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Research Article

Effect on Performance and Emission Characteristics of C.I Engine by Preheating of Intake Air Using Heat Wheel

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Abstract

The air pollution is one of the major problems I'm now days throughout the world. The main causes of air pollution are exhaust products of automobiles and industries. Exposure to air pollution can lead to respiratory and cardiovascular diseases, which is estimated to be the cause for 6.2 lakhs early deaths in 2010. To control air pollution from the automobiles, the Indian government implement some emission standards i.e. BSES. Bharat stage emission standards (BSES) are emission standards instituted by the Government of India to regulate the output of the air pollutants from the Internal Combustion Engines. The standards based on European regulations were first introduced in 2000. Progressively stringent norms have been rolled out since then. Up to March 2017 the automobiles are run under the Bharat stage 3 (BS-3). After then Bharat stage 4 (BS-4) were implemented by the Government of India. BS-3 emits are more pollutants (CO, HC, CO2 etc.) to the Environment then BS-4. That is the main reason behind banning the BS-3. In my thesis, I focused on how to control the emission levels as per the BS-4. Heat wheel is a rotary air to air heat exchanger. It comprises porous wire mesh as a matrix material and electric motor for driving wheel. The effect of preheated air on standard diesel fuel engine indicate a good result in performance of engine and on emission control. Higher intake air temperature increases Brake Thermal efficiency and decreases the specific fuel consumption. Easy vaporization and better mixing of air and fuel occur due to warm up of inlet air, which causes lower CO emissions. Better Combustion is occurred due to preheating of intake air, which also causes lower engine noise. The experiment was carried out at different loads (No load, half load, and Full load) at engine speed of 1500 rev/min on single cylinder 4 -stroke variable compression ratio engine. A Test was applied in which the working fuel as pure diesel and blend of diesel and kerosene (90% diesel and 10% kerosene) and results were analyzed. From the results, I observed that by preheating of intake air, emissions are reduced in both the conditions of fuel as pure diesel and blend of diesel and kerosene.

Keywords: *CI Engines, Emission Control, BSES standards, Pre heating, blended fuels.*

1. Introduction

The I.C engine is a device which produces mechanical work as an output due to combustion of fuel converts the chemical energy of fuel into heat and again heat energy in to mechanical work. In general diesel engine have an efficiency of about 35% and thus the rest of the input energy is wasted Despite, recent improvement in efficiency of diesel engine, a considerable amount of energy is still exhausted to atmosphere with the exhaust gases. In water cooled engines about 25% and 40% of the input energy are wasted through the coolant and exhaust gases respectively. Increase in economy the energy demand also increases which results in more usages of fossil fuels which causes the emission of harmful greenhouse gases. Large amount of heat is released in the atmosphere from the engines without utilizing for any purpose. If some amount of this waste heat could be recovered it possible to reduce the primary fuel required. Waste heat utilization is the major source of cost saving. If exhaust gases of engines are directly released into atmosphere it will not only waste heat but also causes the environmental problems, so it was utilized the waste heat for useful work to increase the efficiency of engine. The-recovery and utilization of waste heat from engine results in reduction in fuel consumption, reduction in waste heat loss and engine emission, increases the engine efficiency.

1.1 Various Emissions Emitted by Vehicles

Pollution from vehicles especially automobiles is responsible for about two third of air pollution in the urban area. Main sources of emission from automobiles are as described:

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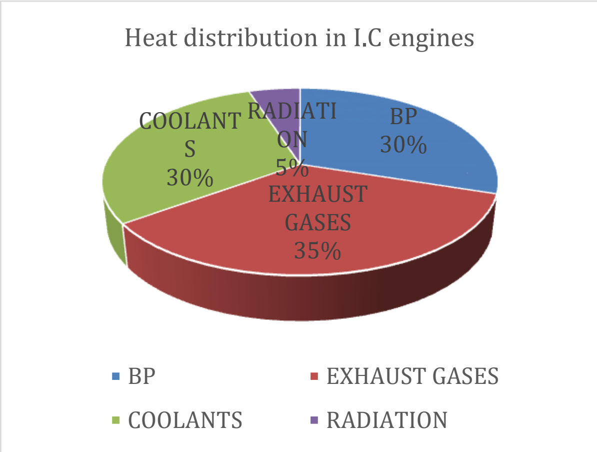


Fig 1 Heat Distribution in I.C Engine

Crankcase Emission: Crankcase Emission (also called running loss emissions) is unburnt or partially burned fuel components that, under pressure, escape from the combustion chamber, pass the pistons and enter the crankcase. This mixture is called blow-by.

Evaporative Emissions: Evaporative Emissions HC vapours, lost constantly and directly to the atmosphere due to volatile nature of petrol, mainly from the fuel lines, fuel tank and carburetor depending upon fuel composition, engine operating temperature and ambient temperature. Losses from the carburetor, called Hot Soak Emissions, occur when a hot engine is stopped.

Exhaust Emission: Automotive exhaust is the major source constituting about 60% of the total emission. Automobile exhaust consists of wide range of pollutants from simple to carcinogenic substances such as Hydrocarbons (Unburnt), Carbon monoxide, Oxides of nitrogen (NOx), Lead oxides, Particulate matters

The major pollutants emitted from exhaust emissions of gasoline fueled vehicles are CO, HC, NOx and Pb while pollutants from diesel-fueled vehicles are particulate matter (including smoke), NOX, SO2, PAH. The detailed information of these pollutants is as given below.

Carbon Monoxide (CO) - colorless and odorless gases slightly denser than air. Residence time and turbulence in the combustion chamber, flame temperature and excess O2 affect CO formation. Conversion of CO to CO2 in the atmosphere is slow and takes 2 to 5 months.

Hydrocarbon Compounds (HC) - Compounds consist of carbon and hydrogen and include a variety of other volatile organic compounds (VOCs). Most HCs are not directly harmful to health at concentrations found in the ambient air. Through chemical reactions in the troposphere, they play an important role in forming NO2 and O3 which are health and environmental hazards.

Benzene and Polyaromatic Hydrocarbons (PAH) - Motor vehicles emit toxic HC including benzene, aldehydes and Polyromantic hydrocarbons (PAH). About 85 to 90% benzene emissions come from exhaust and the remainder comes directly from gasoline evaporation and through distribution losses.

Nitrogen oxides (NOX) - includes nitric oxide (NO), nitrous oxide (N2O), nitrogen dioxide (NO2), dinitrogen trioxide (N2O3) and nitrogen pent oxide (N2O5). NO and NO2 collectively represented as NOX, are the main nitrogen oxides emitted by vehicles. About 90% of these emissions are in the form of NO produced in the vehicle engine by combustion of nitrogen at high temperatures. NO2 formed by oxidation of NO, has a reddish brown color and pungent odor.

Sulphur dioxide (SO2) - is a stable, non-flammable, non-explosive, colorless gas. In the atmosphere, SOX may be converted to Sulphur trioxide (SO3) by means of reaction with O2. SO2 and SO3 react with moisture in air to form sulphurous (H2SO3) and Sulphuric (H2SO4) acids may precipitate to earth as acid rain.

Ozone (O3) - in the lower (troposphere) layer, ground level ozone (GLO) is formed by the reaction of VOCs and NOX with ambient O2 in the presence of sunlight and high temperatures. GLO is a major constituent of smog in urban areas and motor vehicles are the main emission source of its precursors. The reactions that form GLO also produce small quantities of other organic and inorganic compounds such as Peroxy Acetyl Nitrate (PAN) and nitric acid.

Particulate matter (PM) - consists of fine solids and liquid droplets other than pure water dispersed in air. PM2.5 can also be formed in the atmosphere as aerosols from chemical reactions that involve gases such as SO2, NOX and VOC. Sulphate which are commonly generated by conversion from primary Sulphur emissions make up the largest fraction of PM2.5 by mass. PM2.5 can be formed as a result of solidification of volatile metals salts as crystals following cooling of hot exhaust gases from vehicles in ambient air as well.

Black smoke- associated with the soot portion of PM emitted by diesel-fueled vehicles, results from the deficiency of O2 during the full combustion or expansion phase. Blue, grey and white smokes are caused by the condensed HC in the exhaust of diesel-fueled vehicles. Blue or grey smoke results from vaporized lubricating oil and white smoke occurs during engine start-up in cold weather. Diesel fuel additives such as Ba, Ca and Mg reduce smoke emissions but increase PM sulphate emissions.

Dioxins- Cu based additives can reduce PM emissions but may catalyze the reaction between HC and trace amounts of chlorides in diesel fuel to form dioxins which are emitted in the exhaust.

Chlorofluorocarbons (CFCs) - The source of CFC emissions from motor vehicles is the Freon gases used in air conditioners. CFC emitted into the atmosphere rise to the stratosphere layer within 10 years and is estimated to remain there for 400 years. CFC molecules struck by UV radiation release chlorine atoms, which destroy O3 by the formation of chlorine monoxide. Furthermore, when a free O2 atom reacts with a chlorine molecule, an O2 molecule is formed and a chlorine atom is released to destroy more O3.

Carbon dioxide (CO2) - is a greenhouse gas associated with global warming, resulting mainly from increased combustion of fossil fuels including motor vehicle fuels. (Source: Dr. G. C. Kisku, Scientist, Nature and type of pollution from automobiles and strategies for its control).

1.2 Pollution Hazards and Human Health

The major pollutants emitted by motor vehicles including CO, NOx, Sulphur oxides, (SO), HC, lead (Pb) and suspended particulate matter (SPM), have damaging effects on both human health and ecology. The human health effects of air pollution vary in the degree of severity, covering a range of minor effects to serious illness, as well as premature death in certain cases. Most of the conventional air pollutants are believed to directly affect the respiratory and cardio-vascular systems. In particular, high levels of SO2 and SPM are associated with increased mortality, morbidity and impaired pulmonary function. Lead prevents hemoglobin synthesis in red blood cells in bone marrow, impairs liver and kidney function and causes neurological damage.

2. Waste Heat Recovery Options and Technologies

Methods for waste heat recovery include transferring heat between gases and/or liquids (e.g., combustion air preheating and boiler feed water preheating), transferring heat to the load entering furnaces (e.g., batch/cullet preheating in glass furnaces), generating mechanical and/or electrical power, or using waste heat with a heat pump for heating or cooling facilities. The terminology for heat recovery technologies frequently varies among different industries. Since this report addresses multiple industries, the terminology used below is the basis for all subsequent discussion of heat exchange technologies in different industries.

2.1 Heat Exchangers

Heat exchangers are most commonly used to transfer heat from combustion exhaust gases to combustion air entering the furnace. Since preheated combustion air enters the furnace at a higher temperature, less energy must be supplied by the fuel. Typical technologies used for air preheating include recuperators, furnace regenerators, burner regenerators, rotary regenerators, and passive air preheaters.

2.2 Recuperator

Recuperators recover exhaust gas waste heat in medium to high temperature applications such as soaking or annealing ovens, melting furnaces, afterburners, gas incinerators, radiant tube burners, and reheat furnaces. Recuperators can be based on radiation, convection, or combinations:

A simple radiation recuperator consists of two concentric lengths of ductwork. Hot waste gases pass through the inner duct and heat transfer is primarily radiated to the wall and to the cold incoming air in the outer shell. The preheated shell air then travels to the furnace burners.

Recuperators are constructed out of either metallic or ceramic materials. Metallic recuperators are used in applications with temperatures below 2,000ºF [1,093ºC], while heat recovery at higher temperatures is better suited to ceramic tube recuperators. These can operate with hot side temperatures as high as 2,800ºF [1,538ºC] and cold side temperatures of about 1,800°F [982ºC].

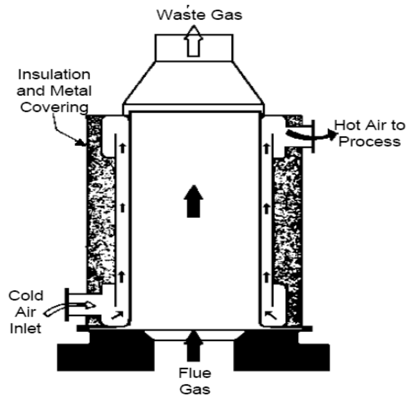


Fig 2.1 Metallic Radiation Recuperator Design

2.3 Furnace Regenerator

Regenerative furnaces consist of two brick checker work chambers through which hot and cold airflow alternately. As combustion exhausts pass through one chamber, the bricks absorb heat from the combustion gas and increase in temperature. The flow of air is then adjusted so that the incoming combustion air passes through the hot checker work, which transfers heat to the combustion air entering the furnace. Two chambers are used so that while one is absorbing heat from the exhaust gases, the other is transferring heat to the combustion air.

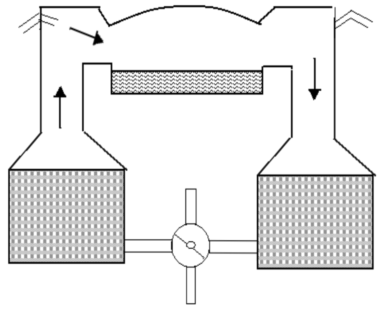


Fig 2.3 Regenerative Furnace Diagram

The direction of airflow is altered about every 20 minutes. Regenerators are most frequently used with glass furnaces and coke ovens, and were historically used with steel open hearth furnaces, before these furnaces were replaced by more efficient designs.

2.4 Rotary Regenerator/Heat Wheel

Rotary regenerators operate similar to fixed regenerators in that heat transfer is facilitated by storing heat in a porous media, and by alternating the flow of hot and cold gases through the regenerator. Rotary regenerators, sometimes referred to as air preheaters and heat wheels, use a rotating porous disc placed across two parallel ducts, one containing the hot waste gas, the other containing cold gas. The disc, composed of a high heat capacity material, rotates between the two ducts and transfers heat from the hot gas duct to the cold gas duct. Heat wheels are generally restricted to low and medium temperature applications due to the thermal stress created by high temperatures.

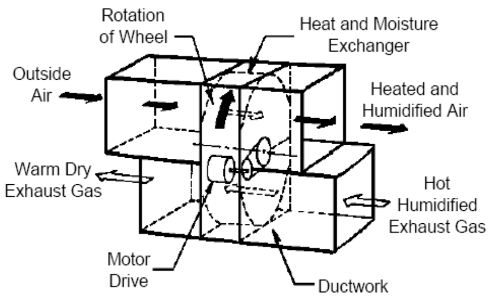


Fig 2.4 Rotary Regenerator

3. Design and fabrication of heat wheel

3.1 Heat wheel

A thermal wheel , also known as a rotary heat exchanger, or heat recovery wheel , or heat recovery wheel is a type of energy recovery heat exchanger positioned within the supply and exhaust air streams of an air-handling system or in the exhaust gases of an industrial process, in order to recover the heat.

Mostly wheel matrix is made from porous material. Metallic wire screen mesh is used due to large values of surface area density; these structures are found to be effective in dissipating heat within a limited designed space. Heat wheel is fabricated from small cast iron wire mesh. Regarding thermal conductivity cast iron has good thermal conductivity and it is much greater than that of steel. Cast iron is also highly resistant to corrosion attack. Cast iron is light in weight and it also has a bright appearance. A number of wire meshes strips are kept over each other and circular thick Mesh is formed. It cuts in to three equal parts for assembly. Outer circular cover- ring is used to hold all wire meshes together to make it as a single wheel. Wheel is rotated by electric motor. Wheel is enclosed in Casing. Arbitrary the standard dimensions are taken for heat wheel technical manual.

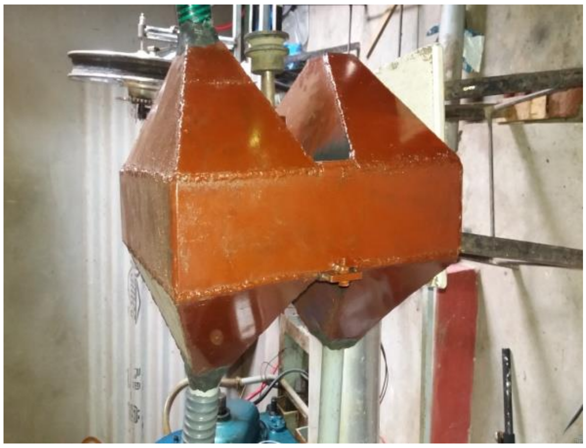


Fig 3.1 Heat Wheel

3.2 Model Assumptions

The physical model and the numerical analysis are based on the following assumptions:
- Temperature and velocity profiles in the channels are fully developed.
- Channels are equal and uniformly distributed throughout the wheel.
- Temperature, humidity ratio and velocity of each inlet flow are uniform at the inlet face of the wheel.
- Heat and mass transfer between adjacent channels is negligible.
- Heat and mass transfer from the wheel to the surroundings is negligible.
- Axial heat conduction and water vapour diffusion in the air stream are negligible.
- Temperature gradient through the channel thickness is negligible.
- Density and velocity variation of air along the channel are negligible.
- Specific heat and thermal conductivity of dry air, water vapour and liquid water are assumed constant.
- Air leakages between the two streams are negligible

Rotary heat exchangers are most effective means of transferring heat. No other device can recover as much heat or cold and no other heat exchanger can handle such large volumes. Energy savings of up to 85% can be achieved.

4. Design of various parts

4.1 General

Design part consists of design of Heat Wheel, design of Ordinary/conventional plate type Heat Exchanger. Before going to design we must have to determine maximum flow rate of steam for which heat wheel is to be design. It can be determine by considering standard part specifications and charts available.

Design of Heat Wheel: Design of heat wheel includes three parameters Diameter D1 and D2, Width W, Porous diameter (d) as shown in figure

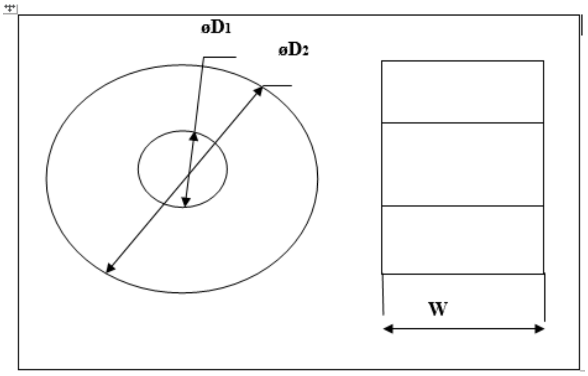
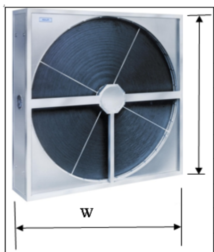


Fig 4.1 Design parameters of heat wheel

Diameter D1, D2
Here, D1= 60mm for constraint of bearing and pedestal.
The standard dimensional data of heat wheel which is ARI 1060 certified for in energy tech Inc. is given in table



Diameter in/mm	Width in/mm	Height in/mm	Depth in/mm	Weight in/kg
48/1219	58/1473	58/1473	15/381	720/327.3
54/1372	64/1626	64/1626	15/381	790/359.1
62/1575	72/1829	72/1829	15/381	910/413.6
70/1778	80/2032	80/2032	15/381	1080/490.9
78/1981	87/2210	87/2210	15/381	1230/559.1
88/2235	95/2413	95/2413	16/406	1400/636.4
96/2438	103/2616	103/2616	16/406	1560/709.1
108/2743	115/2921	115/2921	16/406	1800/818.2
120/3048	127/3226	127/3226	16/406	2080/945.5

From this table we select relation between diameter D2 and width W specified by Diameter and Depth respectively as

1) Volume capacity (Q):

Mass flow rate of exhaust gases (mg):
mg = (ma+ mf)
= (0.55+22.81) kg/hr
= 23.36 kg/hr
=0.0064 kg/sec
mg= 6.4 Lit/sec Q g = 6.4 lit/sec

Peripheral velocity (v):

$$v = \frac{\pi D1 N}{60}$$

D1 = 50mm
N = 30 rpm

$$V = \frac{\pi \times 50 \times 30}{60}$$

= 78.5 mm/sec ... from equation,

$$Q = \frac{1}{8} \times \pi \times (D2^2 - D^2 1) \times W$$

$$6.4 = \frac{1}{8} \times \pi \times (D2^2 - 50^2) \times 0.16D2$$

By trial and error method

D2 =400 mm =40cm
t = 64mm =6.4cm

In the above equation „t" is the time period between entry of steam to porous hole and exit of steam from it, assuming steam to be condensed through total length i.e. width of wheel. Time required covering distance from point A to point B (t)
Speed of wheel = 2 rpm to 20 rpm, Speed range is given by Cadant-Johnson Heat Wheel.

As design for any speed between above range is correct but selection of speed depends on standard gear box available or standard geared motor available. Standard geared motors are of 3.5rpm, 30rpm, 100rpm etc. Thus, Speed (N) = 3.5rpm motor is directly coupled to shaft of wheel.

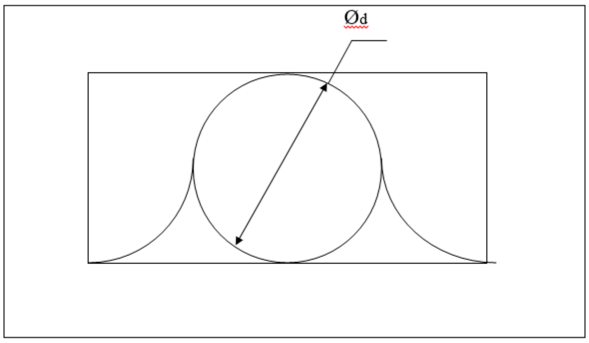


Fig 4.2 Porous Diameter of wheel

Let A1 = area of square excluding thickness of sheet.
A2 = area of square including thickness of sheet.
t = thickness of sheet.

From figure 4.3,
A1= 2(d+t) 2-πdt
A2= 2(d+t) 2
Porosity = A1 = 2(d+t) 2- πdt
A2 = 2(d+t) 2
∴ 0.89 = 1- π × d× 0.32- 2 × (d+0.32)2

By trial and error,
d = 3.1mm
∵ d = 3mm

5. Construction of heat wheel

Rotary heat exchangers have a wheel like construction which is why they are also known as heat wheels or simple rotors made of metal foils, the wheels feature countless small channels through which the air flows and transfers its heat to this storage mass.

5.1 Experimental setup and procedure

The test were conducted on different equipment using heat recovery wheel or rotary heat exchanger. After this, performance and emission tests and thermal efficiency were conducted on variable compression ratio diesel engine coupled with an eddy current type dynamometer, with the help of multi gas analyzer.

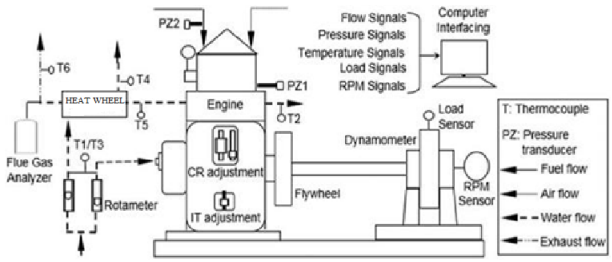


Fig 5.1 Line Diagram of VSR Engine

Engine	Make Kirloskar, Type 1 cylinder, 4 stroke diesel, water cooled, power 3.5 kw at 1500 rpm, stroke 110mm, bore 87.5mm. 661cc, CR 17.5, modified to VCR engine CR range 12 to 18.
Dynamometer	Type Eddy current, water cooled, with loading unit
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type pipe in pipe
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, speed 5500 RPM with TDC pulse
Data acquisition device	NI USB-6210, 16-bit, 250 kS/s.
Piezo powering unit	Make-Cuadra, modal AX-409
Digital milivoltmeter	Range 0-200 mv, panel mounted
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature	Type two wire, Input RTD PT100, Range 0-100 Deg C,
Transmitter	Output 4-20 mA and Type two wire, Input Thermocouple, Range 0-1200 Deg C, Output 4-20 mA
Load indicator	Digital, Range 0-50 kg, supply 230AV
Load sensor	Load Cell, type Strain guage, range 0-50 Kg
Fuel flow transmitter	DP transmitter , Range 0-500mm WC
Air flow transmitter	Pressure transmitter Range(-)250 mm WC
Software	Engine soft LV Engine Performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250LPH
Pump	Type Monoblock
Overall dimension	W 2000× D 2500 × H 1500 mm
Optional	Computerized Diesel injection pressure measurement
Shipping Details	Gross volume 2.64m3
Computer	CPU: Pentium 300 GHz, RAM: Min.512 MB, CD ROM drive
Requirement	USB Port. OS: Windows XP + SP2. Monitor: Screen resolution 1280×1024

5.2 Compression Ratio Adjustment

1. Slightly loosen 6 Allen bolts provided for clamping the tilting block.
2. Loosen the lock nut on the adjuster and rotate the adjuster so that the compression ratio is set to maximum. Refer the marking on the CR indicator.
3. Lock the adjuster by the lock nut.4.Tighten all the 6 Allen bolts gently.
4. You may measure and note the center distance between two pivot pins of the CR indicator. After changing the compression ratio the difference ( ) can be used to know new CR.

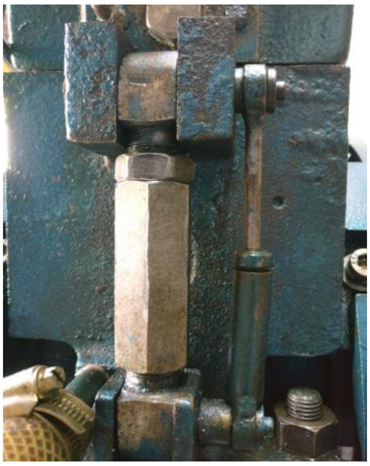


Fig 5.2 Compression ratio setup

5.3 Engine starting

1. Ensure that all foundation bolts, propeller shaft bolts and Allen bolts of tilting block (Of VCR arrangement) are properly tightened.
2. Keep the Decompression lever (Decamp lever) in vertical position. Ensure that Engine stop lever is free and can be pulled towards engine cranking side for the Engine.
3. For first start after installation, loosen the fuel inlet the pipe to the injector.
4. Crank the engine slowly till fuel starts dribbling out from the loosened nut. Then tighten the nut.
5. Rotate the handle 5-6 rotations manually in clockwise direction (viewed from engine side) by right hand. When the flywheel has gathered sufficient momentum make the decompression lever horizontal by left hand while cranking the engine and keep on cranking for additional 2-3 rotations.
6. The handle will release automatically and come out, however do not leave handle.
7. Repeat above steps if it does not start at first instance. Engine starting needs some if engine does not start you may check valve setting as explained below.
8. To stop the engine pull Engine stop lever.
9. Stop the engine after releasing the load.
10. Switch off the pump.
11. For software installation on the computer proceed to software section.

5.4 Performance Parameters

Following are the performance parameters:
Indicated thermal efficiency (ηth): Indicated thermal efficiency is the ratio of indicated power of the energy.

η_{th} =Indicated Power / Fuel Energy

η_{th} = {(Indicated Power (KW) ×3600)/ (Fuel Flow (Kg/Hr) ×Calorific value (KJ/Kg))} ×100

Brake thermal efficiency: A measure of overall efficiency of the engine is given by the brake thermal efficiency. Brake thermal efficiency is the ratio of energy in the brake power to the fuel energy.

η_{bth} = Brake Power / Fuel Energy

η_{bth} ={(Brake Power(KW) × 3600)/(Fuel Flow(Kg/Hr) × Calorific Value(KJ/Kg))} ×100

Emission parameters: Following are the emission parameters

Carbon monoxide (CO), Carbon dioxide (CO2), hydro carbons (HC), unused oxygen (O2)

Auto exhaust gas analyzer: Gas analyzer is mainly used to know the emissions. Gas analyzer measures the concentration of CO, CO2and O2 in volume percentages and the concentration of HC and NOx in parts per million (ppm). The system uses a non-dispersive infrared system for determining the concentration CO, CO2 and HC, and performs the measurement of O2 and NOx by electrochemical cells. It is shown below.

Fig 5.3 Exhaust gas analyzer

5.5 Operating principle

The instrument detects the CO/HC/CO2 content according to the principle by which the selective absorption of infrared is measured for each gas. O2 sensor is measured by means electrochemical sensor. The sample gas is taken through the exhaust by means of the probe. The intake exhaust gas is further made free from the moisture with the help of moisture separator element. Dust is removed with the help of dust element & inward filter. Then condensed moisture is routed to exhaust of the analyzer through pump. Dust / moisture free sample gas is feed to the measuring cell. Infrared light beam is directed to the measurement components (like optical filter & sensor), which is weakened at a certain wavelength by the sample gases in the cell.

Additive: Fuel additives are used in addition to the petrol or diesel. It is mainly used to make fuel high quantity and more efficient. It is useful to improve your vehicle's performance. The additive products which purports to increase the fuel economy and / or reduce emission.

6. Experimental Observations

6.1 Experimental observations for diesel

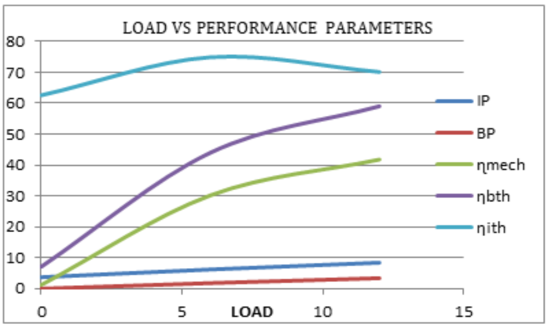
Without Pre Heating

S.NO.	LOAD (kg)	IP (Kw)	BP (Kw)	ηmech (%)	ηbth (%)	ηith (%)	IMEP (Bar)	BMEP (Bar)	SFC (Kg/Kw-hr)
1	0	3.72	0	1.2	7.1	62.6	4	0	1.75
2	6	6.2	1.8	30.2	44	74.9	7.5	2.1	0.19
3	12	8.41	3.4	41.8	59.05	70.14	9.6	4.2	0.01

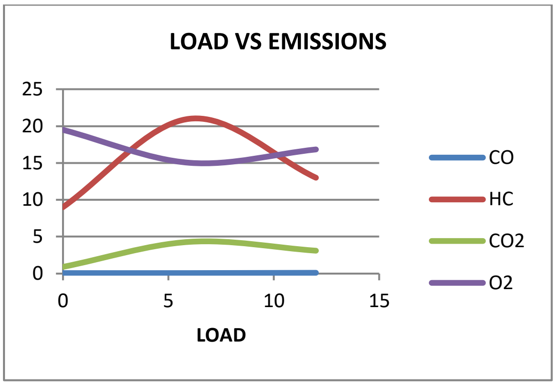
S.NO	LOAD (Kg)	Speed (rpm)	Time for fuel consumption '20' cc (sec)	Temperatures					
				T1	T2	T3	T4	T5	T6
1	0	1576	41	31	38	31	31	33	31
2	6	1539	27.8	31	42	31	33	31	31
3	12	1491	13.6	30	45	30	31	32	31

Smoke Density: 13.4

S.NO	LOAD (Kg)	CO	HC	CO2	O2
1	0	0.06	9	0.90	19.5
2	6	0.06	21	4.30	15.03
3	12	0.10	13	3.10	16.84



Graph 6.1 Load vs performance parameters graph



Graph 6.2 Load Vs Emissions

6.2 Experimental Observation for Diesel

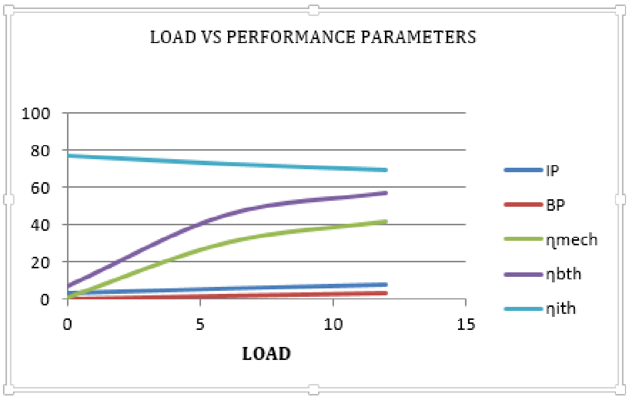
With Pre Heating

S.NO.	LOAD (kg)	IP (Kw)	BP (Kw)	ηmech (%)	ηbth (%)	ηith (%)	IMEP (Bar)	BMEP (Bar)	SFC (Kg/Kw-hr)
1	0	3.5	0	1.2	7.1	77	4.1	0	9.57
2	6	5.93	1.8	30.8	45.5	72.55	6.9	2.2	0.19
3	12	8.02	3.4	42.2	57.3	69.3	9.6	4.2	0.01

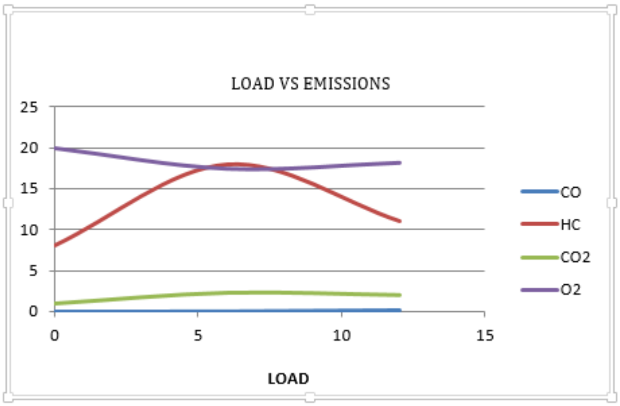
S.NO	LOAD (Kg)	Speed (rpm)	Time for fuel consumption '20' cc (sec)	Temperatures					
				T1	T2	T3	T4	T5	T6
1	0	1573	48.6	31	39	31	31	33	31
2	6	1539	33.9	31	42	31	33	31	32
3	12	1494	18.7	30	37	30	31	32	31

Smoke Density 13.4

S.NO	LOAD (Kg)	CO	HC	CO2	O2
1	0	0.03	8	0.90	19.98
2	6	0.04	18	2.30	17.46
3	12	0.09	11	2.00	18.19



Graph 6.3 Load vs performance parameters graph



Graph 6.4 Load vs emissions graph

6.3 Experimental observations for blend

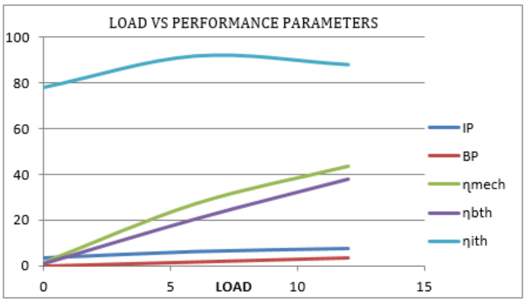
Without Pre Heating

S.NO.	LOAD (kg)	IP (Kw)	BP (Kw)	ηmech (%)	ηbth (%)	ηith (%)	IMEP (Bar)	BMEP (Bar)	SFC (Kg/Kw-hr)
1	0	3.64	0.1	1.34	1.1	78	4.3	0.1	0.98
2	6	6.2	1.7	27.3	20.5	91.8	7.2	2	0.42
3	12	7.44	3.3	43.8	37.7	88	9.3	4	0.23

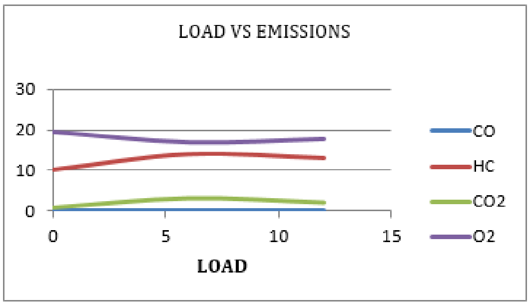
S.NO	LOAD (Kg)	Speed (rpm)	Time for fuel consumpti on '20' cc (sec)	Temperatures					
				T1	T2	T3	T4	T5	T6
1	0	1589	57.3	31	37	31	31	33	32
2	6	1543	30	31	42	31	33	31	31
3	12	1491	26	30	45	30	31	32	31

Smoke Density 13.4

S.NO	LOAD (Kg)	CO	HC	CO2	O2
1	0	0.04	10	0.90	19.65
2	6	0.06	14	3.10	16.82
3	12	0.11	13	2.10	17.71



Graph 6.5 Load vs performance parameters graph



Graph 6.6 Load vs emissions graph

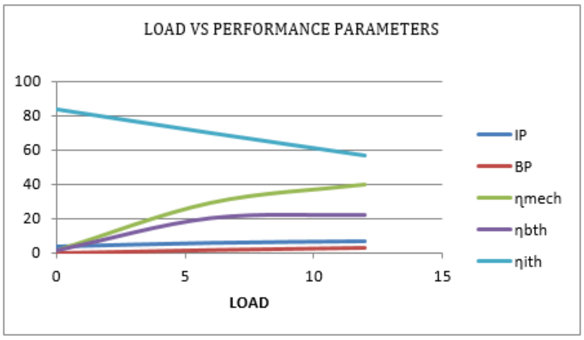
6.4 Experimental observations for blend

S.NO.	LOAD (kg)	IP (Kw)	BP (Kw)	ηmech (%)	ηbth (%)	ηith (%)	IMEP (Bar)	BMEP (Bar)	SFC (Kg/Kw-hr)
1	0	3.8	0.1	1.4	1.1	83.8	4.2	0.1	0.98
2	6	6.03	1.8	29.3	20.3	69.9	7.1	2.1	0.42
3	12	7.1	3.1	40	22.2	56.7	9.1	3.8	0.33

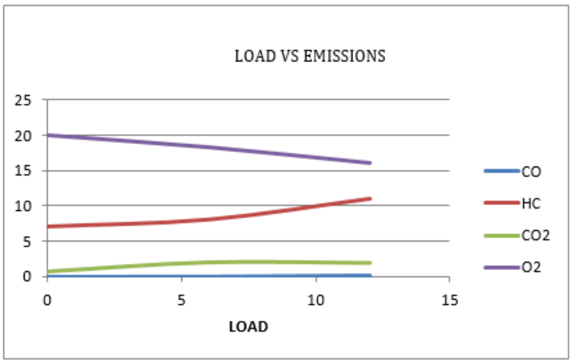
S.NO	LOAD (Kg)	Speed (rpm)	Time for fuel consumption '20' cc (sec)	Temperatures					
				T1	T2	T3	T4	T5	T6
1	0	1589	57.3	31	37	31	31	33	32
2	6	1543	33	31	42	31	33	31	31
3	12	1491	28	30	45	30	31	32	31

Smoke Density 13.4

S.NO	LOAD (Kg)	CO	HC	CO2	O2
1	0	0.03	7	0.70	20.01
2	6	0.04	8	2.00	18.31
3	12	0.10	11	1.92	16.09



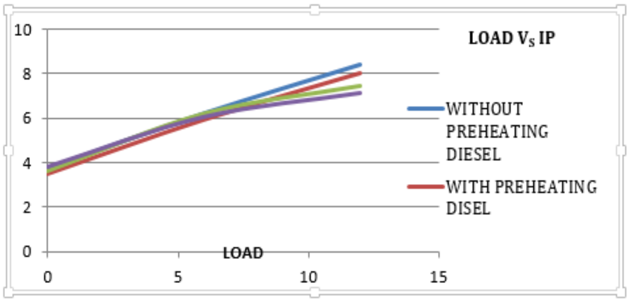
Graph 6.7 Load vs performance parameters graph



Graph 6.8 Load Vs Performance Parameter Graph

7. Results and conclusion

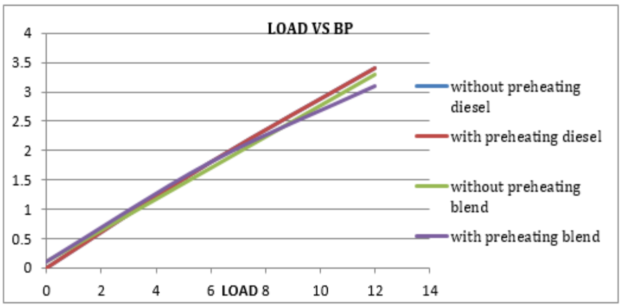
Experiments were conducted on four stroke single cylinder water cooled variable compression ratio diesel engine by varying loads from no load, half load and full. The performance parameters such as mechanical efficiency, indicated thermal efficiency, brake thermal efficiency, exhaust gas temperature, indicated mean effective pressure, brake mean effective pressure and exhaust gas emissions like Carbon monoxide, Hydro carbons, Carbon dioxide and unused oxygen are taken from system which was connected to the engine by using IC engine analysis software and shown in graphs. The variations in performance parameters and emissions were discussed with respect to load to identify optimum result.



Graph 7.1 Load v_s IP graph

It shows the variation of indicated power with respect to load at different working conditions. The Graph illustrates the following:

- As load increases, indicated power increases.
- At half load condition without preheating diesel and blend gives the maximum indicated power.
- At no load condition with preheating blend gives maximum value of IP.
- From the graph it can be concluded that IP is directly proportional to load.

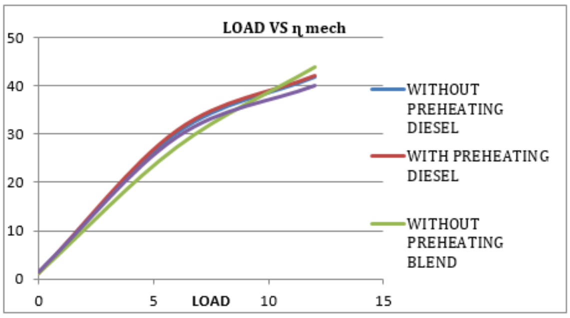


Graph 7.2 Load vs BP graph

This graph shows that Brake Power at different loads in different conditions.

- Brake power is gradually increases with load.
- At half load condition without preheating and with preheating of diesel and blend gives same value.

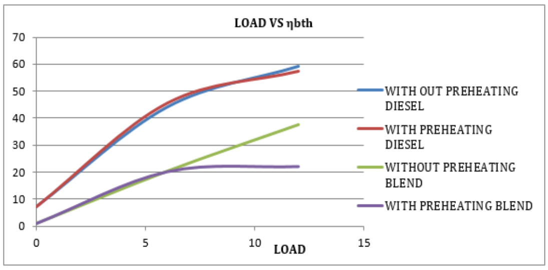
At full load condition with preheating diesel gives the maximum value of BP.



Graph 7.3 Load vs η_{mech} Graph

Above graph shows variation of mechanical efficiency with respect to load at different working conditions.

- At no load condition mechanical efficiency for all the working conditions remains same.
- At half load condition with preheating diesel gives maximum value of mechanical efficiency and following by with preheating blend.
- At full load condition without preheating blend gives maximum mechanical efficiency and following by with preheating diesel. From the graph we observed that mechanical efficiency is higher in with preheating diesel when compared to without preheating diesel.

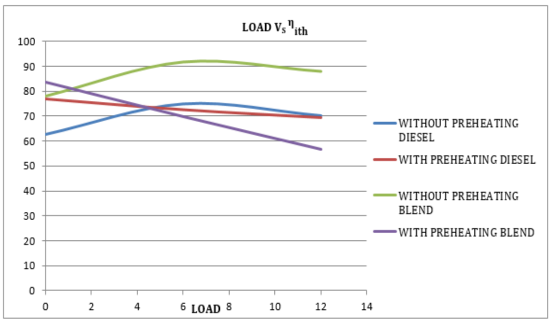


Graph 7.3 Load v_s η_{bth} graph

This graph shows Brake Thermal Efficiency in different working conditions at various loads.

- Brake Thermal Efficiency in all conditions is proportionally increases with increasing load.
- With preheating diesel gives maximum value of brake thermal efficiency at all loads.
- At half load condition with preheating and without preheating blend gives the same brake thermal efficiency.

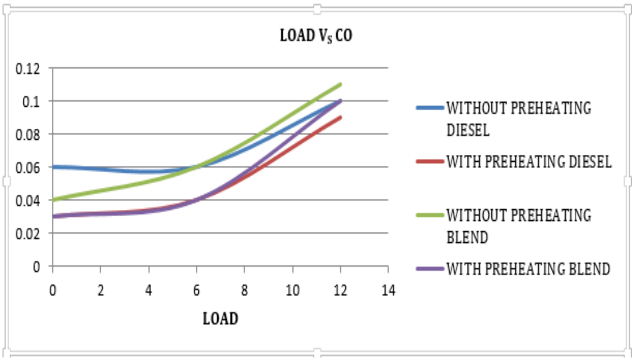
The graph clearly shows that brake thermal efficiency of diesel is higher than the blend. This is because of diesel have higher calorific value.



Graph 7.4 Load vs η_{ith} graph

The graph shows load vs Indicated Thermal Efficiency graph at various loads.

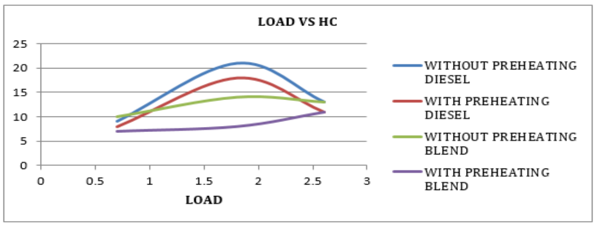
- It is clearly observed that without preheating blend gives the maximum indicated thermal efficiency at half load and full load.
- From the graph without preheating indicated thermal efficiency increases with increasing loads.
- Graph shows with preheating indicated thermal efficiency is decreases with increasing loads.



Graph 7.5 Load vs co graph

This graph shows variation of CO emissions with varying loads.

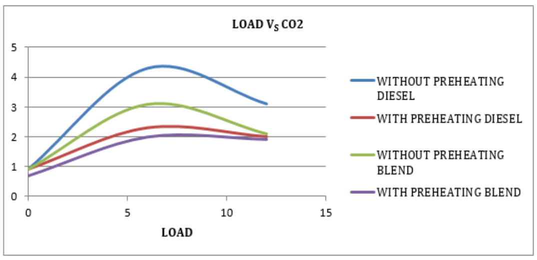
- From the graph at full load with preheating diesel gives less CO emissions.
- Without preheating diesel and blend gives higher CO emissions at every load.
- It is clearly observed that with preheating diesel or blend gives less CO emission



Graph 7.6 Load vs HC graph

This graph shows variation of HC emissions with varying loads.

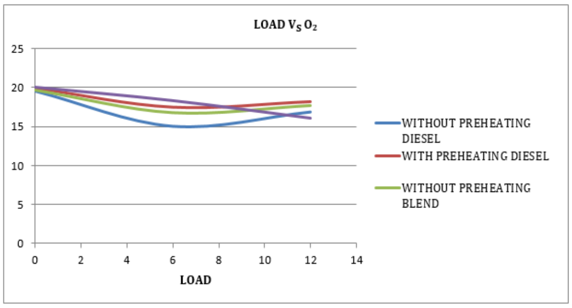
- Without preheating diesel gives higher HC emissions at every load.
- At every load with preheating blend gives less HC emissions then others.
- From the graph it is observed that blend gives less HC emissions then the diesel.



Graph 7.8 Load vs co_2

The above graph shows the variation of CO2 emissions with varying loads.

- The graph clearly shows the difference between preheating and without preheating conditions.
- With preheating blend as well as diesel also gives the less CO2 emissions.
- Without preheating diesel gives higher CO2 emissions the others and follow by the without preheating blend.



Graph 7.9 Load vs o_2

This graph shows the variation of unused oxygen with varying loads.

- From the graph unused oxygen is higher in with preheating diesel and as well as blend at every load.
- Without preheating diesel have lower unused oxygen at every load.

Conclusion

The recovery and utilization of waste heat not only conserves fuel but also reduces waste heat by increasing the efficiency of engine and the greenhouse gases. This study shows the Benefits of waste heat recovery, Heat carried away by the exhaust gas, to pre heat the intake air. Specific fuel consumption decreases with increase in air temperature. CO at various Engine Load and Heat Wheel RPM shows that CO is decreases as heat wheel RPM increases. CO is increases as load on engine increases. The performance and emission characteristics of conventional diesel and blend of diesel and kerosene were investigated on a single cylinder four stroke VCR Engine by varying loads at without pre-heating and with pre-heating conditions. The conclusions from these investigations were as follows:

- The thermal efficiency of the engine was observed as increased during preheating condition when compared to without pre-heating condition.
- The emission of exhaust gases such as Carbon monoxide (CO), Hydro Carbons (HC) and Carbon Dioxide (CO2) were decreased when pre-heating is done using heat recovery wheel.
- Amount of Unused oxygen increased with increase in load during pre-heating conditions.
- Reduction of noise pollution levels were observed during preheating condition.
- The air pollution was decreased as exhaust gas emissions were reduced.

Future scope

- Analysis of exhaust gas emission may also be done by using preheated air on different temperature range.
- The analysis can also be done using alternate fuels.
- Thermal analysis of exhaust gas may also be done.
- Modification in the design of engine cylinder for further improvement in the Performance Parameters are also done in future.

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