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"Synthesis and Performance Analysis of Acetylene for Dual Fuel Mode using S.I Engine"

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***Abstract:** From the reference of past few decades it is believed that crude oil petroleum products are becoming scarce and very costly. As technology is advancing fuel economy of engine is getting improved and will continue to Improve.Also, there is an enormous increase in variety of vehicles which has started dictating the demand for fuel. Gasoline and diesel will become scarce and very expensive in near future. With the increased use and depletion of fossil fuels, there is an almost need to find an alternative fuel, so that some of the problems can be minimized.*

An effort has been made to use an alternate fuel in 4-stroke spark ignition engine. Another reason motivating the development of an alternate fuel for an S.I engine is the concern over the emission problems of use of gasoline. Combined with the other air polluting systems the large no. of automobiles is a major contributor to the air quality problems of the world. The engine used for alternate fuel is a modified S.I engine, which was originally designed for petrol fuelling.

An extensive research and development is done by using acetylene as an alternative fuel which is a gas, obtained from combination of calcium carbide and water. For this, particular storage gas cylinder is designed with certain mechanical elements. Maximum performance and investigation for obtaining the efficiencies can be done using this alternative fuel and hence analysis based on performance is carried out. Also Comparison study of petrol and acetylene, CNG and acetylene is accomplished.

***Keywords:** Alternative Fuel: Acetylene, valve timing for petrol and acetylene, emission, Performance analysis, efficiencies of Acetylene and petrol.*

I. INTRODUCTION

With increase in urban population in countries like India, there has been consistent growth in demand in the areas of fuel. Human life largely depends on the usage of hydrocarbon fuels, with the growth of the economy and consumptions worldwide, there is a great strive of force in order to find an effective solution of alternatives to the hydrocarbon fuels. As we all know power generating hydrocarbon fuels used for distinct number of transport and shipping purposes are diminishing rapidly. Vehicles and

Locomotives which are generally propelled by an internal combustion engine uses fossil fuels to generate the power. Due to excessive usage of fossil fuels by different modes the fuel produced are naturally getting reduced to a higher extent. On the other side of the facts and figures, utilization of excessive hydrocarbon fuel is leading to discharge of harmful gases produced after combustion process. This is adversely affecting the atmosphere and leading to major issues such as ozone layer depletion, greenhouse effect, smog and acid rains. Another prime and major apprehensive issue is to deal with climate variation due to emission of carbon dioxide from automobiles. Hence human life is facing severe problems related to respiratory system. Internal combustion engine is incorporated for power generation, the surrounding conditions are getting critically affected during extraction and purification of crude oil processed for the production of fuels such as petrol and diesel. So as to overcome all this problem it is a matter of concern for all of us. Research and development for finding best alternative fuel can be seen widely. Finding a substitutes for such fuels can be the best possible way to save our environment from getting damaged. Also it will give advantage to hi-tech hybrid vehicles. Alternatives such as CNG, LPG, and Hydrogen has already good results, in comparison other fuels natural gas possess less threat to the environment. Recent development in the area of alternative fuel is acetylene gas produced from chemical reaction of calcium carbide and water. This fuel can be a very promising fuel because of its much higher calorific value, high octane number and off course reduced exhaust emission. Conventional IC Engines uses hydrocarbon fuels which has led to serious threat to the surroundings, using alternative fuels in such engines can be very useful in reducing such harmful gases. Another big advantage in automobile sector can get to hybrid engines. Apart from this it will also help in lowering vehicle emission which will ultimately reduce the pollution. Also it will be more economical with respect to other IC fuels. Another major fact is it will play vital role in economy of the country and will also protect against life threatening global warming. Previous some R & D has been carried out on the usage of acetylene gas but it is not developed hence an attempt has been made to encourage the use of acetylene gas as an alternative fuel in Spark ignition engines.

II. FORMING OF ACETYLENE GAS FROM CALCIUM CARBIDE & WATER

Acetylene (C_2H_2) is not only an air gas but also a synthesis gas generally produced from the reaction of calcium carbide with water. The use of acetylene as a fuel has been largely limited to welding related applications or acetylene for welding, here we are using this gas as an alternate fuel for S.I Engine.

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III. REACTION FOR PRODUCTION OF ACETYLENE

For production of acetylene, calcium carbide must be mixed with normal water. After few seconds the gas is generated. Produced acetylene gas is collected in storage tank (cylinder) which is designed which is specially designed and fabricated for storage purpose. In car boot space acetylene gas cylinder is fitted.

Following is the chemical reaction:

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$$

IV. PERFORMANCE OF ALTERNATE FUEL

For proper performance, testing and analysis Maruti 800 is purchased so as to run the vehicle on acetylene. Also trial is done to run the same vehicle on dual fuel mode, alternatively the vehicle is made to run on petrol as well as on acetylene, in the similar way which is done in hybrid vehicles.

Fig 1: Maruti 800 in which Acetylene fuel is used.

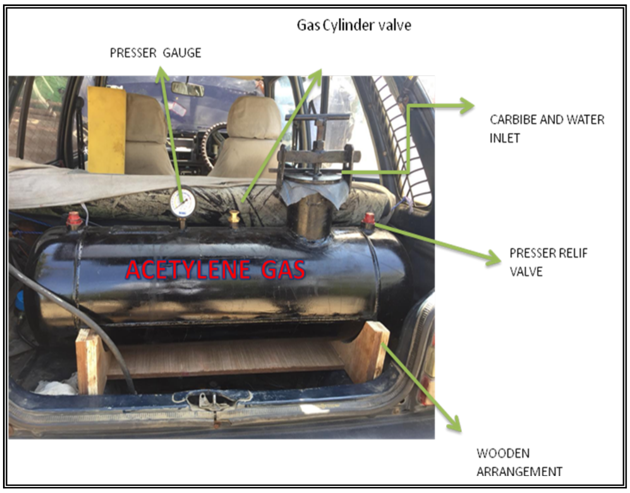

Fig 2: All over arrangement of Acetylene cylinder.

Here, for storage of acetylene gas, storage tank is designed and fabricated with specified dimensions.

V. VALVE TIMING

The timing of opening & closing of valves is specified in degrees corresponding to the position of engine's pistons. Engine valve timing is the most critical process of IC engines. In Engine *Valve diagram*. The inlet valve usually opens few degrees before the piston reaches TDC in its exhaust stroke.

VI. VALVE TIMING DIAGRAM

The valves operate some degrees before or after the dead centers. The ignition is also timed to occur a little before the top dead center. The timings of these sequence of events can be shown graphically in terms of crank angles from dead center position. This diagram is known as *valve timing diagram*.

Following is the comparison of valve timing diagram of petrol and acetylene

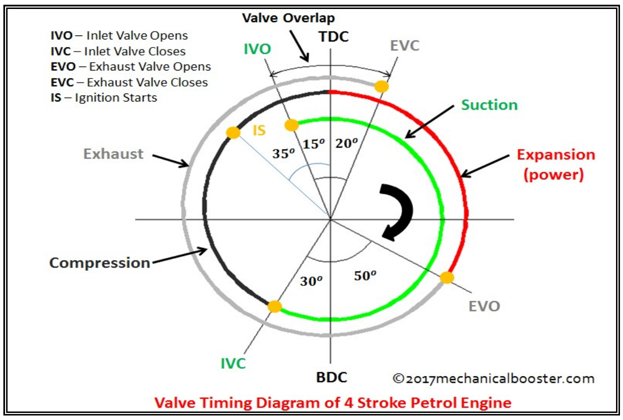

Fig 3: Valve timing diagram for Petrol engine.

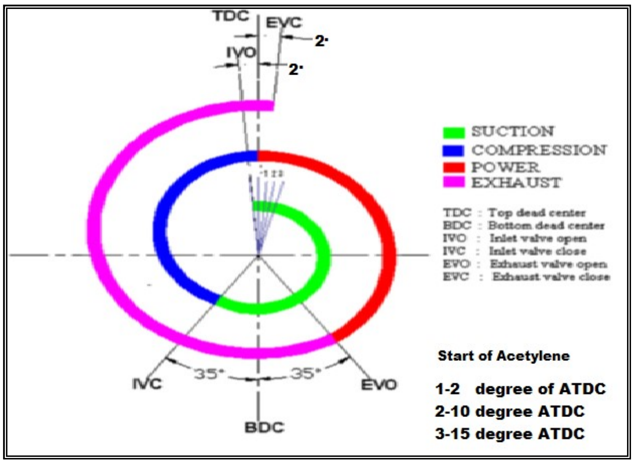

Fig 4: Valve timing diagram for Acetylene.

Here, the valve timing diagram for using acetylene is modified by 2 degrees.

Table-II: Reading for Petrol Engine, at (1500 rpm)

Sr. No.	Load (Kg)	Speed (RPM)	FC final (Kg/min)	FC initial (Kg/min)	FC (Kg/min)
1	12	1500	3.57	3.52	0.05
2	6.8	1500	3.253	3.21	0.04
3	6.4	1500	3.045	3.21	0.04
4	6.8	1500	3.253	3.21	0.04

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Sample Calculation for Petrol Engine

1. Hydraulic dynamometer load, W = 12 Kg
2. Engine speed N = 1500 rpm
3. Fuel consumption= Final reading – Initial reading m^3 /min
   = 3570 – 3520
   = 50 gm/ min
   = 0.05 m 3 /min
4. Calorific Value of Petrol CV= 44000 KJ/Kg
5. Density of water = 1000 Kg/m 3
6. Density of air = 1.16 Kg/m 3
7. Diameter of piston, D = 0.0685 m
8. Stroke length, L = 0.072 m
9. Specific gravity petrol= 0.71
10 Constant of dynamo meter, K= 2719.2

1. Engine Output (Brake Power BP):

$$BP = \frac{W \times N}{K} \text{ HP}$$

$$BP = \frac{12 \times 1500}{2719.2} ¿$$

BP = 6.61 kW

2. Total fuel consumption

$$\text{Fuel consumption in1 minute } Q = \frac{fuel\,consumption}{1000} \text{ Kg}$$

$$= \frac{3570 - 3520}{1000} \text{ Kg}$$

= 0.05 Kg

$$\text{TFC in kg /sec} = \frac{0.05}{60} \text{ Kg/sec}$$

3. Heat supplied,

Qs = TFC x CV
= (0.05/60) x 44000
Heat supplied (Qs) = 36.67 kW

4. Brake Thermal Efficiency

$$\eta = \frac{BP}{Qs} = \frac{6.61}{36.67} x\,100 = 18.05\%$$

Brake Thermal Efficiency = 18.05%

5. Brake specific fuel consumption:

BSFC = (Fuel used in g /hr.) (Brake Power in KW)
= (0.05 x 10^3 x 60) / (6.61)
= 453 g / kW-hr
Brake specific fuel consumption = 0.453 kg/kW-hr

6. Morse Test

Table-II: Results of Morse test

Sr. No.	Load (Kg)	Speed (RPM)	Cylinder position	BP (KW)	IP (KW)	FC (KW)
1	12	1500	All cylinder working	6.61	8.81	2.2
2	6.8	1500	1st cylinder cut off	3.75	2.86	5.06
3	6.4	1500	2nd cylinder cut off	3.52	3.09	5.29
4	6.8	1500	3rd cylinder cut off	3.75	2.86	5.06

Engine Input (Indicted Power IP)

Indicated Power, IP_1= 6.619 – 3.75 = 2.86 KW
Indicated Power, IP_2 = 6.619 – 3.53 =3.09 KW
Indicated Power, IP_3= 6.619 – 3.75 =2.86 KW
Total Indicated Power (IP) = 2.86 + 3.09 + 2.86 = 8.81 KW

7. Mechanical Efficiency:

$$\eta = \frac{BP}{IP} = \frac{6.61}{8.81} x\,100 = 75\%$$

Mechanical Efficiency = 75 %

8. Indicated specific fuel consumption:

ISFC = (Fuel used in g/ hr.) / (IP)
= (0.05 x 10 3 x 60) / (8.81)
= 453.85g/KW-hr
Indicated specific fuel consumption=0.4538 kg/kW-hr

9. Indicated Thermal Efficiency

$$\eta = \frac{IP}{Qs} = \frac{8.81}{36.67} x\,100 = 24.22\%$$

Indicated Thermal Efficiency = 24.22%

VII. TEST HAS BEEN CARRIED OUT FOR ACETYLENE GAS:

Table-III: Reading for Acetylene Engine, at (1500 rpm)

Sr. No.	Load (Kg)	Speed (RPM)	FC final (Kg/min)	FC initial (Kg/min)	FC (Kg/min)
1	12	1500	2.38	2.35	0.03
2	6.8	1500	2.36	2.34	0.02
3	6.4	1500	2.35	2.33	0.02
4	6.8	1500	2.26	2.24	0.025

Sample Calculation for Acetylene Engine:

1. Hydraulic dynamo meter load, W = 12 Kg
2. Engine speed N = 1500 rpm
3. Fuel consumption= Final reading – Initial reading m^3 /min
   = 2380 – 2350
   = 30 gm/ min
   =0.03 m^3 /min
4. Calorific Value of Acetylene CV= 48225 KJ/Kg
5. Density of water = 1000 Kg/m 3
6. Density of air = 1.16 Kg/m 3
7. Diameter of piston, D = 0.0685 m
8. Stroke length, L = 0.072 m
9. Specific gravity (Acetylene) = 0.889
10 Constant of dynamometer, K= 2719.2

1. Engine Output (Brake Power BP):

$$BP = \frac{W \times N}{K} \text{ HP}$$

$$BP = \frac{12 \times 1500}{2719.2} ¿$$

BP = 6.61 kW

2. Total fuel consumption

$$\text{Fuel consumption in1 minute } Q = \frac{fuel\,consumption}{1000} \text{ Kg}$$

$$= \frac{2380 - 2350}{1000} \text{ Kg}$$

= 0.03 Kg

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$$\text{TFC in kg /sec} = \frac{0.03}{60} \text{ Kg/sec}$$

3. Heat supplied

Qs = TFC x CV

$$= \frac{0.03}{60} \times 48225$$

Heat supplied (Qs) = 24.11 kW

4. Brake Thermal Efficiency

$$\eta = \frac{BP}{Qs} = \frac{6.61}{24.11} x\,100 = 27.45\%$$

Brake Thermal Efficiency = 27.45%

5. Brake specific fuel consumption

BSFC = (Fuel used in g /hr.) (Brake Power in KW)

= (0.03 x 10^3 x 60) / (6.61)

= 2745 g / kW-hr

Brake specific fuel consumption = 0.2745 kg/kW-hr

6. Morse Test

Table- IV: Results of Morse test

Sr. No.	Load (Kg)	Speed (RPM)	Cylinder position	BP (KW)	IP (KW)	FC (KW)
1	12	1500	All cylinder working	6.619	8.857	2.238
2	6.8	1500	1st cylinder cut off	3.75	2.869	5.107
3	6.4	1500	2nd cylinder cut off	3.53	3.089	5.327
4	6.8	1500	3rd cylinder cut off	3.75	2.869	5.107

Engine Input (Indicted Power IP)

Indicated Power, IP_1= 6.619 – 3.75 = 2.869 KW

Indicated Power, IP_2 = 6.619 – 3.53 =3.089 KW

Indicated Power, IP_3= 6.619 – 3.75 =2.869 KW

Total Indicated Power (IP) = 2.869 + 3.089 + 2.869

= 8.857 KW

7. Mechanical Efficiency:

$$\eta = \frac{BP}{IP} = \frac{6.61}{8.857} x\,100 = 74.73\%$$

Mechanical Efficiency = 74.73%

8. Indicated specific fuel consumption:

ISFC = (Fuel used in g/ hr.) / (IP)

= (0.03 x 10^3 x 60) / (8.857)

= 203.22 g/KW-hr

Indicated specific fuel consumption = 0.20322 kg/kW-hr

9. Indicated Thermal Efficiency

$$\eta = \frac{IP}{Qs} = \frac{8.857}{24.11} x\,100 = 36.73\%$$

Indicated Thermal Efficiency = 36.73%

VIII. COMPARISON OF PERFORMANCE ANALYSIS OF PETROL AND ACETYLENE:

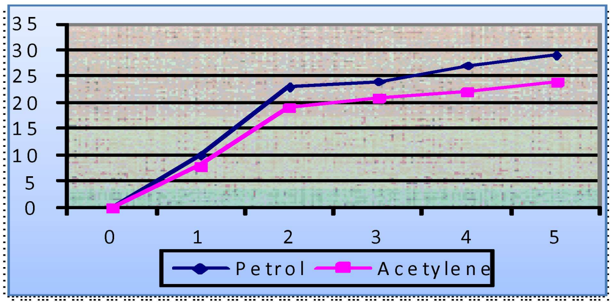
Table-V: Showing test results of Exhaust Emission after combustion:

SR NO	PROPERTIES	PETROL	ACETYLENE
1	BP	6.61kW	6.61kW
2	IP	8.81kW	8.81kW
3	BSFC	0.453Kg/kW-hr	0.2745 Kg/kW-hr
4	ISFC	0.3405 Kg/KW-hr	0.2032 Kg/KW-hr
5	Mechanical efficiency	75%	74.73%
6	Indicated thermal efficiency	24.22%	36.73%
7	Brake thermal efficiency	18.05%	27.45%
8	Heat supplied (Qs)	36.67kW	24.11 kW

Table –VI: Showing Specification of Exhaust Gases.

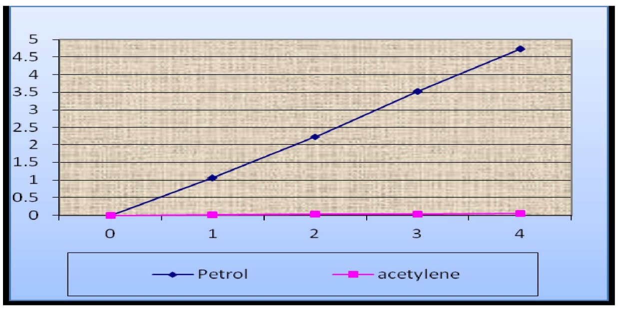
Parameters	Petrol	Acetylene
CO	4.731%	0.049%
HC	559 PPM	72 PPM
CO2	10.30%	6.30%
O2	3.18%	12.47%
NOX	0 PPM	0 PPM
LDA	0.981	0.00%

In the demonstration, initially for ignition process petrol is aspirated and then acetylene gas is sent through inlet valve of SI engine. The execution of vehicle is carried out and then exhaust gas characteristics are compared with baseline petrol operation.



Graph-I: Brake thermal Efficiency Vs. BP

Carbon monoxide (co):- Carbon monoxide gas is a colorful gas which forms due to incomplete combustion of fuel. It is produced when carbon is incomplete and there is limited supply of air. It is a pollutant formed when operating an internal combustion engine in an enclosed space. During experimentation the value observed of carbon monoxide comes from petrol is 4.731% whereas acetylene contain 0.049% which is a lesser value.



Graph-II: CO Vs. BP

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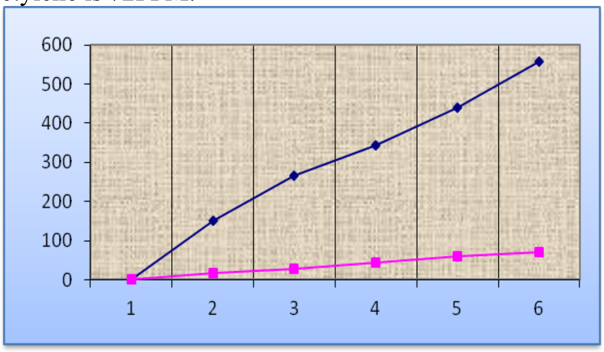
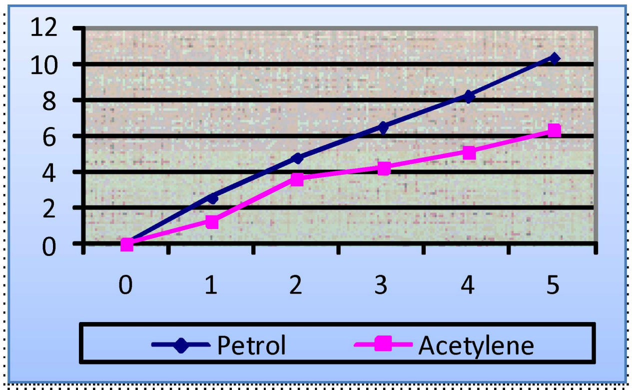
Hydrocarbons: Hydrocarbon is the major emission resulted from the incomplete combustion of fuel, mainly produced from SI engine fuel. The amount of percentage of hydrocarbons released from carburetor, crankcase and exhaust valve is 15%, 20% & 65%. This proves comparatively the exhaust emitted from using acetylene as a fuel in SI engine is less, for petrol it's 559PPM and for acetylene is 72PPM.



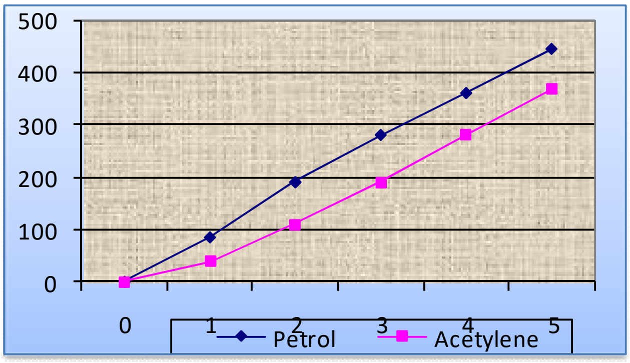
Graph III: HC Vs BP

Carbon dioxide: The CO_2 is an index of complete combustion of a fuel. Although it is not that emission which directly affects our health whereas it is a main cause for global warming. The CO_2 emissions is 6.3% by volume after the combustion of acetylene gas used as a fuel and 10.30% by volume for base line petrol operation.



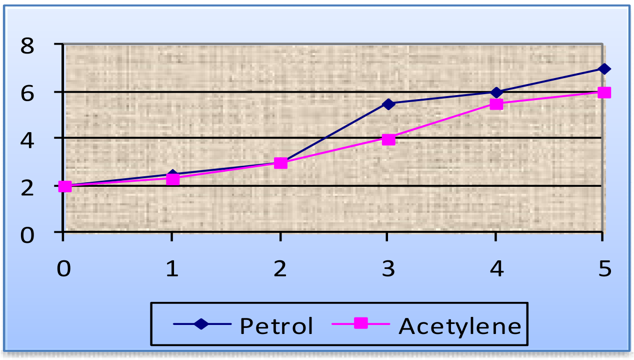
Graph-IV: CO_2 Vs BP

Exhaust gas temperature: - The engine is tested at various loads, keeping track of combustion performance to find out the optimum fuel flow rates and also to have reduced emissions. The results show that the performance of the Acetylene enriched engine is nearer to the pure petrol engine with reduced emissions. The exhaust gas temperature at full load reaches 368^0C in acetylene induction technique and 444^0C in the case of base line operation.



Graph-V: Exhaust gas Vs BP

Smoke: The reason for the emission of engine smoke is attributed to the proper burning of the fuel. Once the soot is formed, it can burn, it comes out with exhaust and become visible if it is burn. The size of soot particles affects the parameters of the engine.



Graph-VI: Smoke V_s Brake power

IX. RESULTS

- Brake thermal efficiency of acetylene gas is more than petrol.
- Brake power increase with increase in specific fuel consumption for petrol.
- Reduced emission than petrol.

X. ADVANTAGES

- Very cheap and available in abundance.
- An engine operated on multi fuel either on acetylene gas or petrol like hybrid engine.
- Reduced emission than conventional fuel.
- Complete combustion of fuel.
- Better efficiency.
- Reduction in maximum use of petrol.

CHALLENGES

- Proper disposal of slurry left in the cylinder

XI. CONCLUSION

The research suggest the best possible method to use alternative fuel produced from calcium carbide and water which is present in abundant quantity. Also it focuses informative and effective solution. As we can observe that acetylene as an alternative fuel as a hydrocarbon fuel. Hence it also gives you the development of modified technique for hybrid vehicles which would be very useful in recent trend and can also be seen as a boon for automobile sector. The article gives you very significant and measurable analysis of acetylene for dual fuel mode using SI engines. Hence synthesis and performance has been accomplished.

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