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DETECTION OF EMISSION OF EXHAUST GASSES AND POLLUTION CONTROL THROUGH REDESIGNING THE CATALYST CONVERTOR AND ENHANCED HEAT TRANSFER TECHNIQUE

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Abstract— **In the below presented work the harmful effects of the gasses emitted by the combustion of the fuel in the engine is being discussed. The efficiency of the engine is also being considered for the twisted tapes type of the heat exchanger is being used in the engine for the better heat transfer and also it helps in complete consumption of the fuel in the engine as the heat transfer rate is being increased. The case of emission of the harmful gasses is being considered and the same is being reduced using the three-way catalytic convertor is equipped with fine copper nano-particles which actually speed up the reaction process and also provides increased surface for the chemical reactions to occur. Two different types of reactions are considered in the three-way catalytic convertor in which the harmful gasses are reduced into the gasses which are comparably less harmful to the lives and nature. The paper is segmented as section I considers the brief introduction of the topic like catalytic convertor and heat exchanger, section II considers the literature review in the field, section III describes the Issues and challenges, section IV describes the Proposed Methodology and section V is all about the comparison results of the work.**

Keywords— Catalytic Convertor, Catalyst, Reduction, Oxidation, Heat Exchanger, Fins, Twisted tapes, Gasses

I. INTRODUCTION

The internal combustion of the vehicles is the major cause of the pollution in air. The conversion of the gasses released by the combustion of the engine is the better approach to reduce the air pollution before the gasses are released in the air. That means the pollution created by the mobile sources are the major cause of the air pollution in the present scenario. If we talk about the automobile industry then the industry is fast growing part of the world and around 50 million vehicles are being manufactured every year and usage of the vehicles is around 70 million per year, which will grow up to 1300 million in the coming decades if the industry is running in same speed. The exhaust of the vehicles produces many harmful gasses in air which includes nitrogen oxide with around 10,037168 tons of release and second is the carbon dioxide with 59,383,083 tons of release in air by vehicles and the study is of year 2008. By these it can be stated that the pollution in air from these sources is the major problem to the world. Rao et. al., H.V.N Rao, Kathuria et.al., Hickey et. al. [1, 2, 3, 2003].

The emission of the harmful gasses from the exhaust of the vehicles is due to the fact that the fuel is not completely combusted. The incomplete combustion of the fuel in the vehicles is affected by many factors like vehicles running conditions, conditions for combustion, composition of the fuel and the fuel to the air ratio. The emission of the harmful gasses increases when the combustion process of the vehicle is not in good condition. The gasses emitted from the exhaust of the vehicles generally contains the particles of lead, carbon monoxide and many more polluting particles. The inhalation of the such kind of pollutant which are being released in the air causes many diseases to the humans like breathing problem, problems related to the skin, and for that the results can be fatal. The excess release of carbon dioxide in air increases the atmospheric temperature and results in global warming.

As the human releases carbon dioxide while completing its respiratory process as they intake oxygen and releases CO2, apart from humans the major part of the CO2 present in the environment is from the exhaust of the vehicles. Along with CO2 the vehicles also emit carbon monoxide which also considered as the toxic gas for the human and pollutes the air. The effect of the release of the harmful gasses can be reduced by using the catalytic convertor which actually converts the harmful gasses into the gasses which are less harmful to the atmosphere.

Catalyst convertor is being used in the different fuel engine which actually converts the harmful gases emitted from the engine in less harmful gasses. The major attention in the work

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proposed is given to the exhaust process of the used passenger cars. The gasses emitted by the vehicles exhaust are converted into other forms which are less harmful to the air by the means of the catalyst which helps the gasses emitted to react and converted into some other form of gasses such that they less polluting. The different reactions occurring are termed as the reduction and oxidation of the gasses. The catalytic convertor can be used in the engine which are running using fuels like petrol, diesel and even for the kerosene operated stoves and heaters Patel et. al. [4, 2012].

The proposed work uses two different techniques as first one the heat exchanger for the better transfer of the heat and catalytic convertor. The process used form the conversion of fluid into other form is known as heat exchanger. Under this process the fluid is separated from the solid walls to resists mixing or to prevent them from the direct contact. They are frequently used in the space heating, cooling, air, acclimatizing, power station, chemical plants, petrochemical plants, fuel refineries, waste treatment. The ancient example of a heat exchanger is an internal combustion engine in which the revolving fluid is called as coolant flows by the way of radiator coils and air flows past the coils, which cools the coolants and heat the coming air. Heat sink is another example which is popularly known as passive heat exchanger that transfers the heat emerged out from the electronic devices to a fluid medium, and also to the air and fluid coolant.

On the basis of the flow of electrons there are three primary division of heat exchangers. In parallel flow heat exchangers, under this classification the two liquids flow in the parallel format one in one side and other in the other ends. In counter flow heat exchangers under this type of flow two fluids flow in the opposite direction. The opposite current pattern is the most efficient, because of the higher heat average temperature it can convert the most heat from the heat medium per unit. Look like as counter current exchange. In a cross-flow heat exchanger, the liquid travel roughly in a ninety-degree way via the exchanger Sinnot et. al., Richardson's et. al. [5,1999].

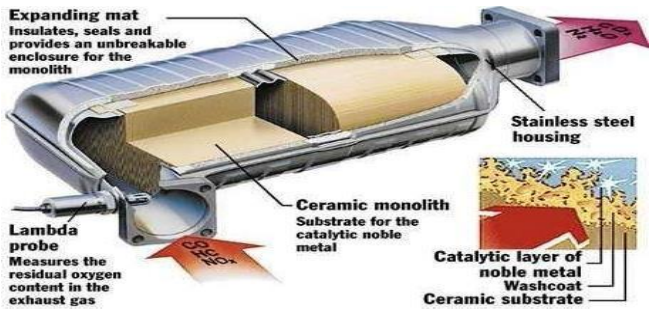

Fig. 1 Cross-sectional view of catalytic convertor

The different modules of the catalytic convertor are as discussed below:

Core – In the catalytic convertor used now the core is just like a honeycomb of ceramics, along with this the honeycomb made of foils of stainless steel are also used as the core. The purpose of using the honeycomb in the catalytic convertor is just to provide surface for the reactions to occur for the transformation of the gasses as shown in Fig.1.

Washcoat – The washcoat is made up of the mixture of the silica and alumina and it adds efficiency to the catalytic convertor. When the washcoat is used with the core then the rough surface is obtained which provides more surfaces for the reactions and more active sites of metal are provided. Before applying the washcoat to the core the catalyst is added to the washcoat.

Catalyst- Catalyst is defined as the metal which is being used to speed up the reactions or for reacting the gasses and is considered as precious in the catalytic convertor. In the most of the catalytic convertors the platinum is used as catalyst and the platinum is not considered as suitable for all of its applications because of the cost factor and the unwanted reacting capacity of the metal.

When the gasses are transformed from one form into the another by burning the gasoline some short of energy is being released which highly depends on the ratio of air and gasoline. Below is the representation of amount of energy released on the formation of specific compound and the energy given is for the formation of single molecule of any compound.

Carbon monoxide CO = 110.5 KJ/mole (releases heat / exothermic)

Carbon dioxide CO_2 = 393.5 KJ/mole (releases heat/exothermic)

Water (steam) H_2O = 241.8 KJ/mole (releases heat / exothermic)

Unburned fuel HC = 0.0 KJ/mole (releases heat / exothermic)

Nitric oxide NO = -90.4 KJ/mole (absorbs heat / endothermic)

II. RELATED WORK

This segment of the paper explains the related work on WSN which specifically talks about the security issues related to the power exhaustion.

The two-way convertor is also termed as the oxidation convertor and goes for two tasks as [6]:

1. Oxidation of carbon monoxide to carbon dioxide: $2CO + O_2 \rightarrow 2CO_2$
2. Oxidation of hydrocarbons (unburned and partially burned fuel) to carbon dioxide and water: $C_xH_{2x+2} + [(3x+1)/2]\ O_2 \rightarrow xCO_2 + (x+1)\ H_2O$ (a combustion reaction)

Two-way catalytic convertor is being for the reduction of the different hydrocarbons and the carbon monoxide emitted from the exhaust of the vehicles. Upto 1981 the two-way catalytic

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convertor was used in the American and Canadian automobile industry. The two-way catalytic convertor fails to convert the different oxides of the nitrogen that are emitted in the exhaust of the vehicle.

The three-way catalytic convertor considers the oxidation process for the conversion of carbon monoxides CO and hydrocarbons HC and the reduction process is being involved for the conversion of the different oxides of nitrogen NOx. The active phase of the three-way catalytic convertor involves the usage of some noble metals. Because of the activity and selectivity of the Pd for hydrocarbons the and the cost of the Pd makes it attractive catalyst. For the conversion of the NO to N2 which involves the reduction process the rhodium and some other constituents are broadly used as catalyst. The efficiency of the three-way catalytic convertor decreases when the temperature goes beyond 600C, Ferrando et. al., Jellinek et. al. [7,2009].

In three-way catalytic convertor the major is the oxidation of the HC and CO, and the reduction of the different oxides of the nitrogen NOx. The TWC also involves the gas shift of water and reactions for steam reforming, some intermediate compounds are generated like N2O and NO2. The NOx storing concept is based on combination of a storage component into the three- way catalyst (TWCs) to store NOx during lean conditions for a time period of minutes Bergles et. al., Brown et. al., Sinder et. al. [10,1971]. The chemical representation of the different reactions occurring in the three-way catalytic convertor:

Oxidation

$2CO + O_2 \rightarrow 2CO_2$

$HC + O_2 \rightarrow CO_2 + H_2O$

Reduction/three-way

$2CO + 2NO \rightarrow 2CO_2 + N_2$

$HC + NO \rightarrow CO_2 + H_2O + N_2\, 2H_2 + 2NO \rightarrow 2H_2O + N_2$

Water Gas Shift

$CO + H_2O \rightarrow CO_2 + H_2$

Steam reforming

$HC + H_2O \rightarrow CO_2 + H_2$

Kalinin et. al. and Yarkho et. al. [8,1966] in their work considered the range of fluids from $1500 \leq Re \leq 400,000$ and $7 \leq Pr \leq 50$ for evaluating the impact of the Reynolds and also of the number of the Prandtl over the efficiency of the heat exchanger for the internal tubes which are outlined smoothly. The groove height which was traversed was considered in the range of $0.983 \leq d/D \leq 0.875$, (where d represents the tip diameter of the tip of the fin and D represents the internal diameter), the nominal diameter of the pipe and maximum spacing of the grooves are just equal. The number of Reynolds which are being considered as critical dropped 1580 from 2400 at $e/D = 0.875$ and the diameter of the pipe of the tube which is being grooved is just double to that of the spacing of the fin, the coefficient of the heat transfer rises upto 2.2 time that computed as the minimum value. As per the author the behaviour of the Nusselt number for the tested range of Prandtl numbers is independent of the Prandtl number.

Vasilchenko et. al. and Barbaritskaya et. al. [9, 1969], described the outcomes of the transfer of heat and drop of the pressure in the case of the flow of the oil in the turbulent where the straight finned tunes are considered with $4 \leq N \leq 8$ and $0.13 \leq e/D \leq 0.3$, for an operating condition range of $103 \leq Re \leq 104$ and $70 \leq Pr \leq 140$. On the analysis done in the work it can be stated that the rate of the transfer of the heat is increased to something like 30% to 70% as compared to that in the case of the smooth tubes of the fin. The author has also considered factor for friction and also the number of Nusselt in their work.

Bergles et al. [10,1971], in their work described the information about the drop of the pressure in the case of the straight and also for the spiral designed tubes of fins with height 0.77 to 3.3 mm in the water was considered as the fluid for working and also for investigating. The hydraulic diameter was considered as the major factor for deciding the Reynolds which actually ranged from 1500 to 50000. Laminar to the flow of the turbulent was considered for the information about the factors of the friction and represented that the correlations of the smooth tube friction factors might also be used in the region of turbulent for finned tubes which are under test.

Ray et. al. and A. W. Date [11, 2001] presented a survey for characteristics of the transfer of heat by inserting the tubes. On the basis of the analysis made by the author it was quite clear that the insertion of the twisted tapes just enhances the transfer of heat in the flow of the turbulence and also decrease in the drop of pressure. The frictional factor is rises concurrently in the case of the insertion of the conical rings and comparison is made with the tubes with plain surface.

P. Promvonge and S. Eiamsa-ard [12,2007] in his investigation analyzed the impact of AL2O3/water nanofluids in convective heat transfer. In his work author considered the transfer of turbulent flow convection of Al2O3/water nanofluid within the annular tubes where the boundaries temperature variables were experimentally analysed. Which we have review the Nusselt numbers of nanofluid they obtained for various heat fluxes which are in the range of 0 - 60 and Nusselt number increases with increase in heat flux. The range of the number of Reynolds is 3500 to 11500 and a concentration of the nan-particles is also to be considered in range 0.25%-1% as per the pressure of the atmosphere. They found increment in the coefficient of the transfer of heat in water and also rise in the concentration of nan-particles also rises the flux heat and also with rate of the flow.

III. ISSUES AND CHALLENGES

- Improper Heat Transfer generated from engine working and combustion of fuel,
- Emission of Toxic Gases,
- Release of excess heat in Environment,

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- Detection and Optimization of the Heat transfer and gasses released,
- Increasing the running time of the engine oil.

IV. RESEARCH METHODOLOGY

In this paper a new technique for catalyst convertor is being discussed and the same is entitled as "Detection of Emission of Exhaust Gasses and Pollution Control through redesigning the Catalyst Convertor and enhanced heat transfer technique" which is used to minimize the emission of the harmful gasses from the exhaust of the vehicles and other similar engines working on fuel and emits gasses. Three-way catalytic convertor is used where the catalyst for speeding the chemical reactions of the gasses emitted by the exhaust of the vehicles is being incorporated, the nano-materials are used as the catalyst which increases the surface for the reaction to occur. The heat transfer rate or the heat exchange is increased using the twisted tapes for the better exchange of heat generated by the combustion of fuel. By doing this actually the gas emitted will be reduced as the exchange rate of heat is increased which will affect the performance of the engine's efficiency.

The three-way catalytic convertor considers the oxidation process for the conversion of carbon monoxides CO and hydrocarbons HC and the reduction process is being involved for the conversion of the different oxides of nitrogen NOx. The active phase of the three-way catalytic convertor involves the usage of some noble metals. Because of the activity and selectivity of the Pd for hydrocarbons the and the cost of the Pd makes it attractive catalyst. For the conversion of the NO to N2 which involves the reduction process the rhodium and some other constituents are broadly used as catalyst. The efficiency of the three-way catalytic convertor decreases when the temperature goes beyond 600C.

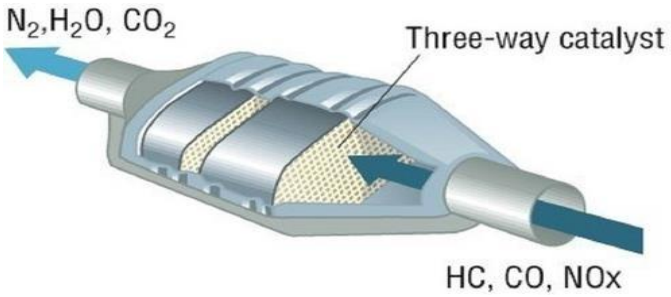

Fig. 2 Block diagram of the three-way catalyst convertor.

Just because of the diverse applications in various fields of the nano particles have been considered as major point of research now a days as it has some special properties. As the cooper metal have many advantages as catalyst hence is considered at most in the recent days, the cooper because of its catalytic, optical, conducting properties is the best for many applications. For the better generation of the nano-particles of the copper several techniques have been developed like thermal reduction, vapour synthesis of the metal, different methods of radiation, methods of micro- emulsion, laser ablation, mechanical ablation and different chemical reductions. For the purpose of speed in the reaction process the fine particles of cooper metal are used which is considered as the heterogeneous catalyst. The fine particles of the metal catalyst provide more surface area hence more reactions can occur at the surface of the catalyst as shown in Fig.2. In the case when the fine particles of any metal is being considered as the catalyst then it is quite easier in the retention of the different activities as compared to that in the case of the bulk particles of the metal which is being used as the catalyst.

Two different roles are played by these catalysts in the overall process as they can provide better support for the catalytic process and can act like a site for the same, so as to prevent the nano-particles from decomposition they are used mild conditions. The catalytic convertor is defined as the device which converts the gasses emitted by the exhaust of the vehicles and other related engine into lesser harmful gasses using some sort of catalyst and other requirements. Installation of the kind of catalytic convertor is based on the purpose for which it is installed inside the tailpipe of the vehicle.

The catalytic convertor using the nano particles as catalyst work on the principle that the surface area of the nanoparticles and the radius of the nano particles are inversely related to each other the surface area of the nano particles also represents the volume of the nano particles. The surface area and the volume of the nano particles are taken in the form of the ratio and on decreasing one factor will increase the other one that means so as to provide more and more surface area for the reaction of the different gasses and the catalyst we need to reduce the radius of the nano particles of the catalyst as they are inversely proportional to each other. Traditionally the liquid phase methods hold on the

room temperature conditions in the natural crystallization process so as form the material for the metal oxide. The material obtained fails to have the larger surface area as when the temperature of the engine and the exhaust goes high as the temperature of the exhaust of the vehicle can go up to 750-degree Celsius. The nano-particles are also produced using the techniques of flame combustion. Different oxidization conditions are required for running the fuel combustion process, temperature should be kept low, the plasma- based technologies are also the part of this research. Both of these features introduce limitations in the array of materials that can be created.

The need to develop efficient heat exchangers has been partially fulfilled by using increased heat transfer rates. In the system incorporation of the heat exchanger the entropy deciding and also setting some minimum limit for the destruction of the power. The major challenge in the design phase of the heat exchanger device is to make it as compact as possible and also to enhance the transfer rate of the heat.

To enhance the heat transfer rate for the equation of heat transfer is $Q = h.A.\ \Delta T$. In this equation we increase the heat transfer mean we want to increase the Q i.e. heat transfer rate we need to increase (h, A, ΔT) these parameters after that the heat transfer rate increases but in this equation the h i.e. heats

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transfer coefficient. And ΔT i.e. change in temperature these two terms we can't increases hence only one parameter we increase i.e. A to improve the heat transfer rate if A increase then and then Q increase hence for improving area, we use the fin are the extended surfaces and inserts the twisted tape. The twisted tapes are been applied at the passage of flow and the same also reduces the diameter of the passage of the device. Heat transfer rate increases with the help of twisted strips as shown in Fig.3. The rate of transfer of heat is being increased just because of blocking at the passage of the flow and the same results in the segmentation of the flow. Just because of the increment in the passage blockage the pressure drop also rises and leads to the viscous effect, as the free flow area is being increased as per S. Eiansa-ard, Thianpong and P.Promvonge, [13, 2006].

Where,

Q is the total heat transfer,

H is the heat transfer coefficient,

A is the convective heat transfer area and
T is the temperature.

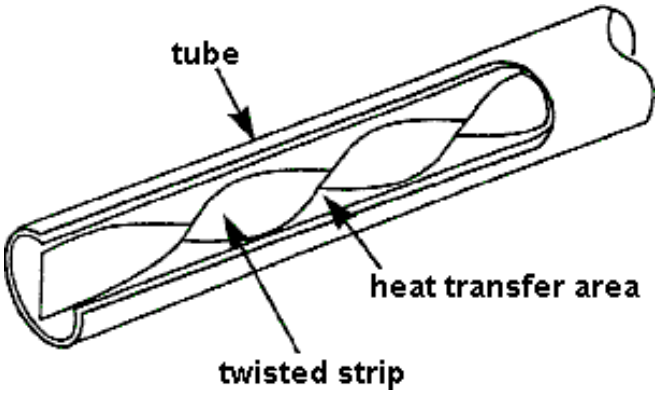

Fig. 3 Twisted Tapes.

The complete methodology works for the better combustion of the fuel in the engine and also for improving the efficiency of the engine, in the case when the heat transfer is being increased then the combustion of the fuel will be more efficient and the better exhausted fuel emits less harmful gasses and after also if there are some remaining harmful particles in the emission then same are converted in the less harmful particles using the catalytic convertor which actually increases the reaction surface area and also provides better catalyst to speed up the conversion and better conversion of the gasses.

V. OUTCOME OF THE RESEARCH

In the experimental results the proposed algorithm ***"Detection of Emission of Exhaust Gasses and Pollution Control through redesigning the Catalyst Convertor and Enhanced Heat Transfer Technique"*** is compared with the other models for catalytic convertor for reducing the emission of the harmful gasses like the two-way catalytic convertor, three-way catalytic convertor, reduction catalytic convertor and oxidization catalytic convertor. Certain factors are being considered for the comparison of the different methodologies of the catalytic convertor like metal used as catalyst, oxygen storage, surface area for reaction, etc.

On the basis of above Table 1 which shows the comparison of different catalytic convertor with the proposed methodology on the basis of certain factors like surface area, catalyst used, oxygen storage, etc. As per the experimental results shown in the Table 1 the following statements may be made that the proposed methodology is better than the other discussed methodologies as more surface area is being provided for the reaction to occurs means the larger surface will speed up the reaction or conversion process.

TABLE I

Comparison Table 1.

No.	Algorithm	Metal used as Catalyst	Surface Area	Oxygen Storage	Heat Transfer Technique
1	Two- way catalytic convertor [18]	Oxidation	Less	Yes	N/A
2	Three- way catalytic convertor [18]	Pd	Less	No	N/A
3	Oxidization catalytic convertor [24, 26]	Oxidation	Less	Yes	N/A
4	Proposed Model	Nano-particles of copper and Twisted Tapes	Increased	Yes	A

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After going through the data observed in the Table 4.2 it can be stated that the amount of CO in the exhaust of the vehicles have been reduced and changes are been seen on the basis of changing the rpm of the engine, by using the nano-particles coating of the copper the amount of hydrocarbon released also decreases. The values shown with respect to the CO carbon monoxide and the HC hydrocarbons are represented PPM (Parts Per Million).

Table 2 (Comparison)

S.No.	Ordinary PPM		Nano Copper coated PPM	
	HC	CO	HC	CO
1.	High	High	High	High
2.	High	High	Average	Low
3.	Lowered	Medium	Medium	Average
4.	Lowered	Medium	High	Low
5.	Lowest	Low	Low	Average

Table 3 (Comparison)

No.	Algorithm	Heat Exchanger Rate	Fuel Efficiency	Emissio of gasses
1	Two-way catalytic convertor [18]	Lower	Medium	Harmful
2	Three-way catalytic convertor [18]	Lower	Medium	Harmful
3	Oxidization catalytic convertor [24, 26]	Lower	Medium	Medium
4	Proposed Model	Lower	High	Less Harmful

VI. CONCLUSION

The heat transfer in the overall combustion process helps in the proper transfer of power and also helps in the combustion of the fuel. The twisted tapes increase the size or surface for the heat transfer which facilitates the engines to absorb the maximum power generated by the fuel combustion. Just because of the fact that the sparks and piston and other related parts of the engine have maximum time for the transfer of power which actually results in the movement of the piston. The basic functionality of the catalyst is to speed-up the chemical reactions and also at the same time it also absorbs the activation energy which is quite less in the case of the un-catalytic reactions. In the work presented in the dissertation, copper is being used catalyst due to the major chemical properties of the copper as cost wise, convertibility into finer particles, structure of the copper particles allows better chemical conversions and also the capability to absorbs the molecules. As the copper reacts to major of the gasses emitted in the exhaust of the vehicle and also converts some into less harmful one and also the capability of the copper particles to absorb the molecules reduces the level of the pollution by the exhaust of the vehicle while the process of the combustion of the fuel.

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