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The Improvement Of After Burning System By Utilize Zeolite Catalyst To Reduce The Engine Exhaust Emissions

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Abstract:- *The gases coming out from the engine exhaust contains toxins that need to be in treatment, one of them using the catalyst. Zeolite filter is a mineral that can be used as a catalyst through the chemical and physical processes. Physical process is used to reduce the size, while thechemical process is used to activate the zeolite to become catalyst. Zeolite powder is then established in the next packaging package with the 200 up to 400grams with the size of 100mesh. The process of calcining and activation is done in an acid at a temperature 550 ^oC for a few hours. The purpose of this research is to know how big carbondioxide and hydrocarbons emissions can be reduced by the zeolite catalyst, then compared to standard conditions. What is the working optimum temperature of catalyst when to reduce emissions of the flue gases.How much the changes in power and the fuel consumption when catalyst is applied, compared further toward the standard. Exhaust emissions and power are then tested using variable speed methodtest up to 4000rpm.The data is then presented in the form of graphs the it is compared to present and analyzed. Based on the results of the test data it shows the optimum temperature zeolite catalyst is 575^oC and the CO emissions reduced by 27.35 % at 3500rpm and HC of 35,94% on 3250rpm. As well as the rise in sfc by 0.56% compared to the standard and reducingpower of 6% from the standard.*

Keyword:- *zeolite, catalyst, engine exhaust, calcinations*

I. INTRODUCTION

The increasing number of vehicles on the streets in every year significantly increases the air pollution which is harmful to human being. There must be a regulation of the threshold gas that allowed, some treatments are needed if the gas emissions are excessive. The thresholds gases include emissions of carbonmonoxide, hydrocarbon and nitrogen oxide. To find out the value of exhaust emissions produced, the exhaust gases that come out of the engine exhaust must be measured using a gas analyzer.

Zeolite is a mineral that comes from the mine with the unique characteristic, it is usually used as absorben, ion exchanger and catalyst, with the particular treatment, zeolite can be used to absorb the exhaust. The comparison between the air and fuel that does not match, changes in component dimensions, inappropriate of engine application, driving model and the condition of the road cause exhaust emissions. During the operation, rotating machine is not constant or not continuously, so it is cause the changes in fuel consumption and the power become down. Besides that, this could be due by the necessary of air is not appropriate, valve overlap, the burning is too quickly or even too slowly.

Some of the earlier researchers have concluded that the use of catalyst zeloit shaped boulder produce the reduction of emissions of 5.82% HC, and the concentration of gas pollutants CO rose 13,39% (Setiawan D.E , 2001). Decreased concentration of gas CO is 36,4%, gas NOx by 10% and HC by 36% result from the research Muhaji (2001), using natural zeolite disclaimed manganese (Mn). On Ronaldo R research (2008), using natural zeolite 80% and chitosan 20% , showed that it will be able to reduce CO until 2,92%. While W. A Yuniarto research (2009) using natural zeloit shows that zeloit can reduce the concentration of gas emissions CO of 5.75%, HC by 5.89 percent when extensive contacts 140 percent of standard, and there is power reduction of 3.07%.

II. MATERIAL AND METHOD

2.1 Working principles of the 4 steps machine

The 4 steps machine in producing energy requires two times of the crank shaft rotation (crank shaft) and 4 times of the piston movement from the top dead point to the lower dead point. Theoretically, the combustion process of the engine 4 steps has 2 steps. There are growth and development of the fire nucleus which developed by itself (preparation phase) and the second is the spreading of the fire to the entire fire space.

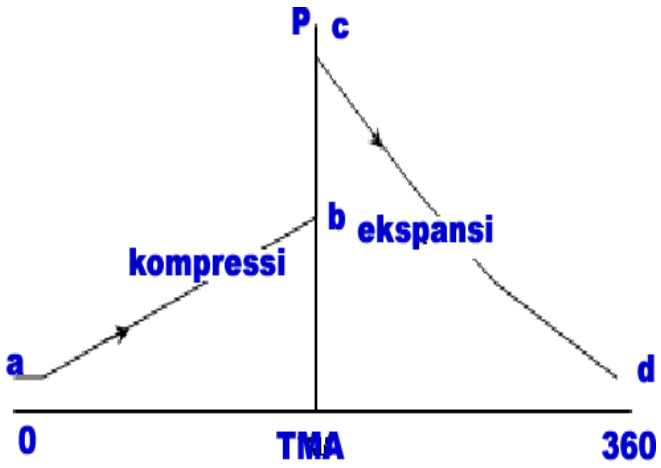


Figure 2.1 Theorytis chart P- θ

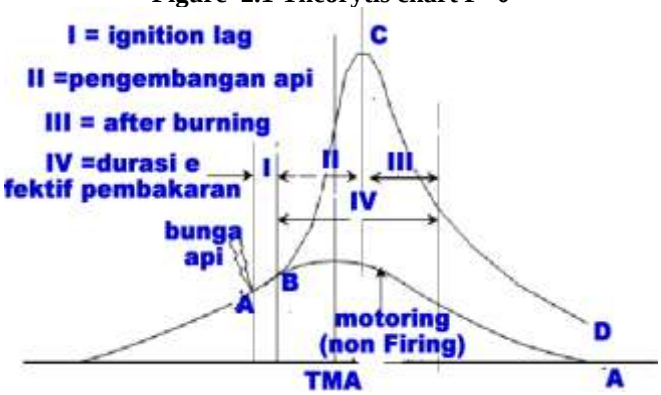


Figure 2.2 Burning process

2.2 Pollutan formed

Pollutants formed by the result of the burning which is less perfect. On uneven burning due the fuel distribution in space combustion is not perfect, high temperatures due the leap of spark plugs do not reach the far location, and because of oxidation CO changed into CO2 is slowly, it is cause that not all of the CO will become CO2. Based on its phases, pollutants consists of solid phase, liquid and gas, solid pollutants shaped as a particle and liquid pollutants form as colloids, and gas pollutants shaped as all the types of air contaminant in gas form. There are two types of pollutants known as primary pollutants. They are partikulat, sulfur oxides (SOx), nitrogen oxide (NOx), hydrocarbons (HC), and carbon monoxide (CO) and secondary pollutants. Secondary pollutants is the result of the reaction between primary pollutants with other components in the air, such as ozone (O2) and peroksi asetil nitrate (PAN) where both of them formed in the atmosphere through the process of hidrolisis, petrochemical or oxidation. Vehicle engine exhaust emissions is a type of primary pollutants.

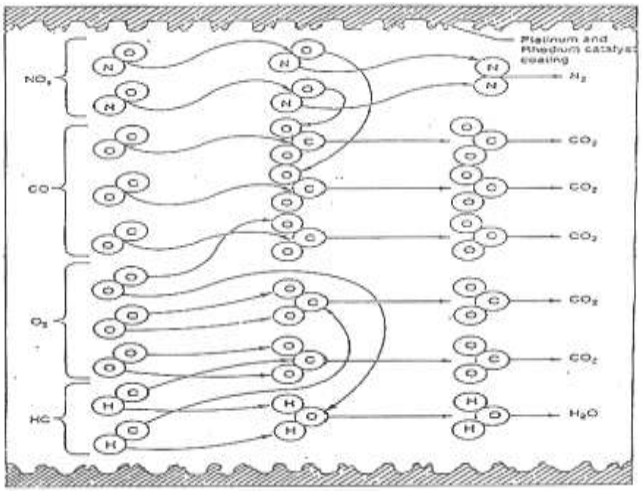


Figure 2.3 N_2, CO_2, and H_2O formed (Source: Heisler, 1995)

2.3 Zeloit

Zeolite is the nature minerals, it is composed of solid crystals known as alumina silicates which is the combination of aluminum (Al), silicone (Si) and hydrated oxygen (O) which is contain of alkali cations or alkaline earth within the framework of the three-dimensional. The framework of the zeolite structure consists of tetrahedral AlO4 and SiO4, each of them is bound with atom O and in the framework of Si4 can be replaced with Al3 (Gates C. Bruce:1992). The existence of the hollow structure causes the ability to exchange cations with the certain pore size, so the zeolite can be used as a molecules filter, ion exchanger, absorbent material and the catalyst.

2.4 Catalyst and Catalystation

Catalyst is a substance that will be able to increase the rate of a reaction and itself won't involved the reaction permanently, and without affecting the reaction equilibrium and composition. Catalysis is a process which help to speed up a reaction, generally catalyst (substance) is not participating in the reaction and will appear as a side product.

2.5 Muffler and Operating Conditions

The production of Catalytic muffler based on the availability of inside space to increase the power, besides its construction.

2.6 Zeloite Selectivity

Adsorbtion process occur on this condition and then go into the pores, this condition is caused by a small diameter. The process takes place continuously and it cause disosiasi, thermal conductivity and the initial characteristic. The zeolite with isomorphic framework substitution tend to select the molecules polar to absorbed, otherwise the non polar molecules will be absorbed by zeolite with comparison of Al and high Si.

1.7 Parameter engine performance

Engine performance consists of power, average effective pressure, fuel consumption and thermal efficiency used to determine the characteristic. The power shows capabilities of an engine to make a movement on a certain distance. The torque shows the ability of the engine to be able to overcome the slip or the result of the results of long multiplication of torque with the load indicated by the dynamometer (Arismunandar, 1994):

$$T = \frac{716{,}2Ne}{n}(kgm)$$

Where :

T = Torque moments produced (kg.m)

Ne = Effective Power (hp)

n = Sequence dinamo meters (rpm)

The specific fuel consumption (SfC) is the number of kilograms of fuel needed every hour machine to produce effective power of 1 hp. The formulation for specific fuel consumption is (Heywood, 1988) :

$$Sfc = \frac{\dot{m}_f}{Ne} \text{ (kg/hp hours)}$$

where :

Sfc = As fuel consumption

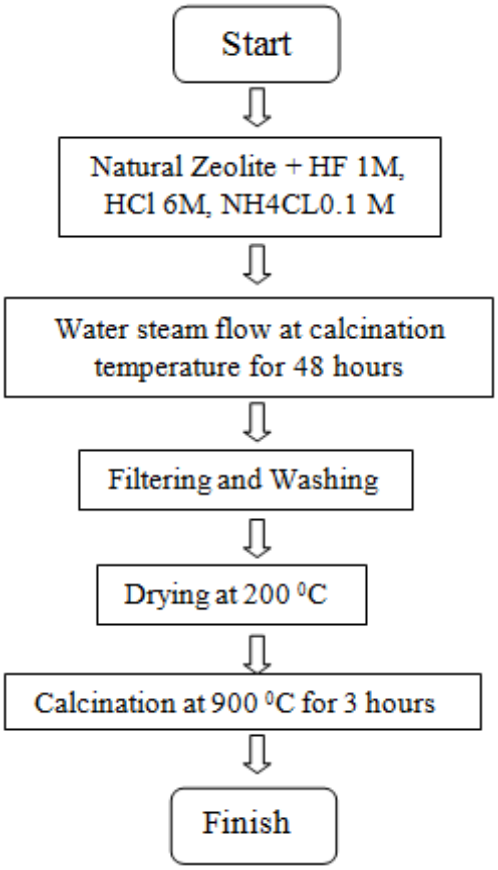
$\dot{m}_f$ = the amount of fuel consumption of each hour (kg/hour)

This research uses an experimental laboratory by comparing between the control group and the test group against standard using laboratory facilities. The equipment for experimental are:

1. The engine1452 cc (Source:www.carinf.com)
   - Bore x stroke : 77mm x 77mm (3,15in x 3,35in).
   - Piston displacemen : 2.563cc (156,4cu in)
   - compression Comparison : 8.5 : 1
   - Max horsepower : 84 HP/5600 barrier rpm
   - Max Torque : 12 kg.m/3600rpm
2. Muffler
   a. The standard exhaust, is the original car exhaust factory standards.
   b. Control exhaust, is the standard exhaust modified.
   c. Test exhaust is the modified control exhaust part it contains packaging package while dimension remains.

Measurement tools used in the experiment are dynamometer, exhaust vent gas analyzer, measurement tools material consumption, this includes gauge displays, Strobotester, Oriface flow meter, Testo data loger 454, manometer ,blower, termokoperl tepe K.

After all the equipment test and measurement tools are prepared, we test the engine. The next step is activating the zeolite with the step as shown below :



The purpose of soaking for acid treatment is to increase the ratio of Si against Al, while stiler used so the zeolite can be mixed evenly and perfect. The leaching by using distilled water used to remove dirt or dirt that carried on, while drying in the oven aims to eliminate the water content which is found in the zeolite filter, expected completely dry. The purpose of calcinations is to activate and open the pores from the granular, so it will be stable at relatively high temperature. Zeolite impregnasi process aim to fill the pores.

Testing for standard groups is the condition when the engine testing using standard exhaust. Control groups, when the engine testing using the modified exhaust without a catalyst. And the test Group 1, when engine testing using the engine exhaust that has been repaired and filled by one package catalyst zeolite. Test Group 2 has the same condition with test group 1 but the extensive of contacts 2 times than test group 1. Test Group 3 contains of packaging package with 3 times than the test Group 1. Test Group 4 contains of 4 packages with mass of 4 times than the test Group 1. Searching for data to be reviewed for each group with this following steps: rotation of the engine, CO gas emissions, lambda, HC emissions, air fuel ratio, the power, fuel consumption time 100cc, temperature inlet and outlet of emmision, round dynamo meter, differences the high of fluida on the manometer.

Engine rotation is 750, 1000, 1250, 1500, 1750, 2000, 2250, 2750, 3000, 3250, 3500, 3750, and 4000rpm. The mass of each catalyst is 200 grams, 300 grams and 400 grams, by using gas emission CO and HC. The process of the test was conducted with turning on the engine during ± 10 minutes.

. After that, the cooling blower is turned on, throttle is opened full then observed on dynamometer. Every change of the engine rotation should be recorded the data of engine rotation, exhaust emissions of CO and HC, exhaust temperatures, lambda, air fuel ratio, fuel consumption time every 100 cc, round dynamo meter, differences of manometer altitudes. At the end of the test, imposition is closed slowly, downgraded the engine round slowly until the idle round, let the engine on the idle rotation, engine off and turn off the blower.

III. RESULT AND DISCUSSION

Results of the comparison from CO emissions when using zeolite packaging and standard conditions for variations of engine rotation when the testing start from 750 until 4000rpm. The standards condition of CO emissions are still high if it is compared with other conditions. One of the reasons is due to the ratio between air and fuel which is not stoichiometric at the early of rotation engine. At that time the mixture is still rich (too many fuel), so the formation of CO and HC is excessive. When the packages packaging contains the zeolite filter 200 (1K), 300 (2K) or 400gr (3K) is installed, occurs reduction of CO emission. The result shows the packaging of 300gr produces the smallest emission, so the energy absorption is huge. The application of modif muffler show the comparison between the condition of standard muffler and modification, the result shows the same tendency. The comparison when the installation of zeolite package on 750 until 1500 rpm emissions produced almost same between the modification condition or the existence of zeolitnya packaging. This condition shows when that time, the zeolite packaging was not working, because if seen from the operating temperature is still ranged between 250 up to 300^{o}C. At that time, the temperature difference before and after out of the package is 14^{o}C. The small difference of temperature and the low operating temperature of the catalyst has not been able to do the adsorption process.

On the engine rotation which is more than 1500 until 2500 rpm produce the differences of emission CO significantly between the modification condition and packaging 300 and 400 grams, and for 200 grams, there is a maximum difference 12,22% of standard. Range of zeolite operating temperature is 300 and 400^{o}C and the temperature differences before and after through the packaging is 62^{o}C. In that time the energy activation is enough so adsorption process can be done. The rotation which is more than 2500 until 4000 rpm, packaging of 300 gram produces the smaller emissions than the packaging of 400 grams, and temperature differences catalyst on the side of the entrance and exit is 88^{o}C. The smallest emissions CO occur on the average of rotation 3500 is 2.11 percent, shown by the gas analyzer, if compared to the packaging of 400 grams there is a reduction occurs 3.65% rpm on 3500 and 27% on 3500 round to the standard. This condition is due to the operating temperature of the catalyst is enough and activated energy to perform the process of adsorption is sufficient, besides that there is an influence of the packaging density, because density is a function of the mass so the mass will influence. Surface area influence the size of the granules, due to the the small granules will increase the surface area and affect the amount of adsorption CO.

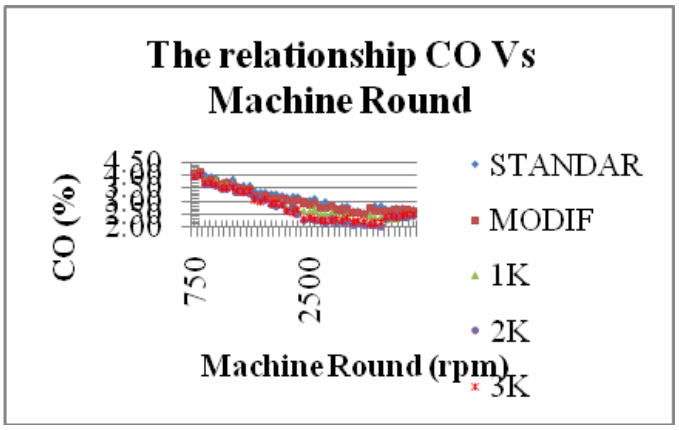


Figure 3.1 Relationship CO on round variations point to point

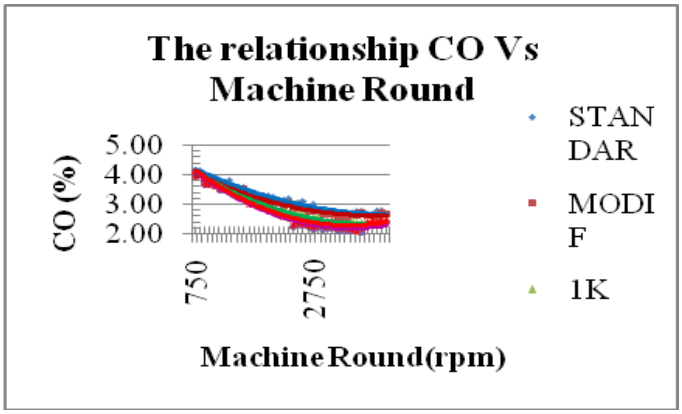


Figure 3.2 Relationship CO on trendline round variations

The results of the comparison unburned hydrocarbon emissions (HC)) on variations of machine rotation when the muffler in standard conditions, modification or zeolite packaging. Variation of machine rotation start from 750 until 4000 rpm, overall there is a tendency in the same emission model on the early where HC formed is high. Up to the certain rotation (3500 rpm) HC formed continues to decline after the engine rotation is more than 3500 occur the increasing of HC, this condition happened because initially the same as the formation of CO is the condition of rich fuel. After that, HC is decreasing due to the rise of temperature in the fuel room, so the fuel can be turned into steam that flammable, as a result, on a distant place the fire can be burned.

When the installation of packages packaging contains the zeolite filter 200 (1K), 300 (2K) or 400 gram (3K) and machine rotation 750 to 1500 rpm emission reduction HC indicated the same gas. If reviewed from the operating temperature of the catalyst is still low so that the catalyst is not working, due to lack of activation energy in the adsorption process. The temperature of the catalyst at that time is 250 until 300^{o}C with the difference of temperature before and after through the zeolite packaging is 14oC as seen in picture 1. On the machine rotation which is more than 1500 until 2500 rpm for packaging contains of 200 and 400 grams HC emissions that can be absorb is almost same, but for packaging of 300 gram there is more adsorption of HC so the measurable emission result is less. For the masses of 200 gram there is a difference of emissions HC 15,94 % toward the standard and temperature differences before and after through the packaging is 62^{o}C. The rotation which is more than 2500 until 4000 rpm, results of HC emissions on 300gram occur decreasing of emissions HC is 34,94% toward the standard at 3250 rpm and catalyst temperature differences entering and exit side is 88^{o}C.

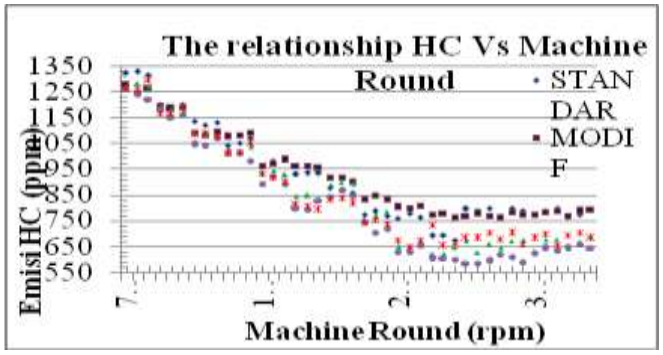


Figure 3.3Relationship HC on round variations point to point

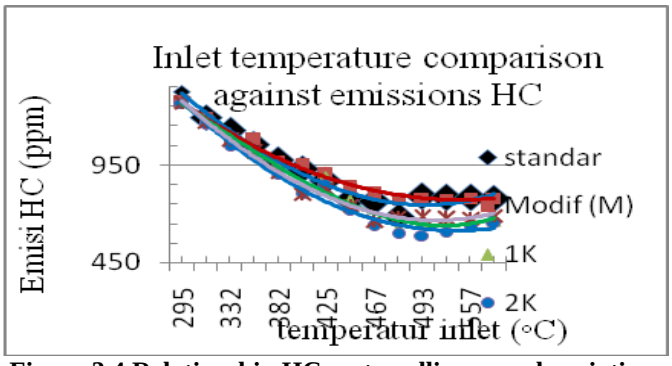


Figure 3.4 Relationship HC on trendline round variations

The smallest fuel requirements for each round variations occur when the packaging contains of the zeolite catalyst with mass of 300 grams. The round condition from 750 until 1500rpm, where maximum consumption fuel fell by 7,47% on 100rpm and minimum is 2.84% on 1250 rpm in packaging of 300grams toward the standard. On 1500 until 2500 rpm, maximum consumption fuel fell by 14.97 percent on 2500 rpm and minimum on the packaging of 300grams toward the standard is 2500 rpm. The rotation from 2500 up to 4000 rpm, maximum consumption fuel fell by 13.73% on 2750 rpm and minimum is 0.56 % on 3500 rpm for packaging of 300 grams toward the standard. On the rotation from 2500 until 4000 rpm occur the reduction of maximum fuel consumption is 18.92 percent and minimum is 12,69 at 2000 rpm for packaging of 300 grams toward the standard.

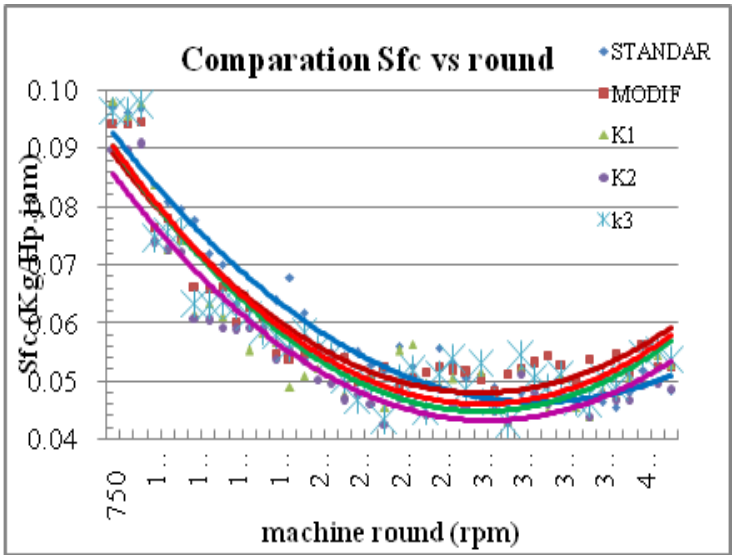


Figure 3.5 Relationship SFC on trendline round variations

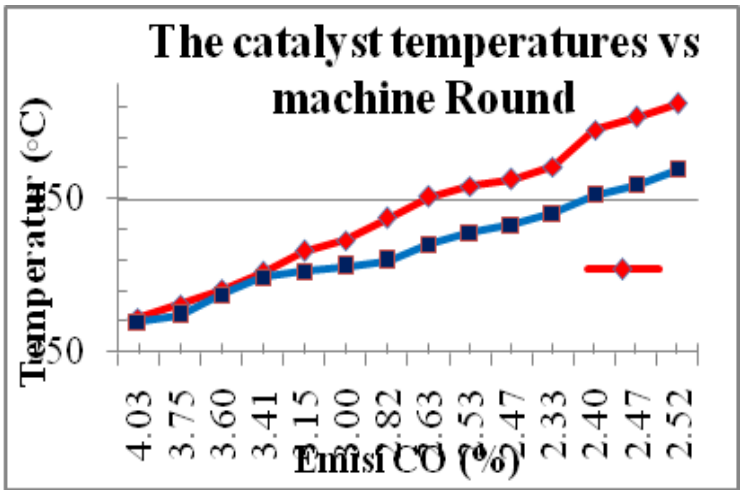


Figure 3.6 Temperature of catalys

IV. CONCLUSION

The optimum capabilities of zeolite packaging to reduce CO for packaging of 200 grams is 14,61% on 2750 rpm, for the masses of 300grams is 27.35 percent on 3500 rpm, and packaging of 400grams is 25,28% on 2750rpm toward the standards. The optimum temperature of zeolite catalyst before entering the muffler is 500oC and out is 435^{o}C. The optimum capabilities of zeolite packaging to reduce CO for packaging of 200 grams is 14,61% on 2750 rpm, for the masses of 300grams is 27.35 percent on 3500 rpm, and for the mass of 400 grams is 25,28% on 2750 rpm toward the standards. The optimum temperature of zeolite catalyst before entering the muffler is 500^{o}C and out is 435^{o}C. The increase of fuel consumption toward the standard for packaging of 200 grams is 0,83% on 3500 rpm, for the masses of 300 grams is 0.56% on 3500 rpm, and for the masses of 400 grams is 0.54 percent on 1500 rpm toward the standards.

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