A Cram of Reciprocating Mechanism with Offset Crankshaft Engine

V.Nandhivarman
Assistant Professor, Department of Mechanical Engineering
EBET Group of Institutions, Nathakadayur, Kangayam, Tamilnadu, India

T.Anbukumar
Assistant Professor, Department of Mechanical Engineering
EBET Group of Institutions, Nathakadayur, Kangayam, Tamilnadu, India

Dr.P.Govindasamy
Director,
EBET Group of Institutions, Nathakadayur, Kangayam, Tamilnadu, India

Abstract- This paper presents a literal study of recent advances in internal combustion (IC) engines. It is very difficult to find the performance comparison for IC engines as the results reported by patents and journals regarding thrust force and torque are usually in conflict with each other. Thus the objective of this paper is to analyze the various research reports and to find the optimal IC engine design. This paper also gives an overview of different IC engines such as offset, twin crankshaft, conventional, crankshaft free engine, kappa engine and the conclusions of different papers are presented here.

Keywords – IC engine, Thrust force, Torque, Offset, Friction Mean Effective Pressure (FMEP)

I. INTRODUCTION

In recent years, IC engines are focused by research community as well as by automobile and pump industries for achieving better efficiency. Even though an approximate solution, analytical methods and experimental database exists, scientifically, various types of IC engines are highly relevant research area in recent times.

An internal combustion is defined as a heat engine in which the chemical energy of the fuel is released inside the engine and is converted directly into mechanical work on a rotating output shaft, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel. [1]

The present study is related in improving the crankshaft mechanism of an internal combustion engine which allows for greater efficiency and increased torque. More specifically the research review includes an engine block, crankcase, piston, cylinder, connecting rod for an offset.

The results reported in various patent obtained through the objective functions are usually in conflict with each other [2-5]. Hence the resent review is done to find a solution which would give the values of all the objective functions acceptable to the decision maker. Instead, a set of solutions called best solution providing a tradeoff between the objective function can be found. The optimal solution for the specified application is selected from the set of best solution by the problem solver.

In 1940, the offset engines were considered for slow speed engines [6]. In recent times Honda and Kawasaki used the offset of 4mm and 2mm of piston and crank respectively in high speed 4 stroke SI engines [7-9].

Thus the purpose of our present study is to improve the efficiency of IC engines by reducing the thrust force and by increasing torque.

The rest of the paper is organized as follows. Proposed embedding and extraction algorithms are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. METHOD TO ANALYZE OPTIMAL IC ENGINE

The methods that are used to find optimal IC engines can be broadly classified as

A. Analytical method –

In analytical method using various parameters such as pressure, thrust force, stroke length, cylinder diameter, and temperature different governing equations will be obtained for different IC engines. The input parameter will be substituted to different governing equations. With the results obtained using thrust force, torque, efficiency, power output optimal IC engine will be found. For example Rollins et al derived basic governing equation for Offset crankshaft engine is given below [10].

$$s(t) = r\cos(2\pi w t) + \sqrt{b^2 - (r\sin(2\pi w t) - d)^2}$$

$$v(t) = -2r\sin(2\pi w t)\pi w - \frac{2(r\sin(2\pi w t) - d)r\cos(2\pi w t)\pi w}{\sqrt{b^2 - (r\sin(2\pi w t) - d)^2}}$$

$$a(t) = -4r\cos(2\pi w t)\pi^2 w^2 - \frac{4(r\sin(2\pi w t) - d)^2 r^2\cos(2\pi w t)^2\pi^2 w^2}{\left(\sqrt{b^2 - \left(r\sin(2\pi w t) - d\right)^2}\right)^3} + \frac{4(r\sin(2\pi w t) - d)r\sin(2\pi w t)\pi^2 w^2 - 4r^2\cos(2\pi w t)^2\pi^2 w^2}{\sqrt{b^2 - \left(r\sin(2\pi w t) - d\right)^2}}$$

Dr. Taj Elssir Hassan et al [11] says theoretical Performance Comparison between Inline, Offset and Twin Crankshaft Internal Combustion Engine. The authors says -The twin crankshaft engine is a new configuration of internal combustion engine that introduced to solve the engine liner wear problems, increase the engine efficiency in addition to other advantages over conventional engines. In this paper, a computational work was carried out to compare the performance of three IC engine configurations, namely, the conventional (inline), the offset crankshaft and the twin crankshaft engines, of the same cylinder bore, speed, crank arm, piston mass and heat addition. The performance measured was the side thrust force that causes liner wear and the output torque. Finally the results obtained was twin crankshaft engine increases the torque hence the efficiency. The side thrust force in twin crankshaft engine equals zero. The offset crankshaft engine decreases the side thrust force, when compared with the conventional engine but it has a smaller torque

Ragot, P. and Rebbert, M et al [12] proposes the influence on crankshaft offset on piston friction. A stribeck curve approach is used to predict friction between piston group and cylinder lines and the influence of crankshaft offset on this portion of friction. The stimulation model was fed by stribeck curves from an experience database. All friction values in this article contain of piston friction plus piston ring friction. No parameter adjustment was done, such that the stimulation has the quality of a real prediction. The friction of all variants were reduced to friction mean effective pressure(FMEP) to express the difference between measured and calculated FMEP as relative error percentage which fills up the matrix. The most probable reason for the difference at higher engine speed in that the measurement setup obviously shows resonance vibrations that cannot be covered by the stimulation & and an of course not realistic. When looking at the engine without this measurement equipment. Crankshaft offset has a great deal of potential to reduce friction. The result is a completely interfaced surface data structure, describing FMEP as function of the engine load and speed.

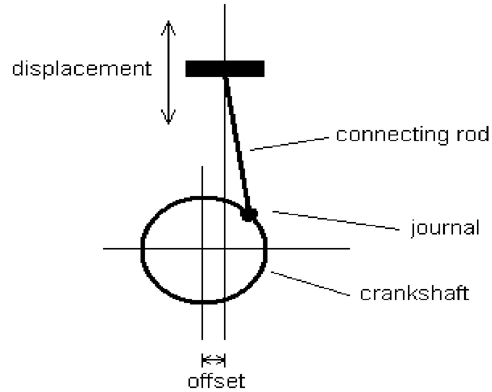

Figure 1. Offset Crankshaft Mechanism

B. Experimental setup –

Different experimental models should be made for each type of IC engines. The models will be running in various input parameters. With the results obtained from the experimental setup, optimal IC engine will be assessed. The analytical method is easier compared to experimental setup but the results will be more accurate in experimental setup.

Michael Inden et al [13] investigates the reciprocating piston mechanism with an extended piston offset is provided. The mechanism of the type that contains at least one cylinder having a longitudinal axis, at least one piston that has a pivot pin and is slidingly installed in the cylinder, a main driveshaft having a central axis which is offset at a distance from the longitudinal axis of the cylinder, a circular cylindrical body eg.circular eccentric, which is non-rotationally secured on the main driveshaft and a rocker arm, which is essence is a second order lever. The lever is pivotally mounted on the circular eccentric. The mechanism is also provided with a connecting rod that connects the cylinder to one arm of the rocker arm/lever. The other arm of the rocker arm/lever has a roller that is guided in a confined pathway and works as a fulcrum of the lever and simultaneously acts as a stabilizer/rudder at the same time. The invention refers to a reciprocating piston mechanism such as internal combustion engine, compressor and pump. This altered geometrical relation provides increased power and torque for an internal combustion engine. The objective of this invention is to provide a reciprocating piston mechanism to increase the force applied to the drive shaft moment arm, reduce the relationship between a piston stroke and the length of the drive shaft/ crank moment arm, increased torque on the drive shaft of the engine, which increases fuel efficiency for the required engine power output.

Edward A.Garvin et al [14] discussed as the offset crankshaft mechanism for an IC engine. An offset crankshaft mechanism for an internal combustion engine allows for greater efficiency and increased torque. The invention includes an engine block, a crankcase, and one piston cylinders having a piston reciprocally disposed within the crankcase and offset at a predetermined distance from the vertical axis of the piston cylinder and connecting rod connecting piston to the crank shaft. The offset crankshaft is located such that at a point during the power stroke the crankshaft is perpendicular to the vertical axis of the piston cylinder and the connecting rod is substantially collinear with the vertical axis of the piston cylinder. The crankshaft must be located far enough below the piston cylinders; it increases the efficiency of the engine by increasing the combustion chamber pressure at top dead center and reducing the return stroke angle which reduces the friction between the piston and piston cylinder. For comparison purposes a conventional engine using a twelve inch long connecting rod and a crank with a three inch throw which is positioned on the axis of the piston cylinder will have the same maximum return stroke for connecting rod as well as crank which have a three inch throw and which have a tree inch offset and twenty four inch connecting rod. But the conventional engine has the same maximum angle on the power stroke as it does on the return stoke, the connecting rod in the offset configuration will never pass vertical during the power stroke .The offset configuration with longer connecting rods will never reduces the overall friction between the piston and the piston cylinders by reducing the average angle between the connecting rod and the axis of the piston cylinder. The use of a relatively long connecting rod, as is disclosed in the present invention, has the added benefit of increasing the dwell of the piston at top dead center. The increased dwell at top dead center when the combustion chamber is at the smallest area will generate higher combustion pressure within the combustion chamber at top dead center if ignition of the fuel is properly started. The high combustion pressure will create more force on the piston which will therefore generate more torque and horse power then is present in a conventional engine.

Ronald F.Markel et al [15] this paper discusses of an IC engine with an offset crankshaft a new and useful improvement to internal combustion engines is disclosed which an engine with an offset crankshaft. When the crankshaft is rotated in a clockwise direction, the distance of the piston travels the top of the stroke (piston at maximum travel) to the bottom of the stroke (piston at the bottom-of it travel) is greater than the diameter of the crankshaft rotation. The angle through which the crankshaft moves during the down stroke is greater than 180o. The engine therefore has a longer time power stroke than exhaust cycle which improves aspiration of the engine. This concept can be applied to Otto cycle engines, Diesel engines, two stroke engine, and may be applied to compressors. When used in compressor, intake stroke is extended which improves aspiration. The objective of having a stroke longer than the down stoke in a standard engine diameter crankshaft. For a standard engine, when the crankshaft is rotated, the time it takes the piston to travel from the top of the stroke to the bottom of the stroke is equal to time its take the piston return from the bottom of the stroke to top of the stroke. However, in an engine with an offset crank shaft embodying the present research, when the crankshaft is rotated, the time its take the piston to return to travel from the bottom of the top of the stroke is greater than the time it takes the piston to return from the bottom of the piston to top of the stroke. The intake cycle is longer in time than the exhaust cycle which improves aspiration of the engine.

Takiguchi et al [16] at Musashi Institute of Technology experimentally investigated the effect of crankshaft offset on piston friction. He used a floating linear method to measure piston frictional force in real time in a single-cylinder engine. In addition, the engine was modified to install a provision to change crankshaft offset up to 15 mm. Crankshaft offset can decrease piston frictional force during the expansion stroke. With a 15 mm offset, the piston frictional force decreased by about 10 and 5 percent when the engine was operated under full load at 1500 and 2000 rpm, respectively. Calculation results indicated the reduction of piston side force during the expansion stroke when crankshaft offset was increased. However, the piston friction did not decrease accordingly, especially at 2000 rpm, the crankshaft offset actually decreased piston side force; however, the upper-skirt contact force against the cylinder wall did not decrease at the same ratio as much as the decrease at 1500 rpm. If crankshaft offset is used to reduce piston friction, a specific piston design modification will be necessary to reduce piston side force, particularly at the upper piston skirt, continued investigation will be necessary to better understand the relationship between the piston and wall phenomenon and piston deformation.

Sumeet Prakash et al [17] discussed, the kappa engine and its advantages, Hyundai launched a new i10 with the kappa engine which is the eleventh in its series of gasoline engines. The new fuel saving power unit, the kappa engine uses new technologies that cut weight and friction to boost fuel economy. The engine block is made from high pressure die-cast aluminum which results inconsiderable eight savings. The ladder frame construction of kappa engine main block provides superior structural stiffness. The most significant engineering innovation is kappa offset crankshaft. By creating this offset distance, engineers have succeeded in minimizing the side force created by the piston. The net effect is an improvement in fuel consumption and reduction in noise, vibration and harshness. Kappa's valve train features a number of innovations roller swing arm lower friction in valve train there by helping improve fuel efficiency, kappa is controlled by two 16-bit 32MHZ microprocessors for digitally precise control of the ignition timing, idle speed, knocking & emissions.

IV.CONCLUSION

In this literature, reciprocating arm, offset, twin crank mechanism were discussed, but detailed numerical results for these parameters have to be evaluated by experimental setups. This article also gives an overview of offset, twin crank which has been used in IC engines and how successful the optimization was. This study highlights that offset and twin crank mechanism seems to be one of the promising optimization method for IC engines, although there are some conclusions on premature convergence. Further research studies should be done on offset twin crank mechanism for better understanding of thrust force, torque, output power and efficiency of IC engines.

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