Compounding Of Ac Compressor Using Waste Heat Recovery From Exhaust Gas

Bheshma Yogendra Kiran, Surya, Annamalai Rajesh, Kandhasamy

Abstract: This project works on the theme of turbocharger in which a low pressure high speed turbine is placed in the exhaust gas manifold. The exhaust gas from the engine is made to rotate the turbine where the thermal power of exhaust gas is converted into rotary motion through turbine. This rotary motion from turbine is given to the turbocharger compressor which compresses the refrigerant vapor. So through this air conditioning effect is obtained without loss of any crankshaft. The kinetic energy extracted from the turbine is used to run the AC compressor by planetary gear train.

Keywords: Turbine**,** Exhaust Gas Recovery, planetary Gears, Exhaust Energy Recovery

I INTRODUCTION:

An internal combustion engine (ICE) is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. IC (Internal Combustion) engine is an important object for energy saving and emission reduction. At present researchers mainly focus on following two aspects for reducing energy crisis and relieving polluting gases. One is the research on IC engine alternative fuels owing to the shortage of petroleum resources and the soaring oil prices; the other is to explore new technologies for IC engine energy saving, including the technologies for IC engine waste heat recovery. Normally, IC engine accounts for 30% brake power , 30% cooling, 30% exhaust and remaining 10% unaccounted loss. Since, significant amount of engine output is used up for exhaust, the recovered energy or, available useful energy, can be recycled back into the vehicle system mechanically to run the AC compressor. Nowadays climate changes are becoming unpredictable. Average atmospheric temperature is increasing at a significant rate. We find it difficult to cope up with the sudden changes in the weather conditions. Hence the need for an efficient air conditioning system is increasing. So, the present day automobile AC system is hence more often put to use. This situation demands for an improvement in the contemporary system. The increasing fuel prices are also one of our main concerns. The power required for the working of the AC system is usually drawn from the automobile engine, which in turn results in increased fuel consumption. The AC increases the fuel consumption of a conventional gas-fueled car by approximately 35% and significantly higher for hybrids. So energy efficient air-conditioning systems are getting significant attention from the automotive industry to improve fuel economy of their vehicles. These situations led us in a search for an alternative powering solution for the automobile air conditioning system, which does not extract engine power directly

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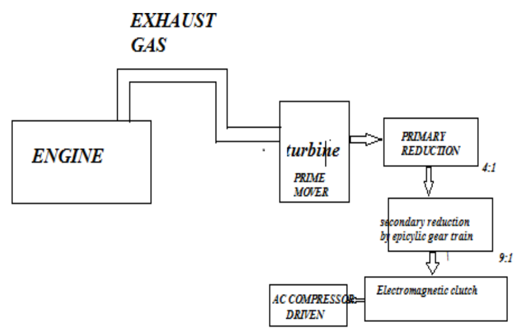
II. METHODOLOGY:

Exhaust gas contains two main forms of energy.

1. **Pressure energy**
2. **Thermal energy**

The pressure energy of the exhaust gas is recovered by using a gas turbine. The power produced by the gas turbine is transmitted to the AC compressor by a planetary speed reduction mechanism called epi-cyclic gearing.

LAYOUT AND BLOCK DIAGRAM:



EPICYCLIC GEAR TRAIN:

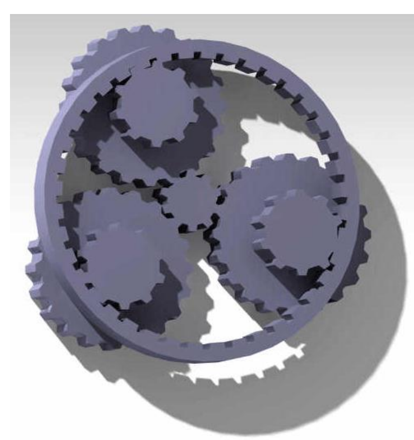


Fig.1. Concept of turbo-compounding

Output power from planetary gear is used to run the compressor of a vapor compression refrigeration cycle. So that automobile air conditioner can be operated by using waste energy with a greater COP.

III. CALCULATION EQUATION AND DESIGN:

EPICYCLIC GEAR CALCULATION:
No. of teeth in planet arm (N_B): 10
No. of teeth in ring gear (NA): 40
No. of teeth in planet gear (ND): 20
No. of teeth in sun gear (NS): 10
Rs = 1 + NA/NB * ND/NS
= 9 : 1

	Planet arm(L)	Ring gear(A)	Planetary gear	Sun gear
CW +1 rev	1	1	1	1
Fix arm CCW(A)	0	-1	-NA/NB	NA/NB * ND/NS
Total	1	0	1 – NA/NB	1 + NA/NB * ND/NS

High output torque ratio is obtained by fixing the ring gear and giving input to planetary arm and obtaining the output from sun gear

CALCULATION OF SHAFT DIAMETER:
For the max torque of 14 Nm to run the AC compressor, the shaft diameter required is 20 mm.

AC COMPRESSOR SPECIFICATION:
Input power : 0.5 HP
Compressor type : Johnny hydrastatic
Torque : 6.3 Nm

Table I. *Engine specifications*

Speed	2500rpm
Displacement	1700x
Turbine efficiency	80%
Mean mass flow rate	0.05 kg/s
Inlet turbine pressure	4.05 bar
Outlet turbine pressure	1.15 bar

PROBLEMS FACING IN THIS CONCEPT:
- ✓ Exhaust back pressure
- ✓ Proper lubrication for gear train
- ✓ Isentropic expansion at turbine

OVERCOMING THE PROBLEMS:
- ✓ Exhaust back pressure is minimized by modifying the exhaust manifold design by introducing a convergent nozzle. So, the entry pressure for the turbine would be high.
- ✓ Separate lubrication system is introduced for planetary gear-train from the engine lubricant.
- ✓ Isentropic expansion can be maximized by using a separate high pressure anlow pressure turbine at the exhaust manifold.

CONCLUSION
One of the major advantages of this concept is that it can be easily employed on low power engine and can ensure high capacity air conditioner .It offers better utilization of exhaust energy. The required torque is attained. The use of an exhaust Rankine cycle to recover the exhaust thermal energy can further result in a best fuel utilizing engine.

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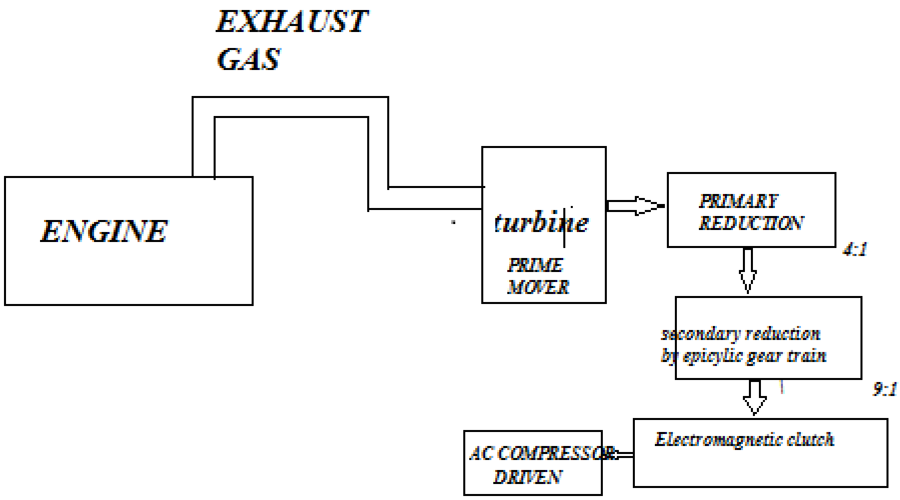
EXHAUST
GAS
ENGINE
turbine
PRIME
MOVER
PRIMARY
REDUCTION
4:1
secondary reduction
by epicylic gear train
9:1
Electromagnetic clutch
AC COMPRESSOR
DRIVEN