Hazard and Operability Study (HAZOP) Based RAMS Plus C Using Genetic Algorithm Optimization in Heater Naphtha Hydro Treater, Oil Refinery Unit, Cilacap Indonesia

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Abstract: Naphtha Hydro Treater (NHT) Plant is a process to process heavy naphtha using the hydrotreating principle so that it will produce sufficient naphtha to go to the next process. One of the equipment contained in the NHT is a charge heater (82-F-201) and a reboiler heater (82-F-202). In carrying out the process, it is necessary to have a good level of safety and to know the potential hazards contained in the plant. The results of research conducted using the HAZOP method showed that 82-F-201 had a high-risk percentage of 27.7% while 82-F-202 was 45.45% high risk. The safety instrumented system (SIS) in actual conditions for the 82-F-201 and 82-F-202 each has SIL 0. Whereas in the SIS design for the 82-F-201 and 82-F-202 the result is SIL 2. The design LCC scores were obtained at USD 477370 for the 82-F-201 and USD 320430 for the 82-F-202. In each section, the optimum type of technology used is technology A with a smart transmitter and air operated valve. As well as the most optimum architecture vote using 1oo1.

1 INTRODUCTION

Energy consumption in Indonesia from year to year has increased in line with the increasing economic growth in Indonesia. The average increase in energy demand each year is 36 million barrels of oil equivalent (BOE) from 2000 to 2014 (Handbook of Energy & Economic Statistics of Indonesia, 2015). Thus the demand for oil and gas energy causes companies engaged in the oil sector to produce oil efficiently to meet domestic consumption. Currently, a state-owned company engaged in the oil sector, namely PT. Pertamina, which has seven processing units, one of which is PT. Pertamina Refinery Unit (RU) IV Cilacap. This company processes crude oil into fuel oil (BBM), non-fuel oil, and petrochemicals.

In the process of processing crude oil into the finished product has several stages, one of which is the hydrotreating stage. This stage occurs in the hydrotreating naphtha unit. Naphtha hydrotreating unit is one of the processing units for heavy naphtha products using a hydrogenation reaction that will remove substances that can interfere with the subsequent process (Anonim, 1989). Thus, you will get naphtha that is suitable for further processing on the platformer. Some of the equipment contained in the NHT unit is not completely safe. Such as the charge heater equipment (82-F-201) and reboiler heater (82-F-202) which have a potential hazard. If a process failure occurs it can cause flammable materials (naphtha) has the potential to be released into the environment. So that if there is a process failure at a plant it will hamper the supply of fuel in a certain area and become an economic loss for the company. Therefore, it is necessary to conduct a study to determine the potential hazards to the plant so that it can be prevented. Hazard analysis can use the HAZOP method. This method is an activity to ascertain the potential hazards that may occur in the factory (Kresna et al., 2017). A safety instrumented system protection system needs to be done to avoid potential hazards to instrument tools. In designing the SIS, a safety integrity level (SIL) value is required based on the IEC 61508 standard. Factors that influence the SIS design are RAMS + C. RAMS affects the level of user confidence in a system represented by the PFDavg calculation. Whereas C is

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the cost or total cost used in an SIS which is represented by the LCC calculation. In the best design,optimization is carried out on the objective variables. The optimization used is a genetic algorithm that draws on previously successful studies (A.C. Torres-Echeverrı et al., 2009), (D. C. Montgomery, 2009). By using this optimization, the best optimization results will be obtained for each variable. So, it is necessary to analyze the potential hazards using the HAZOP method and evaluate the safety instrumented system on the heater naphtha hydro Treater at Refinery Unit IV Cilacap by considering the reliability, safety and cost factors using the RAMS + C calculation. The purpose of this study, among others, is to analyze the potential hazards that occur in the Charge Heater and Reboiler Heater Naphtha Hydrotreater Unit at PT. Pertamina (Persero) RU IV Cilacap using the Hazard and Operability Study (HAZOP) Method, evaluating the Safety Instrumented System (SIS) on the Charge Heater and Reboiler Heater Naphtha Hydrotreater Unit at PT. Pertamina (Persero) RU IV Cilacap, Designing a Safety Instrumented System (SIS) system based on the calculation method with RAMS+C on the Charge Heater and Reboiler Heater Naphtha Hydrotreater Unit, and optimizing the cost of the Charge Heater and Reboiler Heater Naphtha Hydrotreater Unit using a genetic algorithm at PT. Pertamina (Persero) RU IV Cilacap.

2 RESEARCH METHODS

2.1 Data Collection

Data collection consists of PFD, P&ID, process data that occurs in the unit, and data on maintenance or failure of components as well as maintenance costs. PFD and P&ID data are used to determine the process at the plant in addition to determining the control nodes and loops contained therein. Process data is used to determine the deviation that occurs, and maintenance data is used to determine the likelihood value and severity value of a plant. Data obtained from service data contained in the daily report charge heater and reboiler heater located at the Naphtha Hydrotreating Unit Paraxylene Refinery at PT. Pertamina (Persero) RU IV Cilacap for 2005 to 2015. Then the cost maintenance data is used to calculate the LCC value used when optimizing costs using a genetic algorithm optimization.

2.2 Hazard Analysis with HAZOP Method Determine Control Nodes and Loops

Table 1: Node determination.

Section	No	Node
Furnace 82-F-201	1	Heavy Naptha from FOC II to stripper column feed bottom exchange 82-E-203 A/B/C and to recycle compressor section drum 82-V-203 include injection cold condensate through 82-V-201, 82-P-201 A/B, 82-E-201 A-H, 82-F-201, 8-R-201, 82-E-202, 82-V-202, 82-P-205, included make up H2
	2	Fuel gas system from header to 82-F-201
	3	Fuel oil system from header to 82-F-201
	4	MP Steam from header to atomizing 82-F-201
Furnace 82-F-202	5	Feed naphta 82-C-201 to reboiler bottom 82-C-201unit platformer 84
	6	Sweet naptha tank through 82-C-201, 82-F-202, 82-P-202 A/B, 82-E-203 A-C
	7	Fuel gas system from header to 82-F-202
	8	Fuel oil system from header to 82-F-202

Table 2: Control on charge heater (82-F-201).

Node	Control-Loop	Equipment	Instrument
1	Flow 207	82-E-201 A-H	FIC-207
			FT-207
			FV-207
	Pressure 223	82-V-202	PIC-223
			PT-223
			PV-223A/B
	Level 201	82-V- 201	LIC-201
			LT-201
			FIC-201
			FT-201
			FV-201
2	Pressure 252	82-F-201	TIC-208
			TT-208
			PIC-252
			PT-252
			PV252
3	Pressure 251	82-F-201	TIC-208
			TT-208
			PIC-251
			PT-251
			PV-251
4	Pressure 249	82-F- 201	PDIC-249
			PDT-249
			PDV-249
			FIC-207

Table 3: Nodes and Control on a Reboiler Heater (82-F-202).

Node	Control-Loop	Equipment	Instrument
1	Flow 216 A	82-F-202	FIC-216 A
			FT-216 A
			FV-216 A
	Flow 216 B	82-F-202	FIC-216 B
			FT-216 B
			FV-216 B
2	Pressure 265	82-F-202	PDIC-238
			PDT-238
			PIC-265
			PT-265
			PV-265
3	Pressure 264	82-F-202	PDIC-238
			PDT-238
			PIC-264
			PT-264
			PV-264
4	Pressure 262	82-F-202	PDIC-262
			PDT-262
			PDV-262

2.3 Determine the Guideword

After determining the control nodes and loops, the next step is to determine the deviation that occurs in each control loop based on the analysis of the process data plotted on the control chart.

Table 4: Standard guideword.

Guideword	Meaning
No (not, none)	There is no parameter objective reached
More (more of)	Quantitative increments on parameter
Less (less of, lower)	Quantitative drop on parameter
Guideword	Meaning
As well as (more than)	Qualitative increase in parameters
Part of	Qualitative drop on parameter
Reverse	The inverse of parameter goals
Other than (other)	Activity changes on parameter

Deviation that occurs is determined by parameters and guideword. Parameters are used to determine the type of process variable while guideword is used to determine the type of deviation that occurs in these parameters (Anonim, 1998), (N. Hyatt, 2003),. Parameters and guideword using HAZOP reference at PT. Pertamina (Persero) RU IV Cilacap. The following are the standard guidelines used by the company (Pertamina, 2018).

Table 5: Standard guideword.

Parameter	Meaning
Flow	High; Low; None; Reverse
Level	High; Low; Empty
Pressure	High; Low
Temperature	High; Low
Composition	Change in concentration

In Table 4, it is known that there are 7 types of guidelines used by companies in determining changes that occur in parameters. Whereas in Table 5, there are 5 kinds of process variables that become parameters.

2.4 Determine the Likelihood and Severity Value

Each guideword has a value of severity or severity and likelihood value or the chance of a plant failure (ISA, 2002), (Goble, 2005), (Summers, 2010). The value of severity and likelihood value is obtained from estimation against reference. The following is a table to find out the severity value.

Table 6: Severity value.

Level		Decision Issue		
		Economics	Safety	Environment
5	Extreme	Extensive damage	Multiple fatalities	Massive effect
4	High	Major damage	Single fatality	Major effect
3	Medium	Local damage	Major injury	Local effect
2	Low	Mirror damage	Minor injury	Minor effect
1	Negligible	No damage	No injury	No effect

The likelihood value is obtained by estimating the results of the likelihood calculation with the company reference. The calculation formula to find out the likelihood value is as follows.

$$Likelihood = \frac{Time\ Interval}{MTTF} \quad (1)$$

Time interval is obtained from the time between the first failure and the last failure. Meanwhile, the MTTF value is obtained from the average time to failure (TTF) (Musyafa, R.D. Noriyanti, & Novan Yudha, 2019), (Musyafa, R.D. Noriyanti, Azizatus, et al., 2019), (Musyafa, Z.F., & Asy'ari, 2019). Where the likelihood calculation above uses a time interval of 131400.

2.5 Determine the Risk Ranking Value

The last step in making the HAZOP worksheet is determining the risk ranking value for each guideword in the instrument (Musyafa et al., 2015). Determination of risk ranking is obtained in the following way.

$$Risk\ Ranking = Likelihood\ \times Severity \quad (2)$$

The multiplication of likelihood and severity will be included in the standard PT risk matrix criteria. Pertamina (Persero) RU IV Cilacap. This criterion is used to determine risk categories that are high, moderate, or low. The following is a risk matrix category based on company standards.

Table 7: Risk ranking criteria.

Likelihood	Severity				
	1 (Small)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Massive)
D (high)	L	MH	H	E	E
C (medium)	L	M	MH	H	E
B (low)	N	L	M	MH	H
A (Negligible)	N	N	L	M	MH

Note : E = Extreme Risk; H = High Risk; MH = Moderate High Risk; M = Moderate Risk; L = Low Risk; N = Normal Risk

Based on the multiplication of the likelihood value with severity using the risk matrix criteria, the results of the risk ranking guideword on the deviation of each instrument are as follows Table 8.

Table 8: Determination of risk ranking.

Section	Instrument	Guideword	L	S	RR
82-F-201	FT-207	High Flow	C	1	L
		Low Flow	C	3	MH
	PT-223	High Pressure	C	3	MH
		Low Pressure	C	4	H
	LT-201	High Level	C	4	H
		Low Level	C	4	H
	FT-201	High Flow	C	3	MH
		Low Flow	C	3	MH
	LT-206	High Level	B	1	N
		Low Level	B	1	N
	TT-208	High	C	2	M
		Temperature	C	2	M

Table 8: Determination of risk ranking(continued).

Section	Instrument	Guideword	L	S	RR
82-F-201	PT-252	Low	B	3	M
		Temperature	B	3	M
	PT-251	High Pressure	C	3	MH
		Low Pressure	C	3	MH
	PDT-249	High Pressure	C	4	H
		Low Pressure	C	4	H
82-F-202	FT-216A	High Pressure	C	3	MH
		Low Pressure	C	3	MH
	FT-216B	High Pressure	C	4	H
		Low Pressure	C	4	H
	PDT-238	High Flow	D	3	H
		Low Flow	D	3	H
	PT-265	High Flow	D	3	H
		Low Flow	D	3	H
	PT-264	High Pressure	C	2	M
		Low Pressure	C	2	M
	PDT-262	High Pressure	C	3	MH

The potential danger that occurs in the Charge Heater (82-F-201) has a percentage of 27.7% high risk, 33.3% medium high risk, 22.3% medium risk, 5.5% low risk and 11.2% normal . In addition, the percentage of potential hazards that occur in the Reboiler Heater (82-F-202) is 45.45% high risk, 36.36% high risk medium and 18.19% medium risk.

2.6 Genetic Algorithm Optimization

The determination of the objective function in this case is the life cycle cost (LCC) to a minimum. On optimization variables that affect the value of life cycle cost namely PFDavg, type of technology and architecture vote from such control. There are several properties needed for optimization, as follows:

- The number of populations is used to determine the number of chromosomes involved in the optimization process. The number of population used is 50.
- The number of variables that are optimized is three which will affect the objective function, namely PFDavg, type of technology, and architectural vote.
- The optimized upper and lower bounds are intended as a range to randomize the value of the optimization variable so that it fulfills the objective function.
- Iteration is the number of generations that occur in each individual by determining the rotation of the optimization process. Variations to be used between 100 and 250 for best results.

3 RESULT AND DISCUSSION

3.1 Potential Hazard Analysis with HAZOP

At node 1 for the FT-207 tag instrument, high flow and low flow deviations occur. The high flow condition is caused by the failure of the full opening of the FV-207 resulting in a low temperature at R-201, thus no desulphurization process occurs in the reactor which will cause unsolicited product results. Meanwhile, the low flow condition was caused by the FV-207 not opening as desired which resulted in damage to the pump. In PT-223 there is a deviation of high pressure and low pressure. The high pressure condition occurs when the full opening failure of the PV-223B and PV-223A will result in an increase in the consumption of hydrogen make up respectively and the potential for leakage on the V-202 which will cause an explosion. Meanwhile, the low pressure condition occurs when the PV-223A does not open according to demand. This results in low pressure on the R-201, thereby reducing the quality of the product. For LT-201 there is a high level deviation and a low level. In high level conditions it is caused by malfunctioning full openings on the FV-201 which results in an increase in pressure on the V-201. Whereas in low level conditions it is due to failure to close FV-201 which results in potential cavitation on P-201. In FT-201 there is a deviation of high flow and low flow. In high flow conditions it is caused by malfunctioning full openings at FV-201, causing liquid naphtha to be carried over to KOD which causes losses down grade naphtha slope. Meanwhile, the low flow condition is caused by the opening of the

FV-201 not according to demand, which causes a low altitude on the V-201 which will cause cavitation on the P-201. Meanwhile, for LT-206 there is a high level deviation and a low level deviation. In low level conditions it is due to failure to open the LV-206 which results in reduced naphtha product. Meanwhile, the high level condition was caused by the failure to close on the LV-206 which resulted in the naphtha hydrocarbon liquid being carried to the KOD so that the compressor was damaged.

Node 2 for the instrument On the TT-208 there is a deviation in the form of high temperature and low temperature. The high temperature condition was caused by the opening of steam traces which resulted in an increase in COT 82-F-201. Meanwhile, the low temperature condition was caused by the failure of the steam trace which resulted in incomplete combustion at a potential reduction in COT at 82-F-201. At PT-252.

There is a deviation of high pressure and low pressure. The high pressure was caused by failed close valve PV-252 so that it could cause an explosion. While the deviation for low pressure is due to the valve opening of the PV-252 not being as desired. This resulted in a lack of supply of fuel gas flow to the F-201 which resulted in no hydrotreating reaction.

At node 3 for the TT-208 instrument, high temperature and low temperature deviations occur. The high temperature condition was caused by the opening of steam traces which resulted in an increase in COT 82-F-201. Meanwhile, in low temperature conditions due to failure of the steam trace. This failure resulted in the oil drip on the F-201 fuel oil burner tips causing unsafe conditions. Meanwhile, PT-251 had a deviation in high pressure and low pressure. The high pressure condition was caused by failed close valve PV-251 so that it could cause an explosion. The low pressure condition occurred due to the FV-251 not opening as desired, resulting in an increase in the consumption of fuel gas on the F-201.

Node 4 for the PDT-249 tag number occurs high pressure and low pressure deviation. In high pressure conditions it is due to the failure of the opening of the PDV-249 which results in a potential for tube explosion in the convection section which results in an explosion (injury / death). Meanwhile, the low pressure condition is caused by the PDV-249 opening not as desired. This resulted in an explosion and a soot release on the flue gas stack which had an impact on the environment.

Node 5 for the FT-216A instrument, there is a deviation in high flow and low flow. The high flow condition was caused by the failure to open the FV-216A which resulted in a potential low temperature in the reactor which affected the resulting product. Meanwhile, the low flow was caused by the FV-216A not opening as requested, resulting in a trip due to the low temperature of the stripper column. Meanwhile, the tag number FT-216B has deviation of high flow and low flow. The high flow condition occurs due to failure to open FV-216B which results in a potential low temperature in the stripper column which affects the resulting product. Meanwhile, the low flow was caused by not opening the FV-216B as requested, resulting in a trip due to the low temperature of the stripper column

Node 6 for PDT-238 tag number occurs deviation of high pressure and low pressure. In high pressure condition, it is because the pilot burner strainer line is not installed which results in the potential for the pilot burner to light off and is not in a safe condition. Meanwhile, the low pressure condition is caused by the installation of the pilot burner strainer line, which causes the pilot burner to light off and is not in a safe condition. In the PT-265 there is a deviation of high pressure and low pressure. The high pressure condition was caused by failed close valve PV-265 so that it could cause an explosion. Meanwhile, in low pressure conditions, the valve opening of the PV-265 does not open according to demand, resulting in reduced fuel gas supply resulting in a decrease in temperature in the stripper column.

Node 7 for the PDT-238 instrument, there is a deviation in high pressure and low pressure. In high pressure condition, it is because the pilot burner strainer line is not installed which results in the potential for the pilot burner to light off and is not in a safe condition. Meanwhile, the low pressure is caused by the installation conditions of the F-202 strainer line pilot burner. So that resulting in the potential for the pilot burner to light off and not in a safe condition. In PT-264 there is a deviation of high pressure and low pressure. The high pressure condition is caused by a malfunction of the PV-264 open so that there is a potential for a decrease in fuel gas consumption. Meanwhile, the low pressure condition has the reason that the PV-264 instrument does not open according to demand. This resulted in a reduction in fuel oil supply and a decrease in temperature at the stripper column.

Node 8 for oil burner and its flow is controlled by PDIC-262. The PDT-262 instrument occurs with a high-pressure deviation. This condition is caused by a failure to fully open the valve PDV-262, resulting in a flame off of the fuel oil burner and an explosion.

3.2 Actual SIL Calculation

In the calculation of PFDavg the Charge Heater (82-F-201) and Reboiler Heater (82-F-202) below using interval test for 90 days or 2160 hours.

Table 9: Calculation of PFD SIS inlet charge heater 82 FSLL-208A.

Instrument	MooN	MTTF	Failure Rate	PFD	SIL
FSLL-208A	1oo1	41160	2.4295E-05	0.026	SIL 0
FT-208A	1oo1	41136	2.4309E-05	0.026	
UV-212	1oo1	41664	2.4001E-05	0.025	
UV-211A	1oo1	41652	2.4008E-05	0.025	
UV-211B	1oo1	41148	2.4302E-05	0.026	

Based on the PFDavg value from the SIS in Table 9 obtained SIL value for loop 82-FSLL-208A is SIL 0. On the reboiler heater (82-F-202) a loop safety instrumented system is determined. Here's one of the safety loops.

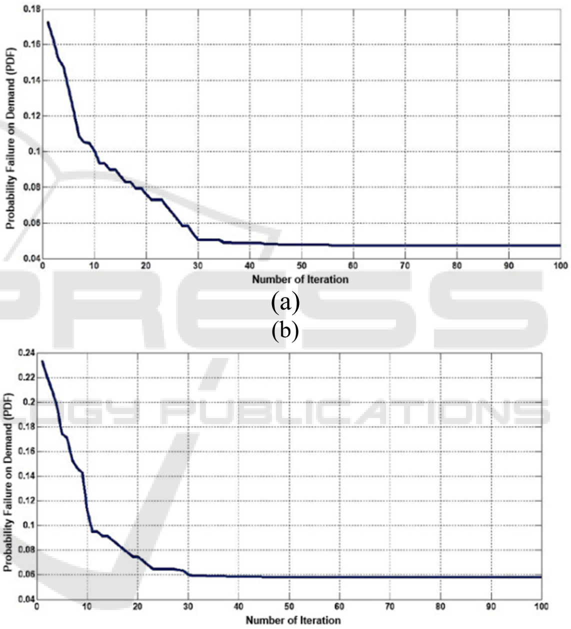
Table 10: Calculation of PFD SIS inlet reboiler heater 82 FSLL-208A.

Instrument	MooN	MTTF	Failure Rate	PFD	SIL
FSLL-216A	1oo1	41124	2.4317E-05	0.026	SIL 0
FT-216A	1oo1	41124	2.4317E-05	0.026	
UV-215	1oo1	41880	2.3877E-05	0.025	
UV-214A	1oo1	41880	2.3877E-05	0.025	
UV-214B	1oo1	41292	2.4218E-05	0.026	

In Table 10, it is obtained that the PFDavg value from SIS with the SIL value for the 82-FSLL-216A loop is SIL 0. As for some of the PFDavg calculations in the safety control loop, the total PFDavg value for the charge heater (82-F-201) is 0.109778 with a SIL value of 0. While the total PFDavg value for the reboiler heater (82-F-202) is 0, 106419 with a SIL value of 0. Thus, the charge heater (82-F-201) and the reboiler heater (82-F-202) have the potential to fail less than once in 10 years.

3.3 Calculation of the SIL and LCC Design

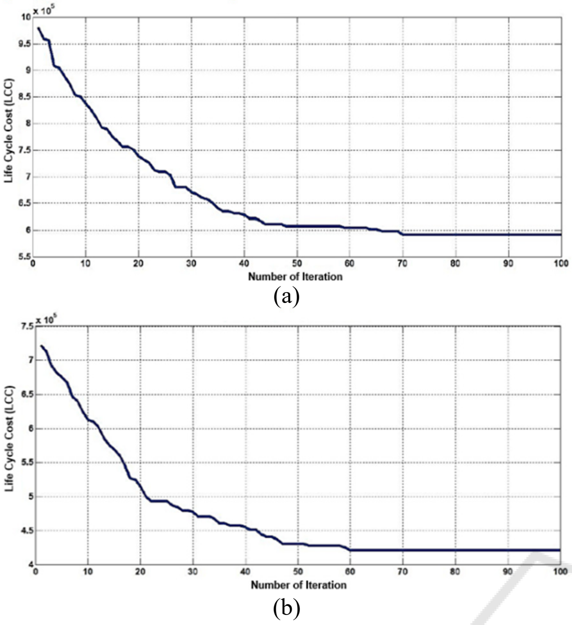
Optimization was carried out to determine the minimum design PFDavg and LCC values. In this case, the objective function used is the LCC. Meanwhile, PFDavg is one of the variables that affects the objective / objective function. The charge heater (82-F-201) and the reboiler heater (82-F-202) have different optimization values for PFDavg and LCC. The following is the plot of the PFDavg optimization graph for each section with a population of 50 and 200 iterations.



(a)
(b)

Figure 1. PFDavg optimization design for (a) 82-F-201 and (b) 82-F-202

From Figure 1 (a), the design results of the minimum PFDavg value for the charge heater (82-F-201) are 0.0069. Whereas in Figure 1 (b) the reboiler heater (82-F-202) is 0.0049. By using the criteria of SIL value based on low demand mode, the charge heater (82-F-201) and reboiler heater (82-F-202) have a SIL value of 2. The design results have a lower PFDavg value than the actual PFDavg. This is to adjust the design targets that come from the company. The SIL value for the design with the SIL target of the company is the same, namely SIL 2. With a time interval of 720 hours or one month. Then performed the optimization of the LCC value obtained by the graph as shown in Figure 2.



(a)

(b)

Figure 2. LCC optimization design for (a) 82-F-201 and (b) 82-F-202.

Based on Figure 2 (a), the minimum LCC value is USD 477370, while in Figure 2 (b) the LCC value is USD 320430. Not only influenced by PFDavg, the LCC value is also influenced by the diversity of technology types and the SIS architectural vote. The following is a vote for the SIS architecture and technology types for the charge heater (82-F-201) and the reboiler heater (82-F-202).

Table 11: Architectural vote design and technology types.

Section	Instrument	MooN	Technology Types		
			1/unit	2/unit	3/unit
82-F-201	FT-207	1oo2	2	0	0
	PT-223	1oo1	0	1	0
	LT-201	1oo1	1	0	0
	FT-201	1oo1	1	0	0
	LT-206	1oo3	0	3	0
	TT-208	1oo2	1	1	0
	PT-252	1oo2	0	2	0
	PT-251	1oo4	4	0	0
	PDT-249	1oo1	1	0	0
	FV-207	1oo1	1	0	0
	PV-223	1oo1	1	0	0
	FV-201	1oo3	2	1	0
	LV-206	1oo1	1	0	0
	PV-252	1oo2	1	1	0

Table 11: Architectural vote design and technology types(continued).

Section	Instrument	MooN	Technology Types		
			1/unit	2/unit	3/unit
82-F-201	PV-251	1oo4	2	2	0
	PDV-249	1oo1	1	0	0
82-F-202	FT-216A	1oo1	0	1	0
	FT-216B	1oo1	0	1	0
	PDT-238	1oo2	2	0	0
	PT-265	1oo2	1	1	0
	PT-264	1oo4	2	2	0
	PDT-262	1oo1	1	0	0
	FV-216A	1oo1	1	0	0
	FV-216B	1oo1	1	0	0
	PV-265	1oo1	0	1	0
	PV-264	1oo2	1	1	0
	PDV-262	1oo1	1	0	0

From the optimization results, it is found that the type of technology that is generally used for transmitters is the type A technology or smart transmitter on the charge heater (82-F-201) with a total of 10 instrument units. Meanwhile, the valve uses technology type A, namely air operated, totaling 9 units. Whereas for the reboiler heater (82-F-202) the type of technology that is generally used is Technology A for smart transmitters with 5 units of instruments and 4 units for the type of water operated valve. Then to vote for the optimal SIS architecture is to use 1oo1. From the design results, it can reduce the potential risk to the plant. The following are the potential design hazards for the plant.

Table 12: Design results of potential hazards in the plant.

Section	Instrument	Likeli hood	Severity	RR
82-F-201	FT-207	A	1	N
		A	3	L
	PT-223	A	3	L

Table 12: Design results of potential hazards in the plant(continued).

Section	Instrument	Likeli hood	Severity	RR
82-F-201	FT-207	A	1	N
		A	3	L
	PT-223	A	3	L
		A	4	M
	LT-201	A	4	M
		A	4	M
	FT-201	A	3	L
		A	3	L
	LT-206	A	1	N
		A	1	N
	TT-208	A	2	N
		A	2	N
	PT-252	A	3	L
		A	3	L
	PT-251	A	3	L
		A	3	L
	PDT-249	A	4	M
		A	4	M
82-F-202	FT-216A	A	3	M
		A	3	M
	FT-216B	A	3	M
		A	3	M
	PDT-238	A	2	N
		A	2	N
	PT-265	A	3	L
		A	3	L
	PT-264	A	3	L
		A	3	L
	PDT-262	A	4	M

From the table above, it can be seen that there is a decrease in the potential risk of the charge heater (82-F-201) to 27.77% medium risk, 44.46% low risk and 27.77% normal. The same thing happened a decrease in the potential risk of the reboiler heater (82-F-202) to 45.45% medium risk, 36.36% low risk and 18.19% normal.

4 CONCLUSIONS

Potential hazards that occur in the Charge Heater (82-F- 201) has a percentage of 27.7% high risk, 33.3% medium high risk, 22.3% medium risk, 5.5% low risk and 11.2% normal. In addition, the percentage of potential hazards that occur in the Reboiler Heater (82-F-202) is 45.45% high risk, 36.36% high risk medium and 18.19% medium risk. The SIS evaluation on the Charge Heater (82-F-201) has a PFDavg value of 0.109778 with an actual SIL value of SIL 0 while the Reboiler Heater (82-F-202) has an actual PFDavg value of 0.106419 with a SIL value of 0. The value of the design SIL on the Charge Heater (82-F-201) is SIL 2. Then the Reboiler Heater (82-F 202) has a design SIL value, namely SIL 2. The SIS design results in an architectural vote of 1OO1 and type A technology, namely smart transmitters and air operated for the entire instrument. Thus, the percentage of potential hazards in the Charge Heater (82-F-201) becomes 27.77% medium risk, 44.46% low risk and 27.77% normal, as for the reboiler heater (82-F-202) to 45.45% medium risk, 36.36% low risk and 18.19% normal. The result of cost design optimization using a genetic algorithm resulted in a life cycle cost (LCC) value for the Charge Heater (82-F-201) of USD 477,370, while for the Reboiler Heater (82-F-202) it was USD 320,430.

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