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Optimization of Process Parameters of Two Stroke SI Engine

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Abstract: *This investigation is an effort to find best optimization method for petrol engine using variable carburetor system. In present position of the world, energy crisis due to fast depletion of fossil fuel is main problem. Increase in fuel price day by day, continuously growth of automobile industry, rapid growth in individual mobility and improved living standard, continuous accumulation of greenhouse gases are the main causes for development of alternative techniques Researchers are continuously finding best alternative solution, which gives the best performance and fuel characteristics When the use alternate techniques in petrol engine, there must have to optimize the parameter of petrol engine The present trend will be used low emission fuels or technique which creates low emission & gives high thermal efficiency in vehicles. The purpose of this study is to experimentally analyze the performance and the pollutant emissions of a Single Cylinder Petrol engine operating by variable carburetor system.*

Key Words: *Air Fuel ratio, Total Fuel Consumption, Brake Thermal Efficiency, Brake Specific fuel Consumption.*

I. Introduction

For the present situation the cost of the fossil fuels are increasing day by day and at the same time fuel abundance may exhaust in another 30 – 40 years. The emissions caused by the present automotive engines which led the air pollution. Along with the population growth the vehicle population growth is also increased. The above problems have made the engineers to think of to over come the above problems. The many researchers have conducted experiments on the existing two stoke petrol engines on to improve its performance and to reduce their emissions. From the earlier studies it is known that the demand for small capacity engines with high power to weight ratio and emissions, two Stroke Engines are predominant as such they are being used in large number of two wheeler vehicles. Though the four stroke engines has replaced its counterpart two stroke engines being used in mopeds, scooters, snow mobiles and hand held power tools. Apart from several advantages that these engines claim there are certain draw backs such as high scavenging losses, low thermal efficiency relatively higher emissions. These defects are due to short circuiting of the fuel supply during the scavenging phase and to the dilution of fresh charge by the exhaust gases. Any investigation towards the improvement of performance of these engines simultaneously reducing their emissions will be a great help to the automotive industries and to protect the environment.

As such developments made by S. S. Chung et al [1] conducted experiment on scavenging a Sub-chamber type CNG fueled engine demented that when all the fuel was injected into the sub chamber the combustion duration was shortened. Zhijun Peng et al [2] conducted experiment on Numerical simulation of charge stratifications to improve combustion and NO formation of lean burn SI Engines resulted that as long as the degree of dilution in the mixing region is within dilution limit of the combustible charge, the gradient, the gradient of dilution has little effect on combustion and NO formation. S.H. Chan et al [3] conducted experiment on the effect of Thermal barrier coated piston crown on engine characteristics made measurements and comparisons of engine performance in particular fuel consumption were made before and after coating. Jinyoung Cha et al [4] conducted experiment on Effect of exhaust gas recirculation on combustion stability, engine performance and exhaust emissions in gasoline engine performed experiment to investigate the effects of EGR on combustion stability and engine performance. Jae Keun Park et al [5] conducted experiment on Comparisons of Predicted and measured results on performance and emission of engine affected by intake air dilution and supercharging results show that correlations are likely to be adequate for the engine operating under diluted intake air and various intake pressure. P. Govindaswamy et al [6] conducted experiments on Performance and emissions achievements by magnetic energizer with a single cylinder two stroke catalytic coated SI engine concluded that magnetically energized zirconium coated engine performed better than the base engine during running. M. Loganathan et al [7] conducted Investigations on performance and emissions of Two Stroke SI Engine fitted with a manifold injection system shown that the engine can work well with leaner mixtures as compared to carbureted engines. D. B. Ganesh et al [8] conducted experiment on Development of Direct Methanol Injection for two stroke coated SI engine for Optimum performance studied with regard to brake thermal efficiency, exhaust emissions, equivalence ratio at constant speed

From the literature survey and from the experimental studies of the earlier researchers on these two stroke engines are found some improvements in the performance and reduction in emissions. But still it requires modifications in the existing two stroke engines to the optimum performance with minimum scavenging losses. It also requires reducing the emissions from these engines.

II. Experimental Details

A single cylinder two stroke air cooled and electrical loading to be tested for the performance is coupled to AC generator with swinging field with spring balance. The rate of fuel consumption measured by using volumetric pipette and air flow measured by manometer connected to air bar. The torque on the engine is measured by spring balance with torque arm and engine speed is measured by clearance digital indicator with thermocouple. The whole instrumentation is mounted on a self contained unit ready for operation.

Testing procedure of experiment follows:-

1. 1.Initially experiments were done on existing carburetor system and readings are taken by varying the loads on the engine using the electrical dynamometer and calculations are done for the engine performances such as Air Fuel ratio, Total fuel Consumption, Brake thermal efficiency ,Brake Specific Fuel Consumption and Brake power, etc., (Table no: 1.)
2. 2.Later changing the existing carburetor system by the variable Carburetor system readings were taken by varying the loads on the engine using the electrical dynamometer and calculations are done for the engine performances such as Air Fuel ratio, Total Fuel Consumption, Brake Thermal Efficiency ,Brake Specific Fuel Consumption and Brake power, etc., (Table no: 2.)
3. Select the parameter levels and construct the computational procedure of simplex array (Table3,4,6 and 7) to find the better optimal values for the existing and new carburetor systems to improve the performance characteristics of the engine.[7][8]
4. Later plotted the response curves for Brake thermal Efficiency for the existing and new carburetor systems.(Fig 1, 2 and 3)

III. Simplex Method Of Optimization

It was developed by G. Danztig in 1947. The simplex method provides an algorithm (a rule of procedure usually involving repetitive application of a prescribed operation) which is based on the fundamental theorem of linear programming.

The Simplex algorithm is an iterative procedure for solving LP problems in a finite number of steps. It consists of

- Having a trial basic feasible solution to constraint-equations
- Testing whether it is an optimal solution
- Improving the first trial solution by a set of rules and repeating the process till an optimal

solution is obtained

Advantages

- Simple to solve the problems
- The solution of LPP of more than two variables can be obtained.

IV. Before Optimization And Results

(Airflow) Max $= (A/F) * mf + \rho_a * Va$

$= (ma/mf) * mf + (ma/Va) * Va$

Let Air fuel ratio $= x_1$

Volume of Air $= x_2$

Zmax $= mf*x_1 + \rho_a*x_2$

Sl. No	m_f (kg/min)	m_a (kg/min)	V_a (m^3/min)	Spring Load(Kg)	ρ_a (kg/m3)	A/F	TFC (kg/hr)	η Bthe %	BSFC Kg/Kw-hr	BP KW
1	0.0108	0.0063	0.0054	4.9	1.17	0.581	0.647	16.70	0.539	1.200
2	0.0120	0.0077	0.0065	6.8	1.17	0.638	0.721	19.83	0.454	1.587
3	0.0133	0.0077	0.0065	8.1	1.17	0.577	0.796	19.12	0.471	1.691
4	0.0148	0.0089	0.0076	8.6	1.17	0.598	0.888	16.48	0.546	1.626
5	0.0159	0.0089	0.0076	8.9	1.17	0.557	0.954	14.49	0.621	1.536

Table1: Existing Carburetor system readings

Sl. No	m_f (kg/min)	m_a (kg/min)	V_a (m^3/min)	Spring Load(Kg)	ρ_a (kg/m3)	A/F	TFC (kg/hr)	η Bthe %	BSFC Kg/Kw-hr	BP KW
1	0.0137	0.0197	0.0168	6.3	1.17	1.655	0.822	14.74	0.611	1.346
2	0.0140	0.0254	0.0211	7.5	1.17	1.814	0.963	14.17	0.635	1.516
3	0.0140	0.0216	0.0184	8.9	1.17	1.542	0.967	13.96	0.645	1.500
4	0.0113	0.0152	0.0129	9.9	1.17	1.550	0.676	21.68	0.415	1.627
5	0.0186	0.0232	0.0192	10.5	1.17	1.633	0.809	18.24	0.493	1.640

Table2: Variable Carburetor system readings

From the above Table 1

Zmax $= 0.0148x_1 + 1.17x_2$

Equations

$0.0107x_1+1.17x_2+1S_1+0S_2-0S_3-0S_4 = 0.01703$

$0.0159x_1+1.17x_2+0S_1+1S_2-0S_3-0S_4 = 0.0247$

$1x_1+0x_2+0S_1+0S_2-1S_3-0S_4 = 0.598$

$0x_1+1x_2+0S_1+0S_2-0S_3-1S_4 = 0.00756$

Constraints

$0.0107x1+1.17x2 \leq 0.01835$

$0.0159x1+1.17x2 \leq 0.0259$

$x1 \leq 0.598$

$x2 \leq 0.00756$

Cj	Solution	0.01125	1.17	0	0	0	0	
Cb	mix	x_1	x_2	S_1	S_2	S_3	S_4	
0	S_1	0.00137	1.17	1	0	0	0	0.0334
0	S_2	0.01861	1.17	0	1	0	0	0.03937
0	S_3	1	0	0	0	-1	0	1.2
0	S_4	0	1	0	0	0	-1	0.0129
	Zj	0	0	0	0	0	0	
	(Cj - Zj)	0.01125	1.17	0	0	0	0	

Table 3: Before optimization results for existing carburetor system

Cj	Solution	0.01125	1.17	0	0	0	0	
Cb	mix	x_1	x_2	S_1	S_2	S_3	S_4	
0	S_3	0	0	72.99	0	1	85.47	0.135
0	S_2	0	0	0.641	1	0	0.4188	0.00107
0.01	x_1	1	0	72.99	0	0	85.47	1.435
1.17	x_2	0	1	0	0	0	-1	0.0129
	Zj	0.01125	0	0.821	0	0	0.196	
	(Cj - Zj)	0	0.00756	-0.821	0	0	-0.196	

Table 4 : Before Optimize results for existing carburetor system.

From the table 3: New element (S_3 row) = 1 0 0 0 -1 0 1.2

Updating other row elements

S_1 row

0.0137 - (0.0137*1) = 0
1.17 - (0) = 1.17
1 – 0 = 1
0 – 0 = 0
0 – (0.0137*1) = 0.0137
0 – 0 = 0
0.0334 – (0.0137*1.2) = 0.01696

S_2 row

0.01861 - (0.01861*1) = 0
1.17 – 0 = 1.17
0 – 0 = 0
1 – 0 = 1
0 – (0.01861*-1) = 0.01861
0 – 0 = 0
0.03937 – (0.01861*1.2) = 0.01708

S_3 row

0 - 0 = 0
1 – 0 = 0
0 – 0 = 0
0 – 0 = 0
0 – 0 = 0
-1 – 0 = -1
0.0129 – 0= 0.0129

From the table 4: Since all values of (Cj – Zj) are zeros and negative and parameters optimized

New elements of Zj

$Zx_1 = 0.01125$, $Zx_2 = 1.17$, $ZS_1 = 0.8211$, $ZS_2 = 0$, $ZS_3 = 0$, $ZS_4 = -0.196$, $x_1 = 1.435$, $x_2 = 0.0129$

Zmax $= (0.01125x1 + 1.17x2)$

$=(0.01125*1.435 + 1.17*0.0129)/2 = 0.0156$ Kg/ Min

Variables	Experimental	Theoretical
Air Fuel ratio	1.542	1.435
Volume of air	0.0152	0.0156
Mass of air	0.0129	0.0129

Table 5: Before optimization results for the Brake power of 1.626KW

V. After Optimization And Results

Zmax = mf*x1 + ρa*x2
From the above table 2 of after optimization
Zmax = $0.01125x_1 + 1.17x_2$

Equations

$0.00137x_1+1.17x_2+1S_1+0S_2-0S_3-0S_4 = 0.0334$
$0.01861x_1+1.17x_2+0S_1+1S_2-0S_3-0S_4 = 0.03937$
$1x_1+0x_2+0S_1+0S_2-1S_3-0S_4 = 1.2$
$0x_1+1x_2+0S_1+0S_2-0S_3-1S_4 = 0.0129$

Constraints

$0.00137x1+1.17x2 \leq 0.0334$
$0.01861x1+1.17x2 \leq 0.03937$
$x1 \leq 1.2$
$x2 \leq 0.0129$

Cj	Solution	0.0148	0.00756	0	0	0	0	
Cb	mix	x_1	x_2	S_1	S_2	S_3	S_4	
0	S_1	0.0107	1.17	1	0	0	0	0.01703
0	S_2	0.0159	1.17	0	1	0	0	0.0247
0	S_3	1	0	0	0	-1	0	0.598
0	S_4	0	1	0	0	0	-1	0.00756
	Zj	0	0	0	0	0	0	
	(Cj - Zj)	0.0148	0.00756	0	0	0	0	

Table 6: After optimization results for variable carburetor system

Cj	Solution	0.0148	1.17	0	0	0	0	
Cb	mix	x_1	x_2	S_1	S_2	S_3	S_4	
0	S_4	0	0	0.9212	-0.07	0	1	0.00113
0	S_3	0	0	-73.56	1	1	0	0.426
0.01	x_1	1	0	-73.56	76.92	0	0	1.024
1.17	x_2	0	1	1.1526	0.07	0	0	1.00869
	Zj	0.0148	1.17	0.2599	1.22	0	0	
	(Cj - Zj)	0	0	-0.2599	-1.22	0	0	

Table 7 : After Optimize results for variable carburetor system.

From table 6 New elements (S_3 row) = 1 0 0 0 -1 0 0.598

Updating the reaming rows

S_1 row

0.0107 - (0.0107*1) = 0
1.17 - (0) = 1.17
1 – 0 = 1
0 – 0 = 0
0 – (0.0107*1) = 0.0107
0 – 0 = 0
0.01703 – (0.0107*0.598) = 0.01063

S_2 row

0.0159 - (0.0159*1) = 0
1.17 – 0 = 1.17
0 – 0 = 0
1 – 0 = 1
0 – (0.0159*-1) = 0.0159
0 – 0 = 0
0.0247 – (0.0159*0.598) = 0.01573

S_3 row

0 - 0 = 0
1 – 0 = 0
0 – 0 = 0
0 – 0 = 0
0 – 0 = 0
-1 – 0 = -1
0.00756 – 0= 0.00756

From the table 7 : Since all values of (Cj – Zj) are zeros and negative and parameters optimized
New elements of Zj
$Zx_1 = 0.0148$, $Zx_2 = 1.17$, $ZS_1 = 0.2599$, $ZS_2 = -1.22$, $ZS_3 = 0$, $ZS_4 = 0$, $x_1 = 1.024$, $x_2 = 0.00869$
Zmax $=(0.0148x_1 + 1.17x_2)/2$
= (0.0148*1.024 + 1.17*0.00869)/2 = 0.0126 Kg / Min

Variables	Experimental	Theoretical
Air Fuel ratio	0.598	1.024
Volume of air	0.007568	0.00869
Mass of air	0.008854	0.0126

Table 8: Results for the Brake power of 1.627KW

Parameters	Before Optimization	After Optimization	Comparison to Before and After results
Air Fuel ratio	0.598	1.55	Increased by 159%
Volume of Air	$7.568*10^{-3}$	0.0129	Increased by 70.45%
Mass of Air	$8.854*10^{-3}$	0.0152	Increased by 71%
Mass of Fuel	0.0148	0.0098	Reduced by 51%
Brake Power	1.626	1.627	Increased by 0.184%

Table 9: Comparison results of existing and variable carburetor system before and after optimization

VI. Analysis For Response Curve

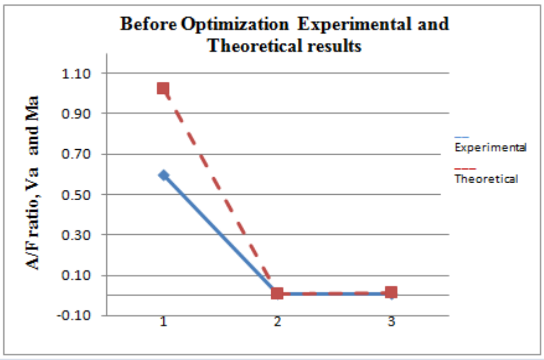

Fig1 : Before Optimization Experimental and Theoretical results

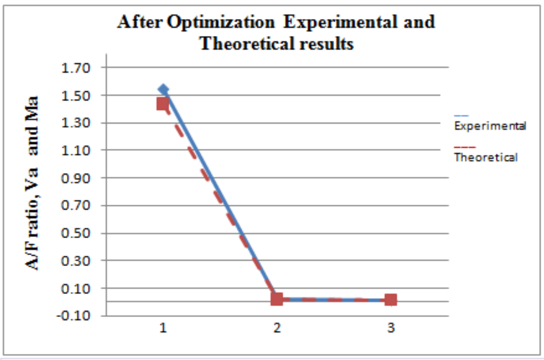

Fig2 : After Optimization Experimental and Theoretical results

From the fig1 **Before optimization** :Air Fuel ratio, Mass of air and volume of air is reduced by experimentally. But from the fig 2 **After optimization:** Air Fuel ratio, Mass of air and Volume of air is drastically increased by experimentally.

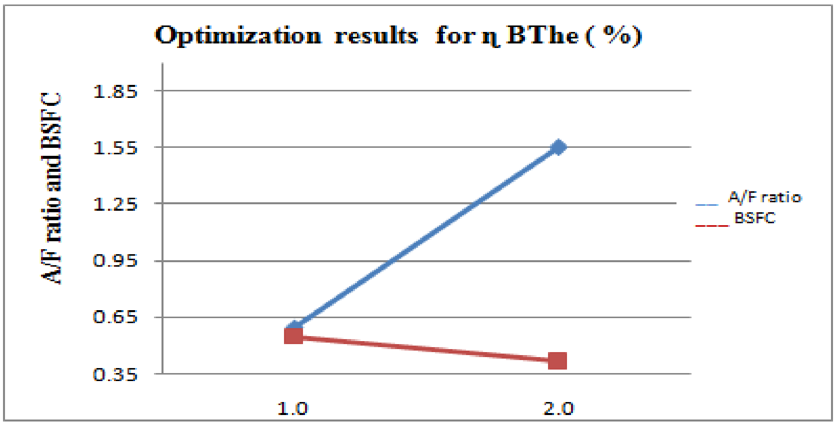

Fig3 : Optimization results for Brake thermal Efficiency

From the fig3: Air Fuel ratio and Brake Thermal Efficiency, Brake Specific Fuel Consumption is increased by using optimization technique.

VII. Conclusion

This is simply the first step in developing a procedure for solving a more complicated linear programming problem. But it is an important step in that we have been able to identify all the corner points (vertices) of the feasible set without a having three or more variables.

The Simplex method was found to be an efficient technique in Linear Programming for quantifying the effect of control parameters. The highest performance at set 1.55 A/F ratio, Mass of Air 0.0152 Kg/Min, and Mass of Fuel 0.0098 Kg/Min for variable carburetor system after optimization where as for existing carburetor system results are 0.598 A/F ratio, Mass of Air 0.008854 Kg/Min, and Mass of Fuel 0.0148 Kg/Min, which are optimum parameter setting for highest Brake Thermal Efficiency. Engine performance is mostly influenced by A/F ratio and is least influenced by load. It was found out experimentally that brake thermal efficiency and Air Fuel ratio was improved after modification. In other words Fuel economy was improved after using the variable carburetor system

VIII. Future Scope

Using variable carburetor system and adopting the Simplex optimization technique results in estimating the best carburetion system for achieving maximum fuel economy. This procedure also helps us to assess preliminary viable and non viable procedures so as to get maximum efficiency from the existing system without changing any component of the system and can also be applied for any heat transfer applications.

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