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ABSTRACT

Cepu is a mature field that has been producing since 1877 with a total production of 2,200 BOPD, with the challenge of developing new wells to control the decline in well production coupled with the high water cut in each well. In addition, production facilities in some sub-districts still use conventional equipment with durability and functions that need to be updated and are generally not equipped with the use of gas flares and purification equipment and in actual conditions in which gas is burned directly into the atmosphere. The thermoelectric Peltier is an innovation in the form of a device with a solid-state electric cooling component that functions to pump heat in the air during the cooling process. By being installed on a flowline leading to a flare stack, it is able to maximize the cooling process to enable the collected condensate and sweet gas be reused as a fuel gas engines. On this basis, the use of Thermoelectric Peltier in mature fields has great potential in reducing exhaust emissions of fuel gas/zero flares, heavy hydrocarbons (CH3+) contained in gas flares can be fully condensed and potentially to increase oil recovery from the Cepu field. In addition, the material used is user friendly requires only a power source, easy to be operated as it uses a 9-12 VDC power source, can be applicable in mature fields because it doesn't need spacious place, simply installed on the pipes, low price cost of Rp 5.312 million and is easy to find in the market.

INTRODUCTION

Cepu Field is one of the field clusters located in the PT Pertamina EP area with current production of 2039 BOPD and 59 MMSCFD. The gas field is currently produced from 8 gas wells that producing 56 MMSCFD of crude gas, 41 MMSCFD of gas sales and 387 BCPD of gas. Meanwhile, oil field currently produced from 79 oil wells that produces 3 MMSCFD of gas and 1652 BOPD oil. The majority of these oil fields are mature oil fields with water cuts reaching 98%.

The use of associated gas in the old field is currently used for company needs as generator fuel, while the remaining will be flared if it does not used. According to the Regulation of the Minister of Energy and Mineral Resources No. 31 of 2012 concerning the Implementation of Gas Flaring (Flaring) in Oil and Gas Business Activities, gas flares must go through facilities by means of a liquid trap before it gets burning into the atmosphere which potentially polluting the environment. Some challenges in associated gas use in old fields are caused by using simple existing facilities, namely separators and scrubbers, including:

- Potential for condensate production losses caused by the high liquid content (produced water and condensate) which is still high in the gas flaring.
- Associated gas purification is not optimal to be used as own used generator fuel.
- The high emission of gas flaring is caused by the inadequate dehydration process to liquified the gas flaring.

SELECTED METHODS

This research is a trial and error methods which will be applied in a Gas Flare in the Early Production Facilities (EPF) Field “X”. If this research is successful, it will be developed in other fields in the company under the same field. In general, this research procedure begins with gas testing of three wells in the “X” Field. This test is carried out with a gas chromatograph, resulted from the test; in which the gas composition is obtained. Once the gas composition is obtained, a simulation is carried out to find out the best practice to condense gas to achieve the maximum rate. Simulations were carried out using Aspen Hysys V.8.8 simulator application. A diagram flow of the simulation is shown in Figure-1.

Gas in the Field "X" is obtained by separating liquid and gas in a separator. The output gas from the separator is 0,15 MMSCFD with separator pressure of 17 psi and temperature of 101^{0}F. Under such conditions, a mass gas of 1.144,82 lb/h was obtained. Gas composition in “X” field has been re-calculated by adding water composition (H_2O). Aspen Hysys V.8.8 is used to obtain the overall gas composition as show in TABLE-1.

Condensate Recovery Solution

When conducting condensate recovery, it is necessary to carry out a process to achieve below the dew point conditions of some hydrocarbon gas components. Because a gas dew point in this field “X” is unknown, the trial and error simulations were performed using Aspen Hysys V.8.8 software in some heat-exchangers.

The use of chiller and fin-fan applications showing that these applications can produce a better result. It also eliminates the use of other separation equipment such as sealer and flare, when producing condensate. The main goal of using chiller and fin-fan is to reduce the temperature of the volatile oil produced, turning its gaseous phase into condensate, which would otherwise waste in a flare. Chiller shows better result of converting gas into condensate, compared to fin-fan. These results were obtained through the simulation process using data obtained from the gathering system. The details of each scenario are as follows:

Fin-fan is a heat exchanger that uses ambient air to cool fluid (air cooler heat exchanger). Heat transfer occurs between the fluids in the tube with the surrounding air without direct contact. The main advantage of fin-fan is no water needed, which means that this cooling equipment does not have to be close to the cold-water supply. In the fin-fan, the heat is transferred from the fluid to the surrounding air without environmental issued, or without enormous costs of water supply and maintenance. The design of the fin-fan is shown in Figure-2.

An air-cooled heat exchanger comprises several parts, namely fans and tubes that arranged in a bank and driver. The fan functions as cooling air to the air cooler, the bank is composed by tubes as a means to process fluids; while the driver functions as a fan drive. The heat transfer that occurs in the fin-fan is just like the ambient of air temperature. Hence, the stability of the ambient air temperature ambiance needs to be noticed.

Fin-fan or water-cooled exchanger is a heat exchanger method in which ambient air is used to cool the process fluid. Therefore, the lowest temperature that can be achieved is about 25^{0}C. The simulation results using the Aspen Hysys 8.8 software is show in Figure-3.

Based on the simulation in Figure-3, a condensed component comes out the bottom of the scrubber device. The components of condensation is shown in Table-2.

From Table-2, it can be seen that the condensate component is about 46,66 barrels/day consist of high amount of water and less amount of CO_2. At the same time, the hydrocarbon component remains in the gas phase. It shows that the cooling process is still over the dew point of the hydrocarbon which proves that, this method is not suitable to use.

Chiller system is a cooling system that uses the liquid generally water as a cooling medium in the secondary system in which the evaporator in the primary system cooling the liquid (chilled water) in the second cycle and can be used to cool the room through the Air Handling Unit (AHU). The primary system is the central cooling unit using the Steam Compression Cycle (SCC), which consists of main components, like compressor, condenser, expansion valve, and evaporator. Chiller system is a process where expenditure and heat absorption occur. Water entering the Chiller will be cooled and circulated by the pump to the AHU and followed by heat exchange process between air and cold water. Cold air coming out of this unit will be then circulated by the fan to the conditioned room. The design of this fin-fan process is shown in Figure-4.

Chiller can cool down a process fluid to the temperatures below 0 ˚C to conduct condensation on the easily achieved contained condensate. The result of performing sensitivity to the outlet temperature, is displayed in Table-3. By conducting a simulation in which sensitivity is applied to the chiller, it can be seen that the components are condensed from various outlet temperatures, as shown in Table-3.

Based on simulation results in Figure 5, it can be concluded that the lower the temperature, the more condensate obtained. When the chiller reaches the temperature of 0˚C, the highest total liquid was obtained was 53.44 barrels/day, and condensate was 6.58 barrels/day.

After comparing different outlet temperatures, we determined the optimum pipe diameter based on the minimum pressure drop and the maximum result of Condensate production. Table-4 shows the result of pipe sensitivity.

The simulation result in Table-4, it described that fin-fan could not be used because the lowest temperature produced was equal to room temperature. In contrary, the separation process (dehydration) can be obtained with an optimum temperature of 0°C but these conditions can be freezed the liquid. Based on these conditions, the optimum temperature that can be used is at 5°C.

RESULTS

The simulation result, identify that the optimum temperature for the thermoelectric Peltier is at 5°C. Considering of existing condition in early production facilities/EPF and reducing the lower economics issue in a mature field operation, the installation of Peltier Thermoelectric Cooler Generator could be an option for optimizing the associated gas dehydration process. The following details are the advantages by using a Thermoelectric Peltier-based Generator Cooler,

- Relatively safe installation because it does not require hot tapping on existing facilities as the equipment is installed to the facilities that need to be cooled.
- It does not require extra space because the installation is done by attaching it to existing facilities.
- Relatively easy operation is because it uses an energy source in the form of a power source.

Thermoelectric Peltier is a solid-state electric cooling component consisting of two semi-conductor materials (Type-N and Type-P) that a heat pump in the cooling process. When direct current (DC) flows through a device, it carries heat from one side to the other, that makes one side gets cooler while the other gets hotter. Figure-6 and 7 show the component and the work system of the Thermoelectric Peltier.

Based on Figure-8, Thermoelectric Peltier-based Cooler Generator is used as a cold source in existing facilities (separators, scrubbers and other facilities) in order to maximize the separation process (dehydration).

Currently the Peltier Thermoelectric remain limited to its small dimensions which can be seen in Figure-9. However, the main advantages of Peltier coolers if it is compared with the pressure and evaporation technology, is the absence of moving parts or rotating fluids, that makes it long-life span, strong against leakage, has a size that is small, and easily customizable shape. Unfortunately, it is low power efficiency, but now many researchers and companies are trying to develop cheap and efficient Peltier coolers. The most common Peltier Thermoelectric type the market are the TEC-12076 with the following specifications as in Figure-10:

- External dimensions: 40x40x3.75mm
- Internal resistance: 2.1 ~ 2.4Ω (ambient temperature of 23 ± 1 'C, 1kHZ Ac test)
- The maximum temperature difference: Tmax (Qc = 0) above 59 'C.
- Working current: Imax = 4.3-4.6A (rated at 12V)
- Rated voltage: 12V (Vmax: 15V starting current 5.8A)
- Cooling power: Qcmax 55W
- Working environment: temperature range -55 'C ~ 83'C (high ambient temperature drop directly affect the cooling efficiency)

The use of conventional heat exchanger tools, generally related to the limitation of its working environment temperatures and installment inconveniency, that makes them less economical option. Chiller, for example, has maximum output temperature of 39°C and requires more space for its installment.

Therefore, with the implementation of a thermoelectric Peltier-based cooler generator at the scrubber outlet at temperatures of up to 5°C, a more optimal gas dehydration process can be obtained and the gas can be used.

CONCLUSIONS

1. The use of associated gas in the mature field is still quite low. For example, Cepu field using simple separation process (separator & scrubber). Associated gas that is not optimally hydrated will cause potential problems in combustion gas emissions, loss of condensate and cannot be used.
2. Thermoelectric Peltier-based cooler generator is a relatively cheaper equipment, that is more applicable, more portable, and more economical option compared to other heat exchanger technologies such as fin-fans, chillers, and so forth. As an example, Peltier-based cooler generator can still function when surrounding temperature reaches 83°C whereas Chiller is limited to 39°C.
3. The potential uses of Peltier thermoelectric technology for heat exchanger applications in gas flare utilization comprises the monetization of gas flares to increase revenue, the used of gas as generator fuel, and the increase of condensate production by optimizing the separation process in gas flares.
4. Peltier Thermoelectric application has a limitation from its developed size in smaller module. The potential used in a gathering station or production facilities requires further research for installation compatibility.

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TABLE 1
GAS COMPOSITION IN FIELD "X" ALONG WITH WATER CONTENT

Compositions	Value		
	% Mol	% Vol	% Mass
Nitrogen	0,001	0,001	0,001
Carbon Dioxida	0,010	0,016	0,020
Methane	0,112	0,183	0,080
Ethane	0,023	0,060	0,031
Prophane	0,045	0,120	0,089
i-Butane	0,020	0,064	0,052
n-Buthane	0,017	0,051	0,044
i-Penthane	0,010	0,034	0,031
n-Penthane	0,008	0,029	0,026
Hexane	0,008	0,031	0,030
H_2O	0,747	0,412	0,598
Total	1,000	1,000	1,000

TABLE 2
PERCENTAGE OF MOLES OF EACH COMPONENT IN THE FIN-FAN RESULT

MATERIAL STREAM CONDENSATE			
Component	LiqVol Flows	Vapour Phase	Aqueous Phase
Nitrogen	0.0000	0.0000	0.0000
CO2	0.0052	0.0000	0.0052
Methane	0.0000	0.0000	0.0000
Ethane	0.0000	0.0000	0.0000
Prophane	0.0000	0.0000	0.0000
i-Butane	0.0000	0.0000	0.0000
n-Butane	0.0000	0.0000	0.0000
i-Pentane	0.0000	0.0000	0.0000
n-Pentane	0.0000	0.0000	0.0000
N-Hexane	0.0000	0.0000	0.0000
H20	46.6552	0.0000	46.6552

TABLE 3
SIMULATION RESULTS USING CHILLER WITH OUTLET TEMPERATURE VARIATIONS

Parameters	Outlet temperature, ^{0}C			
	0	5	10	25
Molar Flow, lb moles/h	38,76	38,42	38,08	37,06
Cumulative Liquid Production, BLPD	53,44	50,94	48,46	46,67
Cumulative Condensate Production, BCPD	6,58	4,10	1,65	0

TABLE 4
POTENTIAL PRODUCTION LIQUID & CONDENSATE

Output Temperature °C	Liquid Production	Condensate Production
	BLPD	**BCPD**
0	53.44	6.58
5	50.94	4.10
10	48.46	1.65

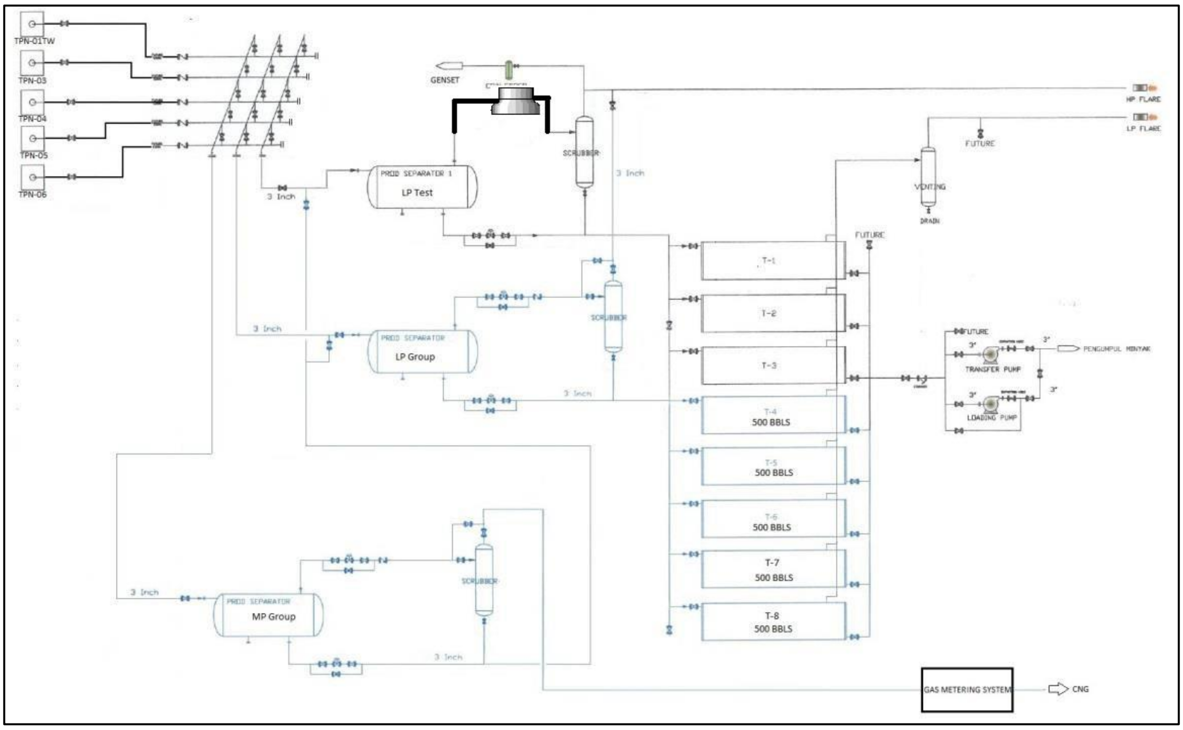

Figure 1 – Flow Diagram

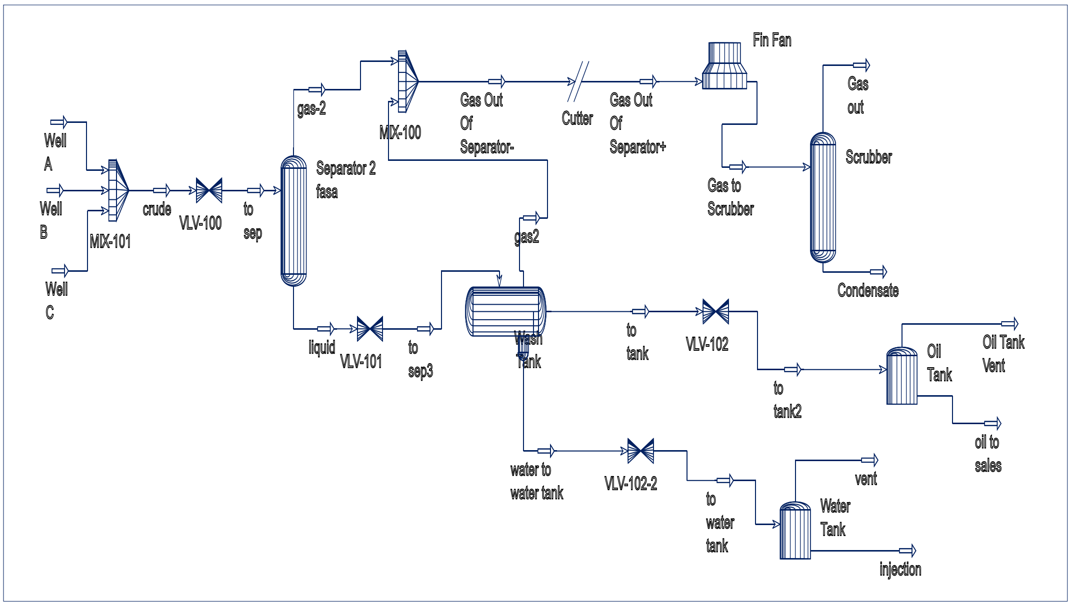

Figure 2 - Design of Fin-fan by Using Aspen Hysys V.8.8

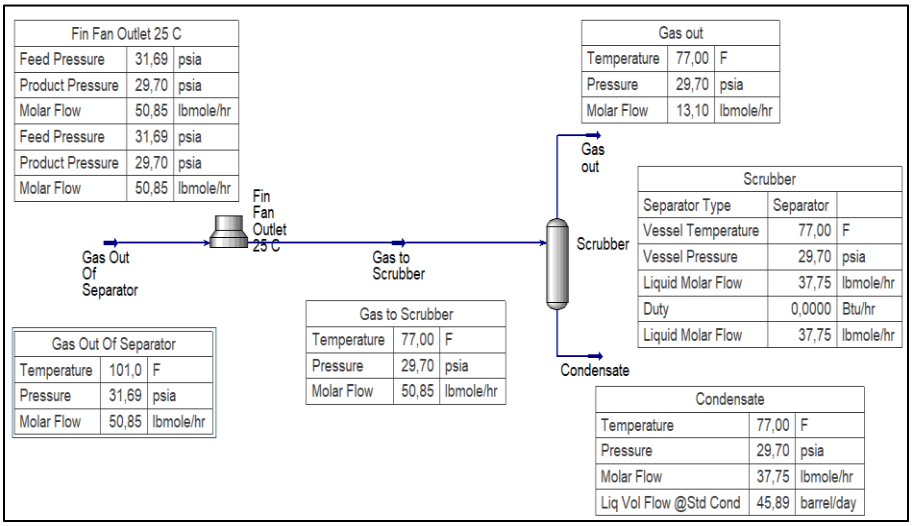

Figure 3 - Simulation Results with Fin-fan

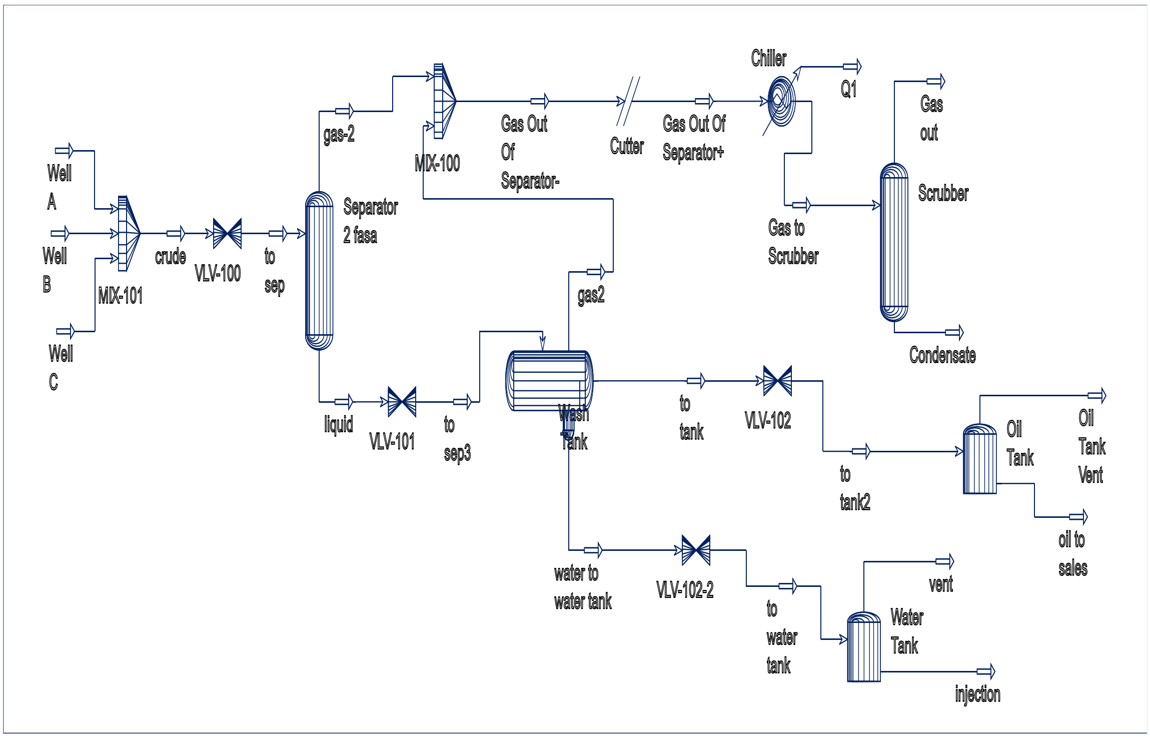

Figure 4 - Chiller Design by Using Aspen Hysys V.8.8.

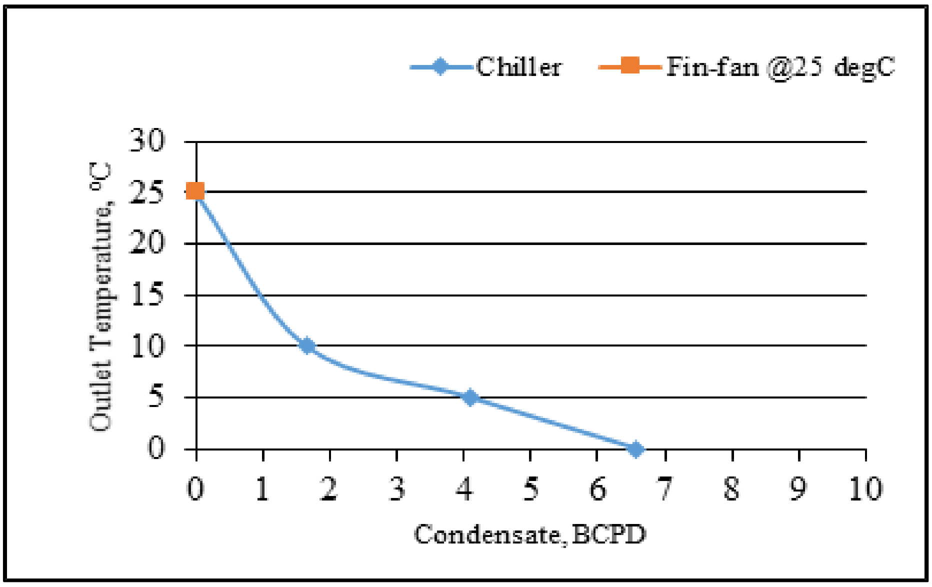

Figure 5 - The sensitivity of Outlet temperature vs. Condensate Results from Simulation

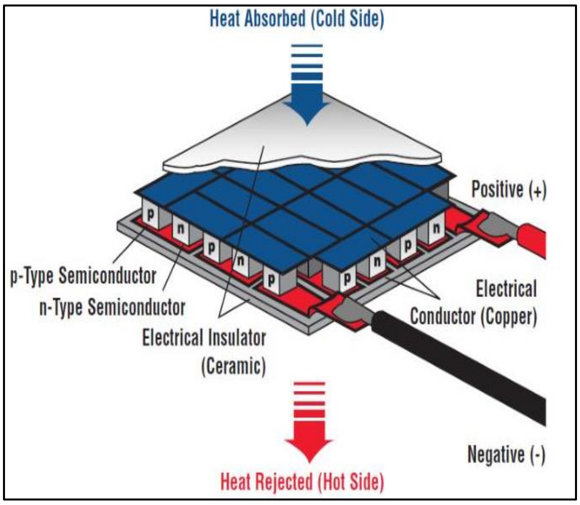

Figure 6 - Component of Thermoelectric Peltier

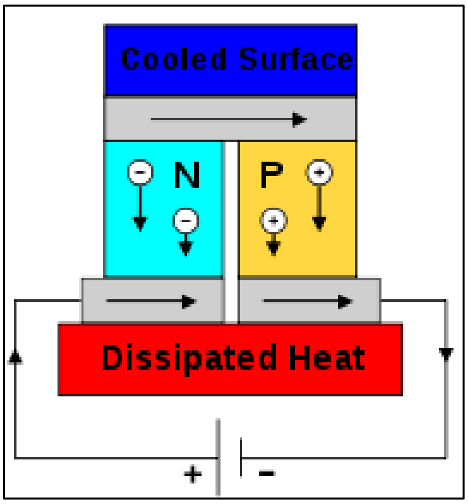

Figure 7 - How to Work the Thermoelectric Peltier

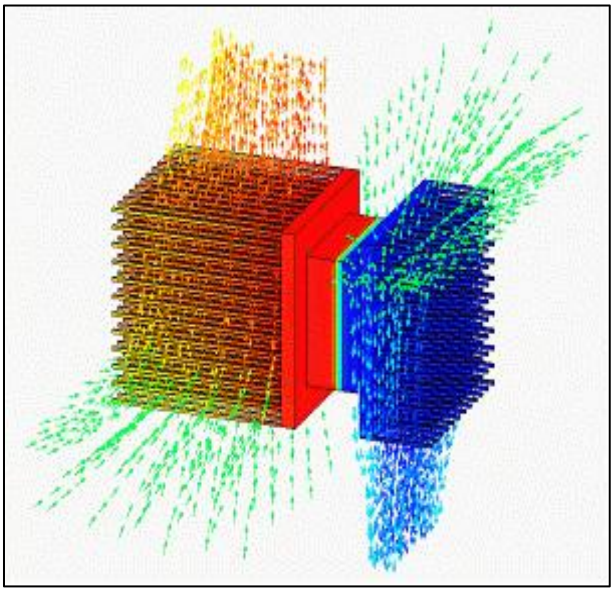

Figure 8 - Cold – Hot Peltier Airflow

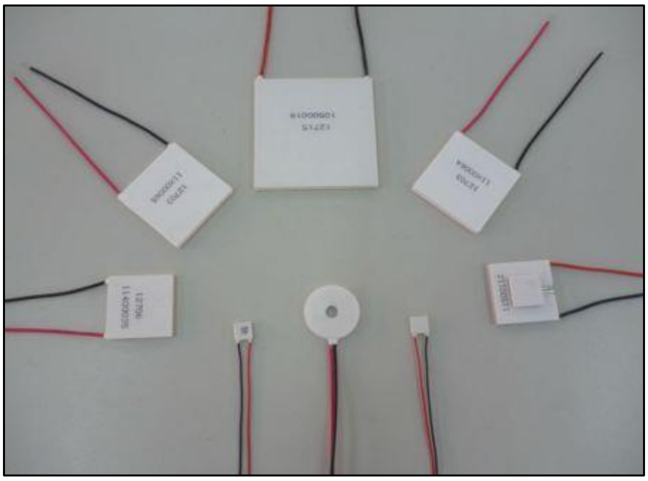

Figure 9 - The Kind of Thermoelectric Peltier