Effect of Different Vane Angle on Compression Ratio and Shaft Output of a Rotary Vane Engine

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Abstract : **Mostly in all automobiles reciprocating I.C. engines are used in spite of having some lacunas i.e. incomplete combustion of fuel, due to which lower thermal efficiency obtained. It having more nos. of moving parts due to which balancing of engine becomes a tedicious task. Also weight to power ratio of engine becomes excessively high. This paper describes a new concept of rotary vane type engine. An alternative approach to reciprocating engine. In this article author has chosen stator, rotor and different vanes i.e. 4, 6, & 8 for optimizing compression ratio, cubic capacity and brake horse power at 6000 rpm.**

Key words: **Rotary vane engine, Stator, Rotor, Balancing, Shaft output, Vane angle, Compression ratio**

I. INTRODUCTION

Generally it has been observed in reciprocating internal combustion engine incomplete combustion of fuel. Because of which engine ejects harmful gases like CO_2 which cause global pollution & ecological nuisance. In addition to this, it occupies more space due to which weight to power ratio is high. Also require wasteful dynamics of an extra revolution to evacuate the exhaust. Even though they are mostly used in all vehicles. Today world facing fuel shortage. U.S. based geo-physics Marion king Hubbert who predicted according to principle of geology, physics & mathematics conventional crude production will attain peak around 1976, there after it will start depleting & within 40 Yrs by 1995 it may cause serious threat to mankind. He also mentioned that worldwide faster consumption of fossil fuel in transport vehicle will result fast depletion to energy resources thereby releasing, huge quantity of pollutant in atmosphere. Considering the above serious issue and lacunas of conventional reciprocating type I.C. engine a thought is given for conceptual design of rotary vane engine with some objectives having less moving parts, can be balanced completely and also free from vibration in addition to this compact is size, with moderate improvements power to weight ratio. In this paper a concept of 6 vane type rotary vane engine has been discussed. Also different vanes chosen for obtaining compression ratio greater than 8.

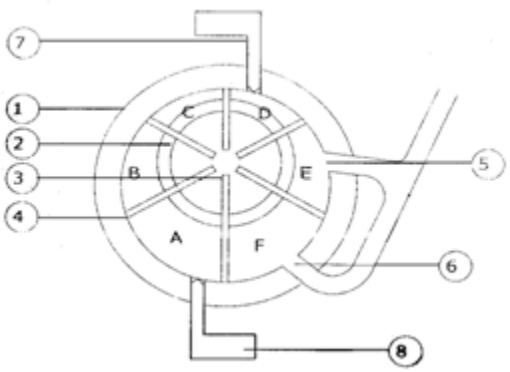
II. LITERATURE REVIEW

It is essential to understand the past and present status of rotary type internal combustion engine process to suggest future area of work. Literature survey has been carried out to find the state of art at rotary engine concept. It provides less moving parts, cheaper to manufacturer and power to weight ratio becomes moderately high with complete combustion of fuel. Initially, different US. Patents has been discussed . {1} Variable vane rotary Engine. Pub. No. us2003/0159673a1 by inventor Matthew Brandon King invented with some objectives, to provide a rotary engine compact and light in weight achieve improved efficiency and increased fuel economy. Yet ,another object of this invention to provide a engine that can use variety of fuel . In this invention stator, rotor, front and rear cover and shaft vanes has been used. 5 vanes are pivoted at 72^{o}on shaft which is fixed on rotor. The vanes act as a barrier dividing the chambers in to an expansion compression region. In it compressed air fuel mixture enter separately . A high degree of efficiency is achieved by the simplicity of the whole structure rotating concentrically about the movement of torque while completing multiple cycles in one revolution. {2} Oil cooled internal combustion engine with rotary piston wall pub no.us 2007/0125320 by inventor Jerry L. Smith and Christine lomeli with some objectives. Highly efficient engine with few moving parts , highly fuel efficient & horse power to weight ratio is extremely high. In this invention a 4 cycle 4 cylinder i.c. engine which consists of a hallow cylinder engine casing

with only 3 moving parts . A single rotary piston wall and two rotable valve cylinder. A hallow type cylindrical motor casing is divided in half vertically by an internal dividing wall. A single oil cooled rotary piston wall pivots back and forth with the firing of 4 spark plugs. Each firing into one of the four cylinders.{3) Method for operating rotary engine pub. No. us 1980/ 4203,410 by inventor James R Ramer with 3 objectives i.e. with less moving parts , power to weight ratio is extremely high& highly fuel efficient by providing low emission. In this patent a rotary engine has a housing and a pair of spaced co axial rotor in the housing connected for joint movement. Each rotor rotates in a separate rotor chamber and each carries radial movable vanes. The outer edges of which engage the configured inner surface of the housing. An axially extending passage in the housing communicates the rotor chambers. The parts are few in number . A gasoline or diesel fuel can be used for operating such rotary engine.{4} Design and experimental results of small scale Rotary wankle Engine by " Kenji Miyaska and Kaory Maruta " in proceeding of 2001 ASME congress Nov 11-16 2001. A micro rotary engine with an epitrocholidal shaped housing under 1 mm^3 in size and with rotor swept volume .08 mm^3. To investigate the engine behaviour and design issue mini rotary engine have been fabricated from steel with chamber s of 1000mm^3 to 1700 mm^3 in size and their displacement range from 78 mm^3 to 348 mm^3. Testing of mini rotary engine has led to the conclusion. There are no fundamental phenomena that would prevents the operation of rotary engine. Primary testing has shown net power output 2.7 w at 9300 r.p.m. {5}Development of vaned type novel air turbine by " B.R. Singh and omkar singh on DOI; 10 1243/09344062 JME993 with objective for search of an an alternative to fossil fuel driven engine. Author has presented small air turbine with vane type rotor by using compressed air as a potential working fluid generates shaft work by testing maximum power obtained to the order of 4.95 kw (6,6) which is sufficient to run the motor bikes. {6} Influence of compression ratio on the performance characteristics of a spark ignition engine. By Aina T Folayan C.O. and pam G.Y. with objective to improve the performance characteristics of a gasoline engine.

The author investigate for brake horse power, brake mean effective pressure, brake thermal efficiency and specific fuel consumption for the Ricardo Variable Compression ratio engine theoretically and experimentally. With As the C.R. increases the fuel mixture is sufficiently compressed increasing thermal efficiency, so that less fuel requires to produce same amount of energy. Fuel consumption reduced at higher c.r. 8&9. {7} Effect of higher compression ratio in two stroke engine by Yur&Toharu (2005) the results of above investigation shows that actual fuel consumption improved by 1-3% for each unit in the compression ratio range of 6.6 to 13.6 . it was concluded that the rate of improvement was smaller as compare to the theoretical value.

III. CONCEPT OF ROTARY VANE TYPE ENGINE



1. Stator	5.Exhaust outlet
2. Rotor	6.Exhaust outlet
3. Radial Slot	7.Spark Ignition
4. Vane	8.Fuel supply

Figure1. Construction of Rotary vane engine.

Assembly of this Design is consist of stator, rotor with integrated shaft, dowel pins & vanes the rotor is provided with 6 slots at 60^0 interval consists of 2 through holes in each slot vanes opposite to each other can be attached via dowel pins as the rotor rotates. The rotor is fix eccentrically on stator & during rotation vanes slides via dowel pins & proper sealing is provided between stator& rotor using concept of vane pump compression volume obtained at top end position & swept volume obtained at bottom end position .During suction stroke by using carburetor/MPFI compressed A/F mixture is sucked through suction port in chamber (A) within the combustion area considering the rotor to be rotating position to next position at chamber(B) where compression of air fuel mixture begins at position (C) compression is completely as the rotor further advances and at position (b) spark occurs by conventional spark ignition system as a result of which combustion place and power stroke rotates the rotor 2 to position (E) & (F) the complete combustion of petrol takes place after the fuel gases are exhausted from PORT E&F entire cycle complete d during 360^0 of rotation.

A. Working principle:

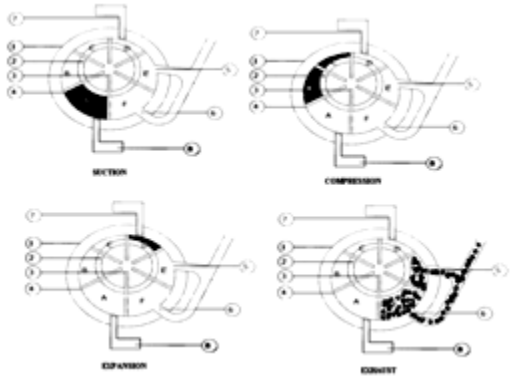


Figure2. Working principle of vane engine

B. Modeling & simulation :

Compression ratio& cubic capacity: in reciprocating I.C. Engine ratio of stroke volume to ratio of clearance volume is compression ratio where as in case of rotary type rotor fixed eccentrically, so maximum volume obtained at bottom end called as swept volume. Minimum volume obtained at top end position, therefore ratio of Swept volume to minimum clearance volume is compression ratio of rotary engine. And swept volume into nos. of vanes is cubic capacity of engine.

Assumptions of input parameters:-

In this study various input parameters are listed in table 1 for investigating optimum value of C.R. and shaft output.

Table1: input parameter

Symbol	**Parameter**
Density of air kg/mm^3	1.15
N(rpm)	6000
c.v. of fuel kj/kg kelvin	42000
Stator/rotor dia and length in mm	100/70& 50
No. of vanes used	4,6 &8
Air fuel ratio	15:1
Brake thermal efficiency	28%

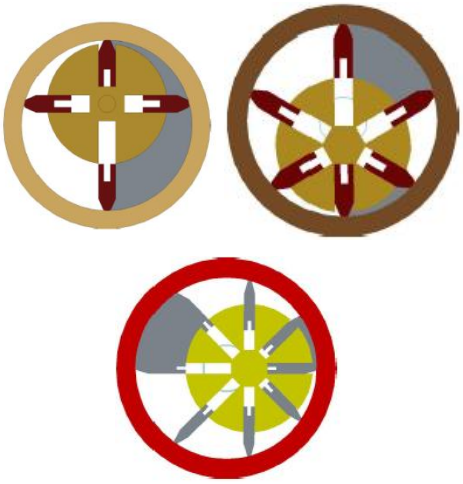


Figure3. Cad model of rotary vane engine with 4, 6, and 8 vanes respectively

Table2. Result of modeling and simulation obtained for above mechanisms based on CAD model.

No. of vanes used	**4**	**6**	**8**
Strokes occurs at different vane angles	Suction =0°-90° Compression =90°-180° Expansion power=180°-270° Exhaust=270°-360°	Suction =0°-60° Compression= 60°-180° Expansion power= 180°-300° Exhaust =300°-360°	Suction =0°-45° Compression 45°-180° Expansion power= 180°-270° Exhaust= 270°-360°
Swept &clearance volume	**A=69.76cm^3** **C=14.82cm^3**	**A=97.99cm^3** **D=11.36cm^3**	**A=41.04cm^3** **E=3.95cm^3**
Compression ratio	**4.5**	**8.64**	**10.38**
Shaft power at 6000 rpm.	**25.24kw**	**25.87kw**	**59.20kw**

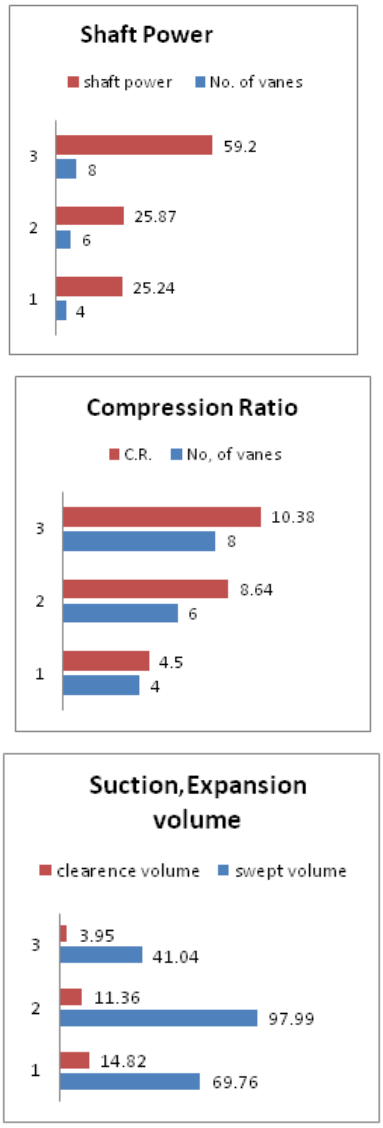


Figure4. (A) No. of vanes V/S shaft power, (B) No. of vanes V/S compression ratio, (C) Swept volume V/S Clearance volume

IV. CONCLUSION

The results obtained from above investigation based on 6000 rpm, compression ratio 15-1, brake thermal efficiency 28%, D/d=100/70;L=50mm and no of vanes used 4,6&8 also volume at different stages by making CAD model . General conclusions drawn from conceptual Design of rotary vane engines are as follows,

1. There exists an optimum value of compression ratio more than 8 of rotor casing diameter 100/70 for vane angle 60^0 and no of vanes 6.
2. As the no of vanes increases, compression ratio increases, shaft output also increases. And number of vanes decreases C.R. decreases. Shaft power BHP also reduces.
3. In comparison with reciprocating engine, it has very fewer moving parts. And all the moving parts rotates about the main shaft axis and contribute to a common movement torque.
4. During one revolution of shaft multiple sequential cycles performs different operations. So it eliminates the possibility of bigger size flywheel.

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