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Increase Engine Efficiency by Using Inlet Air Preheating Method through Exhaust Gas Temperature with Convective Mode of Heat Transfer

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Abstract: ***Now a days we are facing a lot of problems with respect to fuel demand. A common problem is how to increase engine efficiency? and how to manage the fuel economy?. Etc...So, the objective of this project work was to gain a better understanding of the efficiency characteristics of engine with inlet air pre heater. For this purpose, the effect of inlet air pre heater orientations, no. of testing, types of sophisticated fuel, types of material used for the purpose of inlet air pre heater. have been investigated. In the sample preparation the experimental setup designed with IAP. Results shows that efficiency properties in terms, of mechanical efficiency, brake thermal efficiency, indicated thermal efficiencies are increased mainly depending upon the IAP orientations followed by the number of trails. Hence compared to without IAP the difference were not highly significant. The results indicate that the efficiency property of engine setup with IAP is generally slightly greater than engine setup without IAP setting. It may be due to thermal phenomenon like that convective heat transfer mode. it can be conclude that the order of efficiency properties of engine setup with IAP is greater than efficiency properties of engine without IAP. In addition, the efficiency difference was not highly significant.***

Keywords: fuel economy, IAP orientation, sophisticated fuel, convective heat transfer, slightly significant

1. Introduction

Recent trend about the best ways of using the deployable sources of energy in to useful work in order to reduce the rate of consumption of fossil fuel as well as pollution. Out of all the available sources, the internal combustion engines are the major consumer of fossil fuel around the globe. Out of the total heat supplied to the engine in the form of fuel, approximately, 30 to 40% is converted into useful mechanical work. The remaining heat is expelled to the environment through exhaust gases and engine cooling systems, resulting in to entropy rise and serious environmental pollution, so it is required to utilized waste heat into useful work. The recovery and utilization of waste heat not only conserves fuel, usually fossil fuel but also reduces the amount of waste heat and greenhouse gases damped to environment. It is imperative that serious and concrete effort should be launched for conserving this energy through exhaust heat recovery techniques. Such a waste heat recovery would ultimately reduce the overall energy requirement and also the impact on global warming. The Internal Combustion Engine has been a primary power source for automobiles and automotives over the past century. Presently, high fuel costs and concerns about foreign oil dependence have resulted in increasingly complex engine designs to decrease fuel consumption. For example, engine manufacturers have implemented techniques such as enhanced fuel-air mixing, turbo-charging, and variable valve timing in order to increase thermal efficiency. However, around 60-70% of the fuel energy is still lost as waste heat through the coolant or the exhaust. Moreover, increasingly stringent emissions regulations are causing engine manufacturers to limit combustion temperatures and pressures lowering potential efficiency gains.

Given the importance of increasing energy conversion efficiency for reducing both the fuel consumption and emissions of engine, scientists and engineers have done lots of successful research aimed to improve engine thermal efficiency, including supercharge, lean mixture combustion, etc. However, in all the energy saving technologies studied. Engine exhaust heat recovery is considered to be one of the most effective. Many researchers recognize that Waste Heat Recovery from engine exhaust has the potential to decrease fuel consumption without increasing emissions, and recent technological advancements have made these systems viable and cost effective

This paper gives a comprehensive review of the waste heat from internal combustion engine, waste heat recovery system and methods of waste heat recovery system through heat transfer with convection mode.

2. Possibility of Heat Recovery and Availability from I.C. Engine

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then “dumped” into the environment even though it could still be reused for some useful and economic purpose. This heat depends in part on the temperature of the waste heat gases and mass flow rate of exhaust gas. Waste heat losses arise both from equipment inefficiencies and from thermodynamic limitations on equipment and processes. For example, consider internal combustion engine approximately 30 to 40% is converted into useful mechanical work. The remaining heat is expelled to the environment through exhaust gases and engine cooling systems.

It means approximately 60 to 70% energy losses as a waste heat through exhaust (30% as engine cooling system and 30 to 40% as environment through exhaust gas). Exhaust gases immediately leaving the engine can have temperatures as high as 842-1112°F [450-600°C]. Consequently, these gases have high heat content, carrying away as exhaust emission. Efforts can be made to design more energy efficient reverberatory engine with better heat transfer and lower exhaust temperatures; however, the laws of thermodynamics place a lower limit on the temperature of exhaust gases. These tests are used to determine the actual performance of the engine.

1. Indicated Mean Effective Pressure
2. Indicated Power
3. Brake Power
4. Mechanical Efficiency
5. Fuel Consumption
6. Air Consumption
7. Thermal Efficiency
8. Volumetric Efficiency
9. Heat Balance Sheet

To Find Area of Orifice;

$A = \pi d_0^2/4\ m^2$
$=3.14x0.018^2/4$
$=0.000254\ m^2$

To Find Head of the Water

$^{H}{}_{a} = H_w x1000/\rho_a$ m of water
=0.57x1000/1.2
=475 m of water

To Find Mass of Air;

$M_a = A_O x c_d x3600x\rho_a x(2xgxH_a)^{1/2}$ kj/hr
$=0.00025x0.62x3600x1.2x(2x9.81x475)^{0.5}$
=64.642 kj/hr

To Find Brake Power;

$B_p = 2\pi N$ x Wx(R+r)x9.81/60000 kw
=2x3.14x1400x1x(0.15+0.0095)x9.81/60000
=0.229 kw

To Find Mass of Fuel Consumption;

$M_f = 3600x\rho_f/t_1x1000$
=3600x0.85/10x10000 kj/hr
= 0.306 kj/hr

To Find BSFC;

BSFC $=M_F/B_P$ kj/kw-hr
=0.392/0.26
=1.508 kj/kw-hr

To Find Air Fuel Ratio:

$A_F = M_A/M_F$ (no unit)
=64.642/0.306
=211.248 (no unit)

To Find Friction Power:

F_P = 2 KW (according to M_F V_S B_P graph)

To Find Indicate Power:

$I_P = F_P + B_p$ KW
=2+0.26
=2.26 KW

To Find Brake Thermal Efficiency:

$\sum_{BT} = B_p x3600x100\%/(M_F\ Xcv)$
=0.26x3600/(0.306x41800)
=7.31%

To Find Indicated Thermal Efficiency:

$\sum_{IT} = I_P\ x3600x100\%/(M_F\ Xcv)$
=2.26x 3600x 100%/(0.306x41800)
= 63.61%

To Find Mechanical Efficiency:

$\sum_{MECH} = B_P/I_P$
= 0.229/2.229
= 10.273%

To Find Heat Carrying Away Cooling Water:

$H_C = M_W\ x\ C_{pw}\ x(T_2-T_1)$ kj/hr ------------(1)
But,
$M_W = t_2\ x3600/(36x1000)$ kg
=3.6 kg------(2)
(2) put in (1),
H_C =3.6x4.186x 1
=15.0552kj/hr

To Find Heat Carrying Away Exhaust Air:

$H_E = M_E x C_{PE}\ x\ (T_4-T_3)$ kj/hr-------(3)
But, $M_E = M_a + M_F$ kg/hr
=64.642+0.306
=64.948 kg/hr--------------(4)
(4) put in (3),
H_E =64,948x1.005x(95-30) kj/hr
=4242.728 kj/hr

Find Heat Input:

$H_I = M_F x C_V$ kj/hr
=0.306x 41800
=12790 kj/hr
We know that,
% of heat input= heat input x100%/ heat input
= 12790 x100%/12790
=100%

To Find Heat Converted in to Useful Work:

$H_b = B_p x3600$ kj/hr
=0.229x3600
=824.4 kj/hr
We know that,

% of heat converted in to useful work= heat converted in to useful work x100%/ heat input
= 824.4 x 100%/12790
=6.44%
Similarly,
% of anything of heat constant = the particular heat value x 100%/ heat input

To Find Heat Carrying Away Cooling Water:

$H_C = M_W \times C_{pw} \times (T_2 - T_1)$ kj/hr--------(1)
But,
$M_W = t_2 \times 3600/(36 \times 1000)$ kg
=3.6 kg-------------(2)
(2) put in (1),
H_C =3.6x4.186x 1
=15.0552kj/hr

To Find Heat Carrying Away Exhaust Air:

$H_E = M_E \times C_{PE} \times (T_4 - T_3)$ kj/hr------(3)
But, $M_E = M_a + M_F$ kg/h
=64.642+0.306
=64.948 kg/hr-----------(4)
(4) put in (3),
H_E =64,948x1.005x(95-30) kj/hr
=4242.728 kj/hr

To Find Unaccounted Losses:

$H_{UN} = H_I - (H_b + H_C + H_E)$ kj/hr
= 12790-(824.4+15.0552+4242.728)
=7707.8168 kj/hr

To Find Total Heat:

$H_T = H_b + H_C + H_E + H_{UN}$
=824.4+15.0552+4242.728+7707.8168
=12790 kj/hr
In terms of %,
% of H_T =(% of H_b+% of H_C+ % of H_E+% of H_{UN})
= (6.445+ 0.118 + 33.172 + 60.26)%
= 99.9950%

OBSERVATION WITH INLET AIR PREHEATING

Manometer reading in cm		Spring load in kg	Speed of pulley in rpm	Time for 10cc of fuel taken in sec	Time for 500cc of water taken in sec	Temperature readings in °c			
						Cooling water inlet temp	Cooling water outlet temp	Inlet air temp	Exhaust air temp
h_1	h_2	S_1	N	t_1	t_2	T_1	T_2	T_3	T_4
23	80	1.0	1400	10	36	28	29	30	095
23	80	1.5	1370	10	36	28	30	33	108
23	80	2.0	1300	09	36	28	30	35	114
23	80	2.5	1250	09	36	28	30	35	120

HEAT BALANCE SHEET WITH INLET AIR PREHEATING

Heat input in (H_I)		Heat converted useful work (H_B) in		Heat carrying away cooling water (Hc) in		Heat carrying away Exhaust (H_E) Iin		Un accounted losses (H_{un}) in		According to heat balance sheet (h_T) in	
KJ/hr	%	KJ/hr	%	KJ/hr	%	KJ/hr	%	KJ/hr	%	KJ/hr	%
12790	100	0936	7.318	15.0552	0.118	4242.72	33.172	7596.22	59.39	12789.995	99.999
12790	100	1368	10.696	30.110	0.235	4895.45	38.272	6496.44	50.79	12789.996	99.997
14212	100	1814.4	12.76	30.110	0.212	5156.54	36.281	7210.95	50.73	14212.000	100.00
14212	100	2210.4	15.553	30.110	0.212	5551.08	39.052	8240.41	57.98	14211.994	99.999
15967.6	100	2631.6	16.48	30.110	0.189	5750.72	36.014	7555.17	47.31	15967.455	99.999

Benefits of Waste Heat Recovery:

Reduction in equipment sizes: Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gas produced. This results in reduction in equipment sizes.

Reduction in auxiliary energy consumption: Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption

Possibility of Waste Heat from Internal Combustion Engine Today‟s modern life is greatly depends on automobile engine, i.e. Internal Combustion engines. The majority of vehicles are still powered by either spark ignition (SI) or compression ignition (CI) engines. CI engines also known as diesel engines have a wide field of applications and as energy converters they are characterized by their high efficiency.

Availability of Waste Heat from I.C. Engine The quantity of waste heat contained in a exhaust gas is a function of both the temperature and the mass flow rate of the exhaust gas:

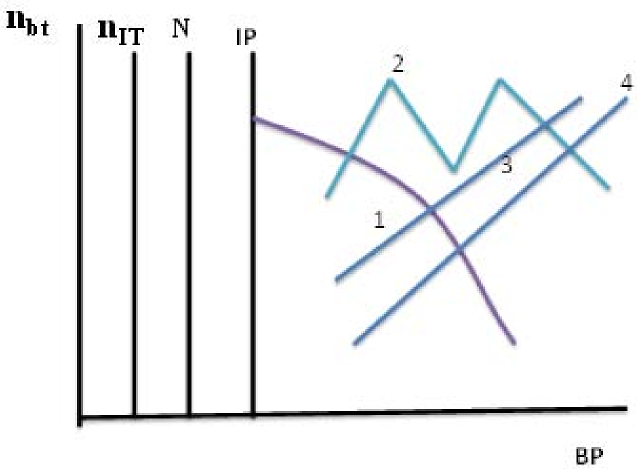
3. Comparison of Performance Characteristics

The following tabulations and graphical diagrams are used to comparison of characteristics of engine with IAP and without IAP.

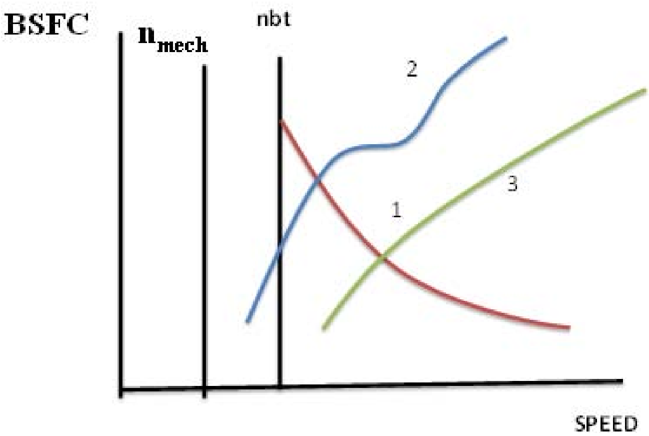
COMPARISON TABLE

Inlet air temperature in °c		Mechanical efficiency in %		Heat converted in useful work(H_u) in			
				With out preheating		With inlet air preheating	
With out preheating	With inlet air preheating	With out preheating	With inlet air preheating	Kj/hr	%	Kj/hr	%
30	30	10.27	12.62	824.4	6.445	0936	7.318
31	33	10.07	17.43	806.4	6.304	1368	10.696
31	35	18.93	21.875	1530	10.765	1814.4	12.76
31	35	20.37	25.437	1842.12	12.961	2210.4	15.553
31	39	22.765	28.881	2122.2	13.29	2631.6	16.48

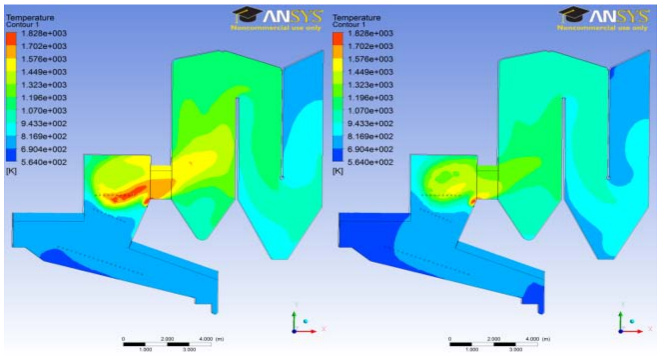
PERFORMANCE CURVE



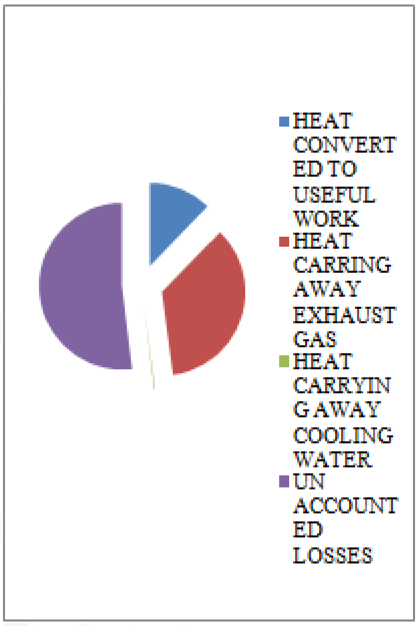
PERFORMANCE CURVE



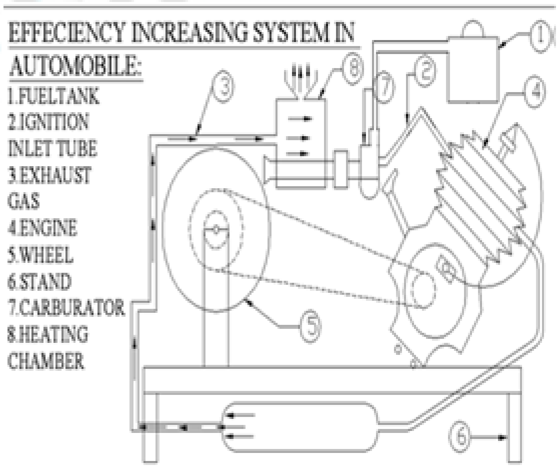
ANSYS Result for Heat Dissipation



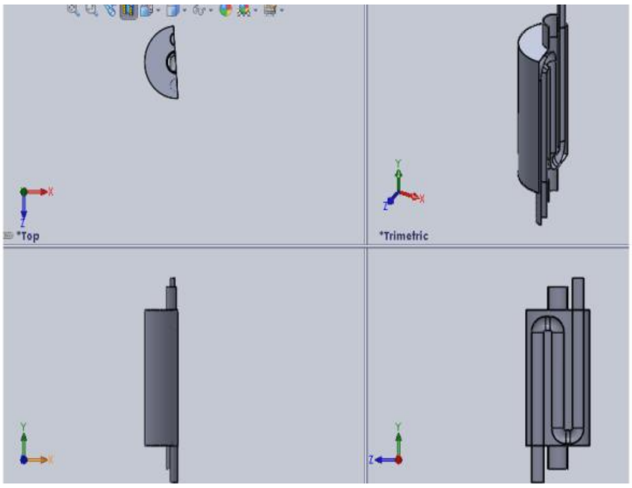
Pie Chart for Heat Dissipation



Circuit Setting Diagram



Sectional View of IAP



4. Conclusion

In this paper, we introduce a new presentation of inlet air preheater model. The new definition of efficiency constraint enables us to find good efficiency criteria instead of using iterative search method, with respect to conventional engine. With the new IAP representation, we can also easily integrate the efficiency criteria with an extra useful heat energy dissipated term. Experimental results on an order of efficiency properties of engine setup with IAP is greater than efficiency properties of without IAP. in addition, the efficiency difference were not highly significant.

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