Software Selection for Analysis and Computational Calculations of Split Cycle Engines

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Abstract— The internal combustion engines are one of the world boosting machines on the earth. The world new upcoming leading approach in engines is split-cycle engine, in which the compressed air in one cylinder is transferred to the other cylinder which is in phase through the crossover passage. The compression in cross over passage helps ignition when the piston is moving away from TDC and that process enhances performance with reduction in pollutants. In order to understand the breathing issue & low thermal efficiency concept in more critical and better way, a proper calculative study of these issues is necessary before practical calculations. This calculative study can only be done through certain softwares which will help to attain computational values which lead to geometric modes. The research regarding software selection results in use of CFD analysis under NSYS atmosphere and use of CATIA for improvement in valves and cross over passage construction.

Index Terms— Basic concepts, Breathing issue, Cross over passage , Calculative Study , Sofware selection, Split Engines, Low Thermal Efficiency issue, Practical Concepts

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RESEARCH HISTORY

Six months before when the author of this research paper plans to start study on Split cycle engines he found that there are a lot of researchers which are working on this concept brilliantly and there is a company named as Scuderi which is working extensively and impressively good on this concept with highly advanced approach. But for any starter who wants to understand and work on computational study of split engines, there must be sources available to him regarding software selection. Hence the author decided to extract some important concepts from previous researches and from his own experience. The main objective of this research paper is to give basic approach for software selection and analysis of split engines approach which will be highly helpful for those who are about to start their working on split cycle approach in engines. Author is also high thankful to previous researchers like Scuderi who really worked hard and one of the pioneers of this concept.

1. Introduction to split approach:

Split cycle engines are the engines in which two separate cylinders named as compression and power cylinders are paired together to divide and separate conventional four strokes of engines (intake, pressure, power & exhaust). Keeping figure in view in compression stroke when the intake air is compressed, cross over passage is used which is not only helpful to compress previously compressed air but also useful to transfer compressed intake air to power stroke. Combustion process undergoes because of fuel injected and then burned to produce power stroke. If two cylinders of split cycle is divided into two portions then they work just like combustion chamber on one side and air compressor on other side. These two pistons are connected to same crank shaft with some phase difference and time lag.

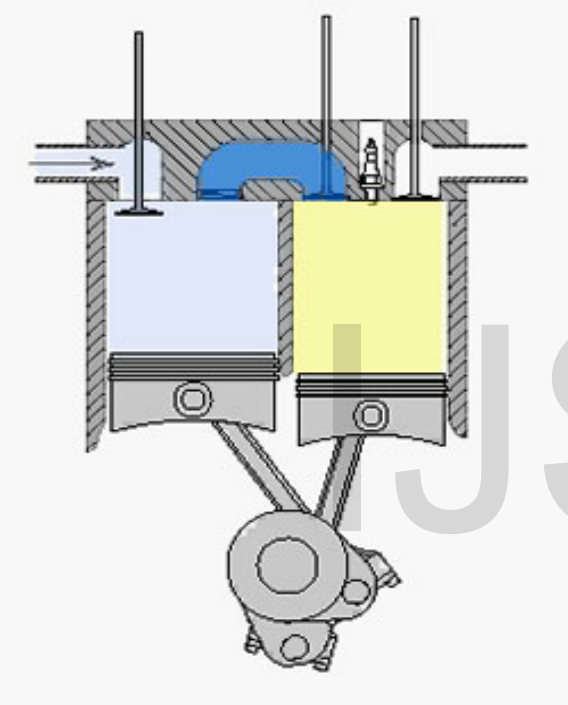
The main class of split engine is production of one power stroke with each revolution similar to that in two stroke engine but pollution contents are very low. However on the other side conventional engine always produces one power stroke in two revolutions. Unfortunately it is observed that there are two main issues in split engines. One is breathing problem which is because of air trapped in compression cylinder and other is low thermal efficiency which is because of lost of work done in compression cylinder due to trapped air [1].

1.1 Breathing Problem:

The first issue, breathing problem, as mentioned earlier, is majorly because of high pressure trapped air in compression cylinder and this trapped pressure gases got re-expansion in compression cylinder before another charge is drawn which results in reduction of engine capacity to

propel air and causes low volumetric efficiency as well [1]. However on the other side high compression ratio values almost Equivalent to 75:1-100:1 is usually required. This can be achieved by unique designing of valves of cross over passage.

In order to solve this breathing issue and designing of valves, proper selection from available softwares is required which will help to determine certain pressure range through which possibility of air jamming should be minimized and valve designing should be made.



[7] Ref:-http://thekneeslider.com/scuderi-split-cycle-engine

1.2 Low Thermal Efficiency:

It was observed that thermal efficiency of conventional engines was always better than split engines with a significant difference. This is because in case of firing before top dead centre (BTDC) in a split cycle engine, the compressed trapped air in the crossover area is allowed to expand in power cylinder during upward stroke of piston. The engine needs to achieve compression work twice leading to low thermal efficiency with allowance to compressed gases to expand in the power cylinder [1].

2. Problem Statement and Tasks:

The main task of this paper is to determine software which will help to achieve correct values of compression and expansion to improve breathing issue, low volumetric efficiency and low thermal efficiency issues.

- Selection of software to perform computational analysis.
- Selection of software for thermal analysis.
- Selection of software for geometric modes.

3. Methodology:

Different resources and different readable print versions were used to create strong literature review for this task. The major resources used for research are following:

Proper search and study of literature available in research journals, text books, websites and collection of data through discussion with world automobiles companies & specialists.

4. Literature Glance & Existing techniques:

Between the conventional SI engines and split engines the comparative CFD analysis is made by Scruderi Group and software named as GT Power is used by them to perform this analysis. They claimed that engine efficiency is highly effected by variance in expansion ratios, phasing between pistons. Compression ratio, combustion timing and duration, cross over passage construction and cross over passage valve configurations. [2] & [1].

Sapsford, in VECTIS, had performed computational calculations by using CFD simulations. Two representative diesel engines were chosen as subjects; a large truck engine and a small HSDI research engine. A complete injection time swing was formed by simulation programmes each consisted of 6 cases. The results obtained from CFD simulation were compared directly against engine tests. For the large truck analysis, in all six cases both the measured and the simulated pressure curves appear smooth over the ignition period, but a slight under prediction of pressure was observed between 20-50 ATDC they stated that this may be due to the insufficient accuracy in specifying the wall boundary temperatures. The trend of NOX decrease with the delay in the injection is perfectly predicted by the CFD simulation. They found out from the HSDI simulation that the in-cylinder pressure is matching to the simulation at the early stages of combustion but there is a slight gradient. They stated that this result is due to more significant premixed burn and quicker flame development, most probably due to the effective fuel/air mixing produced by highly

swirling flow in small engine. [5] & [1]

Scuderi Group has studied on six various styles of the helical passages that used to come out from cross over passage and most commonly required to create swirls and turbulence in combustion chambers. These styles were:

- Combinations of tangential runners
- Radial runner sections
- Counter clockwise helical
- Clockwise
- helical
- directed end sections.

From computer studies it was observed that high level of turbulent kinetic energies were produced because of higher swirl wings produced and especially in case of dual tangential helical passages this situation created in end sections. [3] & [1]

CFD modelling was used by Musu to check the performance and characteristics of naturally aspirated homogeneous charge progressive combustion engine. They based their study on steady state analysis using CFD through various equivalence ratios. They tried to improve the flow efficiency and reduce the speed of air through the duct by performing tests on three different transfer duct geometries. Their study explained the advantages of having a different compression ratio in the combustion and compression cylinders, the impact on Soot and NOx emission under high load conditions.

5. Data Analysis:

After Literature glance and as per methodology defined it was concluded that CFD analysis is the best way to attain thermal calculations on different area of the split cycle engines to obtain information about issues, problems & methodologies.

The first result from deep data analysis of literature review is the CFD analysis, that will carried out for both split and conventional engines keeping approximately same charge and volume.

6. Results & Conclusions

1. CFD analysis will help to solve breathing issues which is one of leading cause of low performance. The performance curves will be plotted and compared in light of CFD analysis which will help to understand combustion at variant speeds. 2. The CATIA environment will be used to understand geometrical modes.

3. In order to calculate Thermal efficiency, ANSYS will be done.

4. The obtained results will be validated by analytical results to attain fool proof picture.

7. References

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