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The Practical Range of Cut Off and Compression Ratios for a Diesel Cycle Engine

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Abstract: The model and theoretical study on an internal combustion engine cycles are of great significance in enhancing the performance of the engine. The overall efficiency of the engine is an important output parameter which depends on a variety of factors under diverse conditions. Here in this paper a specific study is carried out on diesel engine. some of the factors contributing to the performance of an diesel engine are its compression ratio, cut-off ratio, calorific value of fuel and its ignition temperatures, ratio of specific heats of gas used etc… A special interest is given in this study to investigate and analyze how the efficiency parameters of the diesel engine vary its efficiency when the compression and cut-off ratios are varied over an attainable practical range.
Keywords: Performance parameters, compression ratio, cutoff ratio, efficiency

I. INTRODUCTION

The diesel engine, named after Rudolf Diesel, is an internal combustion engine in which ignition of the injected fuel is caused when the air is elevated due to the mechanical compression to a sufficient high temperature. The chemical energy of the fuel is converted into mechanical energy and is used as traction force, to power automobiles (freight trucks etc) , Power plants etc… The diesel internal combustion engine differs from the gasoline powered Otto cycle in terms of higher compression ratio .Hence it is also called as compression ignition engine. The performance of the diesel engine is governed by the diesel cycle. In the diesel cycle combustion is controlled in order to obtain constant pressure at the beginning of the expansion stroke [1][2].

II. STUDY OF DIESEL CYCLE

The idealized Diesel cycle assumes an ideal gas and ignores combustion chemistry, exhaust and recharge procedures and simply follows four distinct processes. Here, Air is assumed to behave as an ideal gas, and all processes are considered to be reversible [3]

1) 1→2: isentropic compression of the fluid
2) 2→3: reversible constant pressure heating
3) 3→4: isentropic expansion
4) 4→1: reversible constant volume cooling

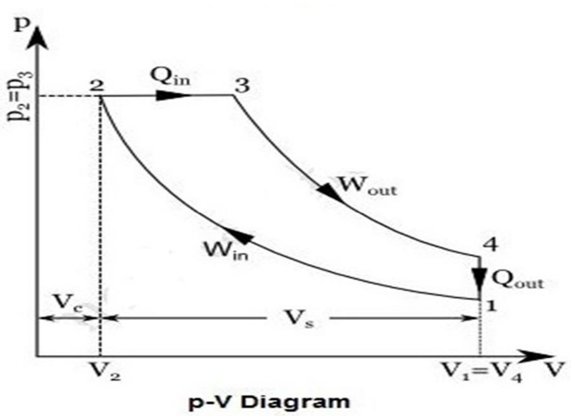

Figure 1

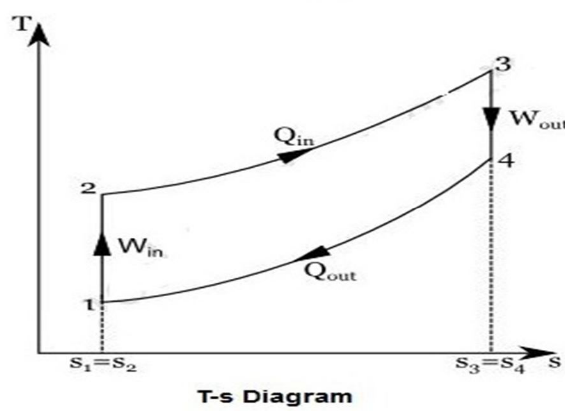

Figure 2

The compression ratio is the ratio between the volume of the cylinder and combustion chamber in an internal combustion engine at their maximum and minimum values. The cutoff ratio is the ratio of the volume after combustion to the volume before combustion.

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The diesel engine has the highest thermal of any practical internal or external combustion engine due to its very high expansion ratio [4] . Rudolf Diesel describes that the effective efficiency of the diesel engine would be in between 43.2% and 50.4% , or maybe even greater [5]. However, average efficiency over a driving cycle is lower than peak efficiency. The highest diesel engine efficiency of up to 55% is achieved by large two-stroke watercraft diesel engines [6]. the factors contributing to the performance of an diesel engine are its compression ratio, cut-off ratio, calorific value of fuel and its ignition temperatures, ratio of specific heats of gas used etc…[7] The maximum thermal efficiency of a Diesel cycle is dependent on the compression ratio and the cut-off ratio(assuming air to be an ideal gas). From FIGURE 1,

Compression ratio, $r = V_2/V_1$

Cut off ratio, $r_c = V_3/V_2$

Efficiency,

$$\eta = 1 - \frac{1}{r^{k-1}}\left[\frac{r_c^k - 1}{k(r_c - 1)}\right]$$

Where k is ratio of specific heats , in this case for dry air k=1.4
In the diesel engine, only air is initially introduced into the combustion chamber. The air is then compressed with a compression ratio typically between 15:1 and 23:1. With high compression ratio, they operate at higher pressures The higher pressure requires stronger build of the engine (in some cases heavier). Chances of knocking in the engine are higher. Due to its high compression ratio, the diesel engine has a high efficiency, and the lack of a throttle valve means that the charge-exchange losses are fairly low, resulting in a low specific fuel consumption, especially in medium and low load situations [8]. The cutoff ratio severely reduces the thermal efficiency of the Diesel cycle as its value increases.

III. GRAPHICAL INSIGHT

The contour plots are drawn as shown in figure 2 taking cut off ratio on x-axis and compression ratio on y-axis and drawing z slices that is efficiency values as shown {0.32,0.45,0.55,0.65,0.70}

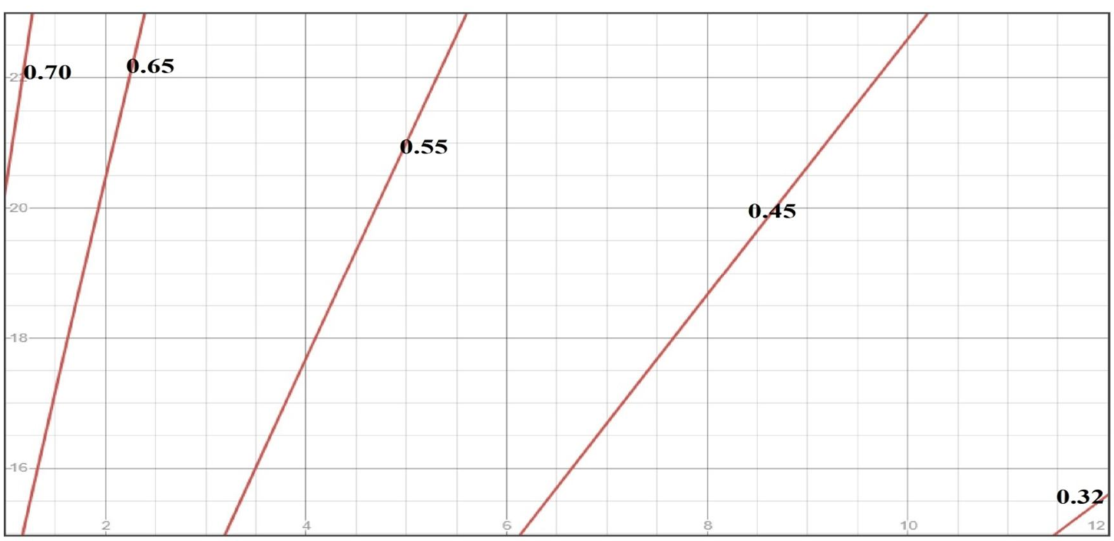

Figure 2

From figure 2 ,we can say that for low efficiency the cut off ratio is tending to 12 and compression ratio is tending to 15 ; and for high efficiency the cut off ratio is tending to 1 and compression ratio is tending to 23 .but as said earlier if compression ratio is high, knocking comes to play.

IV. CONCLUSION

The compression and cut off ratios play cardinal roles in determining the efficient and economical engines for production in practical usage. Hence as said by Rudolf diesel efficiency between 43.2% and 50.4% for which the practical range lies between 3 to 7 for compression ratio and 16 to 20 for cut off ratio and is economical and suitable. One can produce engines of high efficiency controlling the high pressures and high stresses but may not get commercial profit hence they can be sold as a job product only.

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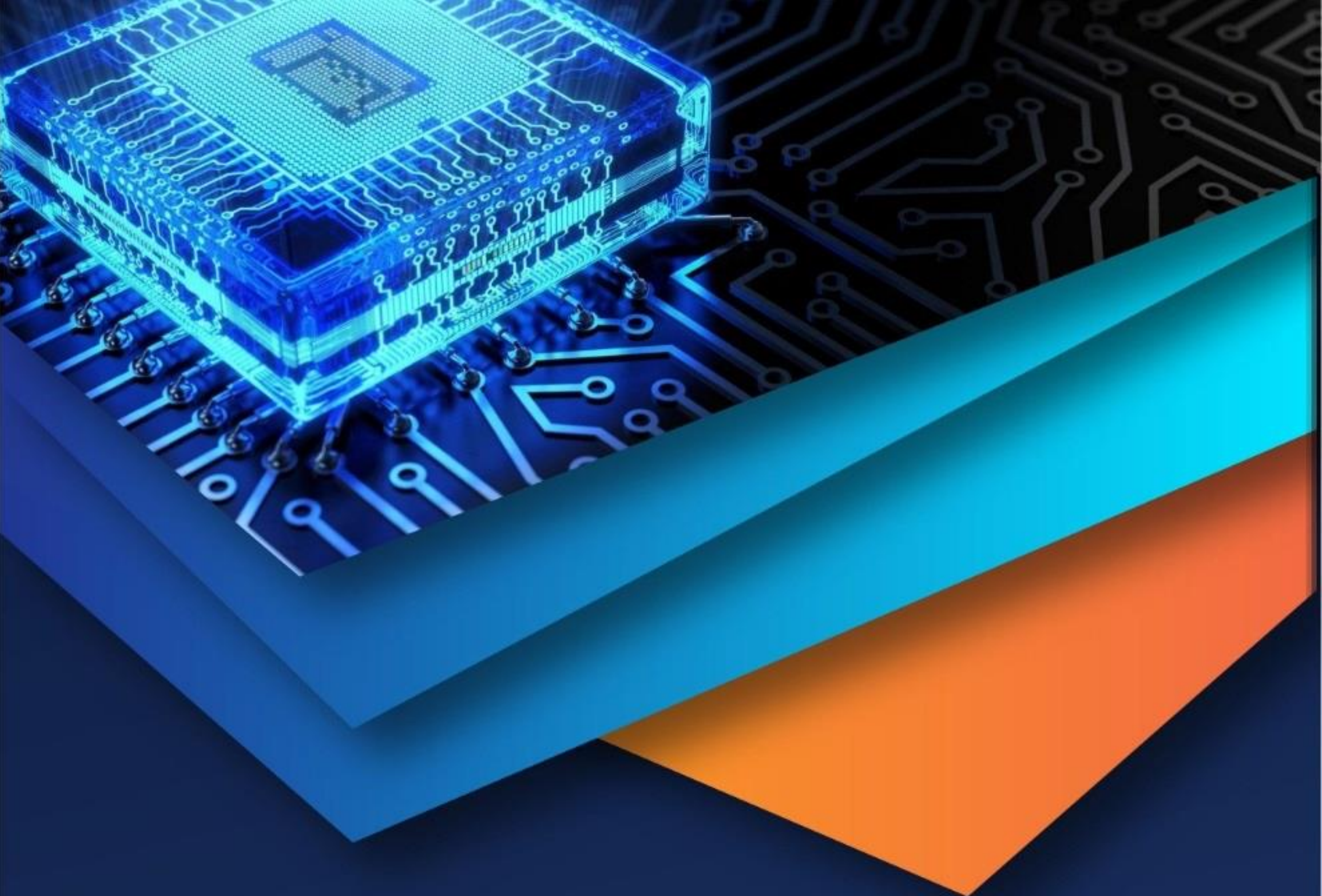

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