Utilization of Gas Turbine Generator Exhaust (GTGE) into DC Energy (A Survey)

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Abstract- Now adays, the phenomenon of energy crisis remains to be one of unsolved problems in the world, especially in industrial world. In fact, as the number of factory or even plant expansion increases, the need of electrical energy gets increasing, too. Therefore, to solve the problem, some renewable energy resources have been developed, such as solar, wind, biomass, etc. Further more, Gas Turbine Generator (GTG) is the first mover that utilizes gas as the working fluid. In the gas turbine, kinetic energyis converted into mechanical energyin the form ofa round wheel that drives the turbine to produce power. Exhausted heat produced by GTG reaches up to ~645 °C (GTG in Petrokimia Gresik Factory, East Java, Indonesia). Exhaust energy from Gas Turbine Generator can be utilized became electric energy using seebeck effect, Peltier effect and Thompson effect. So exhaust energy can be converted into electrical energy. Finally, the energy conversion be used for industrial installation of DC supplies. Thus, the purpose of this paper are: 1) to explain the concept of conversion of gas turbine generator which is changing the exhaust into electrical energy, there by the exhaust can be used a san independent DC power plant supply. The concepts bases on the Seebeck effect that is "when two different metal pieces attached to one of the ends, then given a different temperature on the connection, there will bea voltage difference between one end and the other, so that the voltage difference can generate electricity. 2) to overview the metallic materials that are used based on the level of exhaust of Gas Turbine Generator (GTG).

Keywords- Methalic Material, Electric Energy, DC Energy, Exhaust of Gas Turbine Generator

1. Introduction

The use of technology in every facet of human life became inevitable. Almost all human activities using technology. The use of such technology could not be separated from the use of energy. For example, the use of electric energy, the energy consumption is becoming very widespread, even human beings are very difficult to break away from the needs of the electrical energy.

Energy consumption if it's not balanced energy supply will cause crisis. A State is called a crisis demand is very high and the supply could not meet the demand, Just as happened in Indonesia, namely the energy crisis. Energy demand, such as electricity, fuel, kerosene or gas is very high, but the supply in Indonesia can not meet the demand.

Start from the observation of the writer by the industry practical activity at Factory I of PT. Petrokimia Gresik. The electricity at PT. Petrokimia Gresik is produced by the supply of PLN and the own energy generator which is *Gas Turbine Generator* (GTG) with the capacity 33 MW. The energy generator of*Gas Turbine Generator* (GTG) produces Exhaust, which the outcome of burning the coal and then its steam is taken to move the turbine, then turbine moves the generator. The result of writer's analysis during the activity of Industry Practicalthat Exhaust (~645°Celcius) from GTG at PT. Petrokimia Gresik did not totally be used as the electricity, but it is used as boiler.

Writers interested in conceptualize an idea, change the exhaust with high temperature heat into electrical energy. The authors reflect on the experiments of Nurdin, Maradin and Amalia (2012) with the title Spektronik (Electronic power plant System) which is a new innovation in energy-producing environment-friendly electric micro scale/scales home (output: 5V). This experiment produced a concept that waste heat energy from electronic devices can be used into electrical energy by exploiting the effect of Peltier and Seebeck effects effects of Thompson. So that we made a new concept, which is changing the exhaust with high temperature becomes electricity energy. The exhaust from electricity tools can be used as the electrical energy by using Seedback effect, Peltier effect, and Thompson effect. So that the exhaust can be converted as the electricity energy.

2. Material and Method

2.1. Indonesian Electricity Energy Needs For the Future

Factor in the efficiency of energy generation continues to decline due to increasing energy consumption. Not to mention the majority of Indonesia's energy suppliers just leaning on fossil fuels that are increasingly getting a rebound in prices. "50% of national energy consumption of Indonesia as long as it comes from petroleum. This shows that the people of Indonesia is still very dependent on a source of energy on non renewable energy. But, sooner or later these energy sources will run out. One of the solutions that can be done to overcome these problems is to optimize the potential of renewable energy Indonesia namely owned by 311. 232 MW and just 22% which utilized" (source: www.bppt.go.id). The State of energy in Indonesia are required to specify a description of the problem of energy crisis. Muhammad Alfian Mizar, M.P, renewable energy is outlining the conditions of energy in Indonesia as follows:

a. Public access to energy (modern) is still limited. Communities in Indonesia still have yet to get energy supplies completely. So, even distribution of energy is still not up. Electrification ratio (2008) 66% (34% do not have electricity); The development of the infrastructure of rural/remote/outer islands generally have not got access to energy.

b. High dependence on fossil energy, more limited reserves. It is a fact that cannot be denied, Indonesia using almost 95% of the source of energy for power plants using fossil fuels, including: stone fuel, petroleum, and natural gas.

c. Energy consumption growth of 7% per annum, not balanced supply sufficient energy. Energy consumption as demand always grow rapidly and demand growth is not accompanied by a proportionate supply.

From these facts, it can be concluded that the need for a change in mindset on energy supply. The renewable energy is an energy alternative, instead of the main energy sources. In fact, we know that energy is not a renewable energy source that should be limited to alternative energy. The result of this is when international petroleum prices soared, the price of electricity has soared, so the subsidies increasingly bloated and fulfillment needs electricity in Indonesia were declining. One example, a solar power plant will not operate if the funds to supply solar no resulting from soaring fuel prices. The electricity supply was dwindling and blackouts to equalization applied to electrical energy. From the corner, we already know that one of the problems is the reliance power plants against fossil fuel whose price fluctuates.

2.2. Gas Turbine Generator

Gas Turbine Generator (GTG) is a driving force that makes use of gas as the working fluid. In gas turbines kinetic energy converted into mechanical energy in the form of a round wheel that drives the turbine to produce power. Simple cycle turbine Abdul Kadir (1996: 31) consists of a compressor, a combustion chamber, and a gas turbine with generator power. Here's a GTG sample PT Petrokimia Gresik.

Fig. 1. Gas Turbine Generator (GTG) at PT. PKG

As for the hot exhaust from combustion is ~645 Celsius, high temperature is used for Boiler (Haidar, 2012).

2.3. Thermoelektrik Effect

Thermoelektrik effect is the effect of physics that allows direct conversion of heat energy into electrical energy without an intermediate energy conversion process.

While the working principle of Thermoelectrik is based on Seebeck Effect, i.e. "If two different metals connected one of the end, then given a different temperature on the connection, then the voltage difference at the end of the case the one with the other end." (Yudhi, 2012).

The phenomenon of thermoelectric was first discovered in 1821 by the scientists of Germany, Thomas Johann Seebeck. He connected the copper and iron in a series. In between the two metal is then placed needle compass. When the metal is heated, the compass needle turns moving. In recent times, this happens because the flow of electricity that occurs on the metal causing the magnetic field. The magnetic field that moves the needle of the compass. The phenomenon came to be known as the Seebeck effect. There are three important thermoelectric materials properties, namely: (1)

Coefficient Seebeck, (2) Conductivity of heat, and (3) Resistivity.

Fig.2. Hot water can be used to turn on the Lights with the Thermoelectrik Module(Source: http://www.tegpower.com)

Thermoelectric module uses semiconductor type P type and N arranged such that if there is a difference in temperature between the hot side and the cold side of the module thermoelectric will arise-carrier concentration difference on these materials.

2.4. Literature Study

Thermoelektrik effect is the physics effect which converts directly the exhaust into the electricity without conversion process of energy mediator. While, the work principle of Thermoelektrik is based on Seebeck effect which is "*When 2 different metals is boundone of its point, then it is given the different temperature on its connection, so it will make the difference of tense on the other point."*

The three effects which influences on thermoelektrik principle have a definition below :

"The first effect is Seebeck effect(conversion of the heat into the electricity). The current of electricityflows on the closed combination from 2 different conductors, if the conductors have the different temperature. If the combination is opened, it will be appeared Seebeck at both sources".

For T low => $dE_{AB} = S_{AB}\, dT$

Which : SAB = coefisien Seebeck

(SAB = termolistrik power from material A towards material B

EAB = e.m.f and

dT = temperature changes

Peltier effect is the inverse of Seebeck effect (conversion of electricity into heat). When electricy flows through a connection from 2 different conductors, it will free or absorb the heat.

Rate from this heat : $Q\pi = \pi A\, B\, I$

Which :

$Q\pi$ = the heat which is freed or absorbed per second

I = current (in used)

π AB = Peltier coefisien or u e.m.f. Peltier from material A towards material B.

The requirement : $\pi AB > 0$ if the heat is gone out when the flowing from A to B. Seebeck and Peltier effect is totally reversible thermodinamically.

Thomson effect say about the existence of low on a homogen metal when it has temperature gradien because the absorbance or the freedom of heat (Palinta, 2012).

One of the solution to make the different temperature between both metals are increased is can line the metal which has low thermal conductivity with another material which lower thermal conductivity. This case means to isolate the metal which has low thermal conductivity. The materials that we use :

Table 1. The Thermal Conductivity (*k*) from many Substances

Zat	**Konduktivitas Termal, K**	
	kkal/s.m.^{0}C	**J/s.m.^{0}C**
Glass (biasa)	$2{,}0 \times 10^4$	0,84
Batu bata dan Beon	$2{,}0 \times 10^4$	0,84
Air	$1{,}4 \times 10^4$	0,56
Jaringan tubuh manusia (tidak termasuk darah)	$0{,}5 \times 10^4$	0,2
Kayu	$0{,}2 - 0{,}4 \times 10^4$	0,08-0,16
Isolator Floerglass	$0{,}12 \times 10^4$	0,048
Gabus and serat kaca	$0{,}1 \times 10^4$	0,042
Bulu angsa	$0{,}06 \times 10^4$	0,025
Busa polyurethane	$0{,}06 \times 10^4$	0,024
Oxsigen	$0{,}055 \times 10^4$	0,023

(Source : The moving of Heat Part 1, 2004)

2.5. Design Exhaust Power

Thermoelectric module uses the semiconductor material type P and type N which are arranged variously so that when there is a temperature difference between "hot" and "cold" from Thermoelektric module will appear the difference of content consentration on that material.

To produce the flow of electricity, we need 2 metals, in which metal 1 has a high conductivity and metal 2 has a low conductivity. This means to make a difference of temperature in which will cause the persisting of electricity flow "hole-hole" and will cause the electricity flow on the connection of

both metals (Setiawan, 2007). This is the illustration picture of P-N diagram.

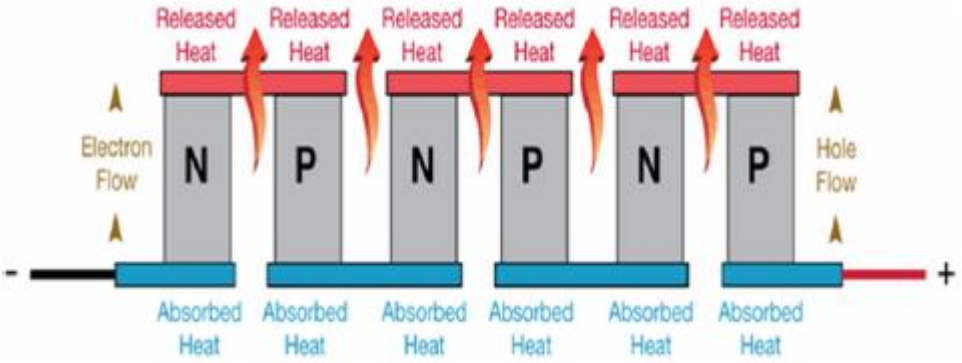

Fig. 3. The system of changing from Heat Energy to Electricity

Objects that have the value of thermal conductivity (k) is a good heat conductor. In contrast, object that has its small thermal conductivity is a bad heat conductor. So the higher the difference in the value of the thermal conductivity (k) of both metals will be able to generate an electric current value is the greater. This provides many advantages of usage of thermoelectric for semiconductor and electronic device applications because a refrigerator solid materials (solid state refrigerator), namely the absence of moving parts or bervibrasi, good performance is related to its ability to localize (spot) cooling, is environmentally friendly, and can be easily used in technology to capture the heat or energy conversion (Inge M., 2010).

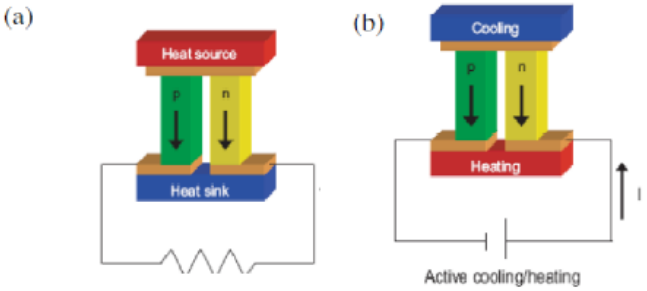

Fig. 4. Working Principle Device Thermoelektric as : (a) Power Generator, and (b) Heats Pumps, I is electric current»

3. Results and discussion

3.1. Materials

Thermoelectric of material is a unique ingredient that can convert thermal energy into electrical energy, or vice versa, without producing toxic gas carbon dioxide and other pollutants such as heavy metals elements (eco-friendly). The work of Thermoelektrik material is determined by the mark of figure of merit (FOM):

$$ZT = \frac{(S^2\sigma)T}{K} = \frac{(S^2\sigma)T}{K_e + K_l}$$

ZT = the work of thermoelektrik

S = Thermopower or Seebeckcoefisien

$\sigma(=1/\rho)$ = Conductivity electricity

K = The total of conductivity thermal which is the sum of electronic contribution (k*e*) and kisi contribution (k*l*)

This is the graphic :

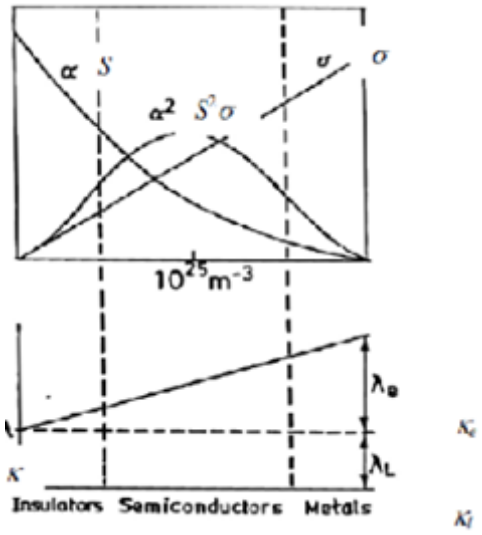

Fig. 5. Thermoelectric Parameters

The Fig.5 tells us that the depend of thermoelectric parameters : electricity conductivity, thermopower, and thermal conductivity on free load bringer consentration. For the optimum mark, power factor reaches maximum mark (Inge M., 2010). Generally, metal has S mark which relatively low related to valensi bond which is filled a half. In this case, both electron and hole (positive content) contribute together on S mark which inversed symbol, so that it creates total S mark which is relatively low. Semiconductor material can be supported by electron or hole (through element doping) so that it can make the higher S mark, in which the symbol of S mark which is produced based on the majority of load bringer type.

The thing which has high thermal conductivity mark is the good conductor of heat. While, the thing which has low

thermal conductivity mark is the bad conductor of heat. So that, the higher of the difference between thermal conductivity mark from both metals will make the higher electricity flow.

3.2. Implementation Tehcnique

Based on the results of the experiments of Nurdin *et al* that: "The bigger the value of different temperatures (C) Semiconductor metals on both the value of voltage (V) and current (I) generated will be greater. So the value of voltage (V) and current (I) generated will be directly proportional to the temperature difference (C)". The following is a picture of the results of his experiment:

Table 2. The results of experiments you wasting electronic the heat into electricity

Electronic Devices	Temperature of waste heat
Kulkas merk LG Expresscoll	35.3 C^0
TV merk Panasonic Quintrix F	32.5 C^0

(source: Nurdin, dkk : 2012)

The results of these experiments of their review of exhaust heat temperature sample device electronic fridge LG, so acquired range voltage obtained results ranged between 0.5 V > V > 1.5 V voltage values for enlarging it brings can be used LM type Input voltage criteria 2623 minimum 0.8 V ~ 14V and output voltage are 1.24 V ~ 14 Volts DC.

This implementation effect can be used to heat system which is higher, such as reaching hundreds of celcius. Like the exhaust from GTG, in which its exhaust reaches 645°C. This exhaust can be changed to be electricity supplying to back-up the supply of electricity in the industry or may be can supply the electricity to the consumers (house, office, school, etc.). In this case, industry also can give advantage to the society. The electricity which is produced by the convertion process is still Direct Current, that electricity can be saved in the battery or it can be changed directly to be through DC-AC inverter combination in which supply the source or reproduced.

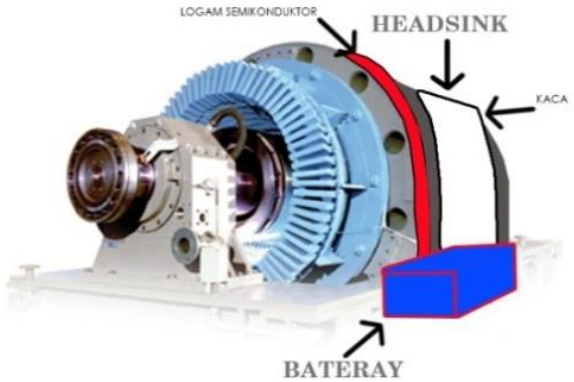

Fig. 6. The concept of Exhaust Energy to be Electricity

But, before moving so far, we should analyze first. This cycle means that the output of the electricity which is produced is totally appropriate as we expect. This is the process of changing of DC to be AC generally :

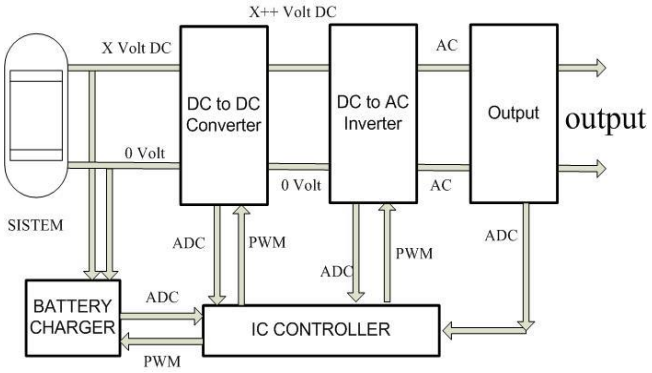

Fig. 7. Process from the System

4. Conclusion

Seebeck concept, when 2 material of metals (semi conductor) which is connected in the circumstance with 2 different temperatures, so in that materials will flow the electricity or the moving of the electricity. When we apply this concept on GTG in which the thrown gas on GTG machine is about 645°C.While, the temperature of circumstance is between 50-60 ^oC,so that by the existence of this diffenece, we can get the electricity moving and then it can be saved in the battery as the renewable energy"The higher of temperature difference *(C°) on both semiconductor metals, so the mark of tense(V) and flow (I) which is produced is also higher. So that the mark of tense(V) and flow (I) which is produced is same as the temperature difference (C°)".*When we can apply in the factory, so the usage of electricity in the factory will be thriftier.

Through this idea, we hope can give positive effect to the electricity company in Indonesia which is located in the supply of renewable energy. The success of this idea could determined by the exhaust of Gas Turbine Generator.

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