12%	95.98%
(g) 10 % (5.5 MW)	92.67%	92.46%
Reactances :	*At rated voltage*	
Deirect axis sub transient	17.30%	
Quadrature axis sub transient	17.00%	
Direct axis transient	19.00%	
Quadrature axis transient	116.50%	
Negative sequence	17.20%	
Zero sequence	4.90%	
Synchronous	208%	
Short circuit ratio	0.52	
Inertia constant	1.36 kW. s/kVA	
Stator		
Length of core	2800 mm	
Internal diameter of core	970 mm	
Air gap	45 mm	
Core material	*High grade cold rolled silicon steel pole*	
Type of slot	*Open*	
No. of slot	48	
Stator coil slot pitch	19/24	
Conductor per slot	2	
Type of winding	*Lap winding*	
Dimensions of copper forming conductor	2.0 x 10.8 (*Strand*)	
Cross section of one conductor	1193 mm2	
Insulation		
Class	B	
Material in slot	*Mica tape with epoxy resin*	
Material on overhang	*Mica tape with epoxy resin*	
Min. Thickness :		
to earth	2.55 mm	
between turns in slot to overhang	-	

between turns in slot	-
Stator end shield material	*Silicon steel* pole
Winding capacitance	0.238 µF/phase
Winding resistance	0.00305 Ω/fasa (75^{o} C)
Rotor	
Rotor winding resistance	0.174 Ω (at 75^{0} C)
Length of motor body	2825 mm
Length over winding	3729 mm
Length over end ring	3973 mm
Space required for removal	Straight : 13,620 mm
	45˚ *Axis* : 8.891 x 4,800 mm
Material of end ring	*Mn-Cr Alloy forging*
Packing material under end ring	*Epoxy glass laminated insulating plate*
Length between centre line of bearings	5,800 mm
Diameter of rotor body	880 mm
No. of winding slots	28
Conductor per slot	19
Section of conductor	211 mm^2
Slot wedge material	*Al alloy*
Insulation on winding	*Epoxy glass laminated insulating plate*
Insulation in slot	*Mica sheet*
Minimum thickness :	
to earth	1.0 mm

	between turns in slot	0.2 mm
6.	***Exciter***	
	Exciter rated capacity	250 kW
	Exciter speed	3000 rpm
	Exciter rated voltage – d.c	240 V
	Exciter rated current – d.c	1042 A
	Exciter ceiling voltage – d.c no load	440 V
	Exciter ceiling voltage – d.c at rated current	440 V
	Frequency	200 Hz
	Stator insulation class	F
	Rotor insulation class	B
	Sailent pole field	*Yes*
	Main field resistence at 75^0 *C*	5.06 Ω
	Field current, no load on generator	3.1 A
	Field current, MCR load generator	10.2 A
	Field time constant	1.3 s
	Diode manufacturer	*Mitsubishi electric*
	Diode type	*Stad*
	Diode rating	DC 240 A/pc
	Diode connecting	Graze, *fullwave*
	Diode per arm	3
	Number of diodes per arm required for generator	2
	Diode protection	*Fuse*
	Pilot exciter for brushless exciter	
	Manufacture	Mistubishi electric
	Type	PMG
	Frequency	300 Hz
	Rated capacity	4.75W
7.	***Transformator***	
	No. Of Phase	3
	Rated Frequency (Hz)	50
	Normal Voltage	11.8/155
	Highest System Voltage (kV)	13.8/170
	Continuous Maximum Rating (MVA)	70
	Type of Cooling	ONAN
	Impedance Voltage	13%
	Vector Group	Yd5

	Transformator Ratio Control Type	*On-Load Automatic*
	Range Variation of Ratio	
	Terminals HV Side LV Side	*Bushings*
		Bushings
8.	***Condenser***	
	Type of condenser	*Direct contact condenser with spray type main condensing part and cascade type gas cooling part*
	Number of set	*one* (1)
	Design vacuum	0.10 bar abs
	Kind of cooling water	*Recirculating water*
	Design cooling water temperature	27 °C
	Hot water temperature	42.8 °C
	Quantity of cooling water	11,800 m^3/hr
	Exhaust steam quantity	376,910 kg/hr
	Geothermal gas quantity	1,885 kg/hr
	Rated steam enthalpy	2,219 kJ/kg
	Gas outlet temperature	29 °C
	Internal volume of condenser	285 m^3
	Internal volume of gas cooler	164 m^3
	Spray nozzle nominal diameter	50 mm
	Number of spray nozzle	528 (42 *BLIND NOZLLES*)
	Minimum requaired spray head	2 mAq
	Spray water head at cooling water inlet	9.04 mAq
	Maximum permissible solid particle size for nozzle	10 mm
	Number of gas cooler tray	3 stages x 2
	Maximum permissible solid particle size for tray	3 mm
	Cooling water inlet pipe number	1
	size	1,320.8 mm ø.D. x 8 mmt
	Hot water outlet pipe number	2
	size	1,524 mm ø.D. x 10 mmt
9.	***Main Cooling Water Pump***	
	Duty	

Fluid	*Geothermal Condensate Water*
Temperature	42.8 ˚C (max 70 ˚C)
Minimum NPSH available	5.7 m
Design Discharge Head	32 m (*Total Head*)
Design Flow Rate	6850 m3/hr
Description	
Type of pump	*Vertical Pit Barrel type Double Suction Centrifugal*
Number of stages	1
Manufacturer & Model No.	YOSHIKURA KOGYO CO., LTD.
Number Suplied	2 x 2 Units
Number Required for Full Duty	2 x 2 Units
Speed	600 rpm
Specific speed	472 rpm
NPSH required	4.0 m
Maximum Total Head	A. 39.8 m , B. 40.0 m
Motor Power (rated)	800 kW
Absorbed Power at design conditions	714 kW
Weight :	
Pump	Approx. 16,500 kg
Motor	Approx. 7,000 kg
Baseplate	Approx. 2,000 kg
Barrel	Approx. 5,200 kg
Materials	
Casing	*TYPE 316 STAINLESS STEEL CASING* (SCS14)
Impeller	*TYPE 316 STAINLESS STEEL CASING*

	(SCS14)
Shaft	*TYPE 316 STAINLESS STEEL* (SUS316)
Shaft Sleeves	*TYPE 316 STAINLESS STEEL* (SUS316)
Wear Rings	*TYPE 316 STAINLESS STEEL* (SUS316)
Bearings	*RUBBER BEARING STEEL* (SUJ2)
Seals	*CARBON & STAINLESS STEEL*

10. *Primary Inter Cooler Pump*

Duty	
Fluid	*Geothermal Condensate Water*
Temperature	27 ˚C
Design Discharge Head	30 m (*Total Head*)
Design Flow Rate	760 m^3/hr
Description	
Type of Pump	*Horizontal Double Station Centrifugal*
Number of Stages	1
Manufacturer & Model No.	YOSHIKURA KOGYO CO., LTD./PN8
Number Supplied	2 x 2 units
Number Required for Full Duty	2 x 2 units
Speed	750 rpm
Specific Speed	205 rpm
NPSH Required	1.8 m
Maximum Total Head	37 m
Motor Power (rated)	85 kW
Absorbed Power at Design Condition	79.1 kW
Weight :	
Pump	Approx. 1500

		kg
	Motor	Approx. 1150 kg
	Baseplate	Approx. 800 kg
	Materials	
	Casing	*TYPE 316 STAINLESS STEEL CASING* (SCS14)
	Impeller	*TYPE 316 STAINLESS STEEL CASING* (SCS14)
	Shaft	*TYPE 316 STAINLESS STEEL* (SUS316)
	Shaft Sleeves	*TYPE 316 STAINLESS STEEL* (SUS316)
	Wear Rings	*TYPE 316 STAINLESS STEEL* (SUS316)
	Bearings	*RUBBER BEARING STEEL* (SUJ2)
	Seals	*CARBON & STAINLESS STEEL*
11.	***Cooling Tower***	
	Type	*Mechanical Induced Draft, Double-Flow Crossflow*
	Manufacturer & Model No.	*Mitsubishi Heavy Industries LTD.*
	Water Temperature In	43^{o} C
	Water Temperature Out	27^{o} C
	Fan Speed	129 rpm
	Motor Speed	1000/750 rpm
	Power	120 kW/shell
	Quantity Shell	5

1.4 Software Pendukung

Software pendukung dalam penelitian ini, diantaranya adalah *Microsoft Visio*, yang digunakan untuk membuat *flowchart* penelitian dan hal lainnya. CorelDraw dan Photoshop yang digunakan untuk menggambar objek apabila tidak ada dalam *factory symbol Wonderware Intouch*. *Microsoft Access* yang digunakan untuk menyimpan *database* dari sistem *virtual SCADA* PLTP Kamojang.