STUDY OF COMPRESSED AIR AS AN ALTERNATIVE TO FOSSIL FUEL FOR AUTOMOBILE ENGINES

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ABSTRACT: *Present paper deals with the study of alternative fuel for automobile engines with a special emphasis on compressed air driven engine. A proposal has been put forward for developing automobile running on compressed air engine.*

1.0 INTRODUCTION

About 100 years ago, the major source of energy shifted from recent solar to fossil fuel (hydrocarbons). Technology has generally led to a greater use of hydrocarbon fuels, making civilization vulnerable to decreases in supply. The current study made in the year 2004, predicts that if the oil is consumed at the current rates, then by 2020, we will be consuming 80% of the entire available resource. This necessitates the search for alternative of oil as energy source or preserving it by tapping some other alternatives such as Non-conventional energy like battery operated vehicles, wind mills, photocells etc. and to convert their output into mechanical energy, which may alternatively preserve oil source.

The worldwide researches are also going on for other alternatives such as use of Hydrogen Fuel Cell (which is presently very costly), use of Bio-Diesel or use of compressed air Vehicle engines which may be made of light material body & cylinders of aluminum body. Work on compressed air engines are in progress since 1979. “Guy Negre” [6.2.9], a French Scientist developed compressed air 4- cylinders engine run on air and gasoline, for car in 1998 and got 52- patents registered sofar. The 4- cylinders engine thus developed run on both air and gas together. The concept of Micro or Mini compressed air engine can be one of the best alternatives for light vehicles, if it runs using air alone and thus causing no pollution.

It is worldwide burning problem to find out best alternatives of fuel oil & to make sustainable energy future. At this time our best knowledge is being utilized to choose the different resources of conventional fossil fuel.

2.0 ISSUES RELATED TO FOSSIL FUEL

Latest studies and projections available indicate that the crises of fossil fuel in near future is inevitable and alternative to fossil fuel must be looked for. Some of the studies made in this regard are detailed ahead.

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2.1.0 Why alternative to fossil fuel is sought?

2.1.1"*We do not inherit the Earth from our parents; we borrow it from our children*." Saint Exupery

2.1.2 When the wells run dry, We use more oil than we find, and if producers are fixing their figures the end could be closer than thought, by Adam Porter, The Guardian [2005 May 25]

"Predicting the end of the age of oil can be a sticky business. The Association for the Study of Peak Oil and Gas (Aspo), a collection of industry figures, politicians and academics, this week held its annual meeting at the Gulbenkian Museum in Lisbon..."

2.1.3 Peaking of World Oil Production: Impacts, Mitigation, & Risk Management, by Robert L. Hirsch, SAIC, Roger Bezdek, MISI, Robert Wendling, MISI for the National Energy Technology Laboratory of the US Department of Energy [2005 February]

"The peaking of world oil production presents the U.S. and the world with an unprecedented risk management problem. As peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented. Viable mitigation options exist on both the supply and demand sides, but to have substantial impact, they must be initiated more than a decade in advance of peaking."

2.1.4.Expert says Saudi oil may have peaked, by Adam Porter [2005 February 22] : "As oil prices remain above $45 a barrel, a major market mover has cast a worrying future prediction. Energy investment banker Matthew Simmons, of Simmons & Co International, has been outspoken in his warnings about peak oil before. His new statement is his strongest yet, 'we may have already passed peak oil."

2.1.5 Full text of landmark document now available: **Nuclear Energy and the Fossil Fuels** by M. King Hubbert, Chief Consultant (General Geology), Exploration and Production Research Division, Shell Development Company, Publication Number 95, Houston, Texas, June 1956, Presented before the Spring Meeting of the Southern District, American Petroleum Institute, Plaza Hotel, San Antonio, Texas, March 7-8-9, 1956.

2.1.6 Chinese demand set to push Opec to limit, by Javier Blas and Kevin Morrison in London [2005 February 16] "The Organisation of Petroleum Exporting Countries signalled a significant tightening of oil markets towards the end of this year, warning on Wednesday it would have to pump close to its maximum capacity next winter to meet rising demand from China against the backdrop of slowing Russian production."

2.1.7 U.S. Energy Policy: A Declaration of Interdependence, by David J. O'Reilly Chairman and CEO, ChevronTexaco Corporation [2005 February 15] "Simply put, the era of easy access to energy is over. In part, this is because we are experiencing the convergence of geological difficulty with geopolitical instability... [W]e are seeing the beginnings of a bidding war for Mideast supplies between East and West."

[*Note: By reading this carefully, one can discover that the head of a major oil company is aware of the impending oil crisis. Editor.*]

2.1.8 New Oil Projects Cannot Meet World Needs This Decade, by Oil Depletion Analysis Centre [2004 November 16] "World oil supplies are all but certain to remain tight through the rest of this decade, unless there is a precipitous drop in demand, according to the results of a study by the London-based Oil Depletion Analysis Centre (ODAC). "The study found that all of the major new oil-recovery projects scheduled to come on stream over the next six years are unlikely to boost supplies enough to meet the world's growing needs."

2.1.9 Over a Barrel, by By Paul Roberts in *Mother Jones* [2004 November]:"Experts say we're about to run out of oil. But we're nowhere near having another technology ready to take its place." "The fifth revolution will come when we have spent the stores of coal and oil that have been accumulating in the earth during

hundreds of millions of years... It is to be hoped that before then other sources of energy will have been developed... Whether a convenient substitute for the present fuels is found or not, there can be no doubt that there will have to be a great change in ways of life. This change may justly be called a revolution, but it differs from all the preceding ones in that there is no likelihood of its leading to increases of population, but even perhaps to the reverse." Sir Charles Galton Darwin, 1952

We are consuming oil at an incredible pace. Sooner or later we will run out. It is really only a question of when. The answer is that it will be sooner than the authorities would like us to believe. And they know it! Just consider the following.
"…by 2010 we will need on the order of an additional fifty million barrels a day. So where is the oil going to come from?" - Vice President Dick Cheney in a speech at the London Institute of Petroleum Autumn lunch in 1999 (when he was chairman of Halliburton).

2.2.0 Influence of fossil fuel on environment and ecology: It is observed that with increasing pace of civilization, uses of transport have become essential part of life and increasing in geometrical progression. This is leading to very hazardous condition due to high rate of pollution.

2.2.1 Automobile Emission: Emissions from an individual car are generally low, relative to the smokestack image many people associate with air pollution. But in numerous cities across the country, the personal automobile is the single greatest polluter, as emissions from millions of vehicles on the road add up. Driving a private car is probably a typical citizen's most "polluting" daily activity. Gasoline and diesel fuels are mixtures of hydrocarbons, compounds which contain hydrogen and carbon atoms. In a "perfect" engine, oxygen in the air would convert all the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide. Nitrogen in the air would remain unaffected. In reality, the combustion process cannot be "perfect," and automotive engines emit several types of pollutions.

2.2.2 Automobiles & Ozone : Ozone in the upper atmosphere (the "ozone layer") occurs naturally and protects life on earth by filtering out ultraviolet radiation from the sun. But Ozone at ground level is a noxious pollutant. Ozone is not emitted directly but is formed in the atmosphere through a complex set of chemical reactions involving hydrocarbons, oxides of nitrogen, and sun-light. The rate at which the reactions proceed is related to both temperature and intensity of the sunlight. Because of this, problematic ozone levels occur most frequently on hot summer afternoons. Hydrocarbons and nitrogen oxides come from a great variety of industrial and combustion processes. In typical urban areas, at least half of those pollutants come from cars, buses, trucks, and off-highway mobile sources such as construction vehicles and boats.

2.2.3 Automobiles and Carbon Monoxide: Carbon monoxide (CO) is a colorless, odorless, poisonous gas. A product of incomplete burning of hydrocarbon-based fuels, carbon monoxide consists of a carbon atom and an oxygen atom linked together. Carbon Monoxide creates Public Health Problem & enters the bloodstream through the lungs and forms carboxyhemoglobin, a compound that inhibits the blood's capacity to carry oxygen to organs and tissues. Persons with heart disease are especially sensitive to carbon monoxide poisoning and may experience chest pain if they breathe the gas while exercising. Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive. Carbon monoxide can affect healthy individuals, imparting exercise capacity, visual perception, manual extremity, learning functions, and ability to perform complex tasks. Carbon monoxide results from incomplete combustion of fuel and is emitted directly from vehicle tailpipes. Incomplete combustion is most likely to occur at low air-to-fuel ratios in the engine. These conditions are common during vehicle starting when air supply is restricted ("choked"), when cars are not tuned properly, and at altitude, where "thin" air effectively reduces the amount of oxygen available for combustion (except in cars that are designed or adjusted to compensate for altitude).

2.2.5 Auto Emission Control Act: Air pollution and cars were first linked in the early 1950's by a California researcher who determined that traffic was to blame for the smoggy skies over Los Angeles. At the time, typical new cars were emitting nearly 13 grams per mile hydrocarbons (HC), 3.6 grams per mile nitrogen oxides (NOx), and 87 grams per mile carbon monoxide (CO).Since then, the Federal Government in 1995, has set standards to bring down levels of these pollutants, and the auto industry has responded by

developing new emission control technologies. The current Federal certification standards for exhaust emissions from cars are 0.25 gram per mile HC, 0.4 gram per mile NOx, and 3.4 grams per mile CO. The standard for evaporative HC emissions is 2 grams per test.

2.2.4 Wasteful Uses of Fossil fuel: It is essential to reduce carbon emissivity due to higher rate of utilization of transport and to increase thermodynamic efficiency of energy usage. For this, the ecological tax reform should be advanced, harmonized internationally step by step, and be a part of the WTO treaty. Energy prices should be sufficiently high to punish wasteful behavior while honoring efficient energy use across the board, and especially in the road transport sector.

2.3.0 Sustainable Energy Future: Focusing on energy and environment, we would like to give you some indications, what shape a sustainable energy future could have in the next coming years, why the future we project is a sound economic choice and what extraordinary challenges are ahead. The roles of hydrogen, oil, gas, coal and nuclear are reflected, as these are he favorite choices of transnational companies and electricity monopolies. It took 150 years to develop the fossil fuel society we are in. In a little over a century, petroleum has grown into the most widely traded commodity in the world — some say, a narcotic — and into one of the prime drivers of violent conflicts. In America, the petroleum system seems to have reached its summit from which a decline is inevitable, and this new direction indeed has already begun.[6.2.6]

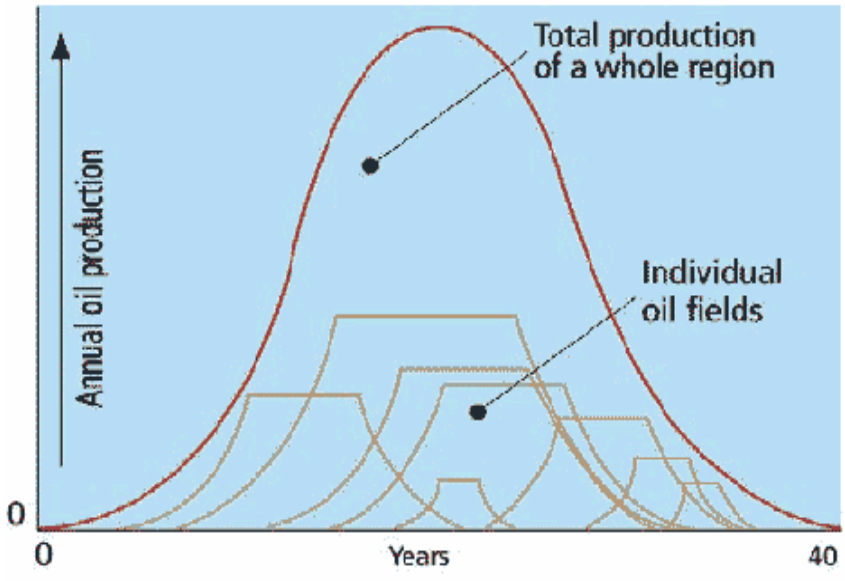


Fig. 1: Hubbert Curve

Many theories have been projected regarding petroleum in the ground and its practical availability above ground. The most successful one came from the **US oil geologist Marion King Hubbert**, who in 1956 predicted that US oil production would peak in 1970 and decline thereafter. The "Hubbert Curve" illustrated above demonstrates empirical experience based on geology and statistics: The practical availability of a region's oil reserves over time describes a bell-shaped curve, similar to the Gaussian (Normal) Curve. Large fields are discovered first, small ones later. After exploration and initial growth in output, production plateaus and eventually declines to zero.

2.3.2 Necessary Steps for Sustainable Energy

- Energy prices should be sufficiently high to punish wasteful behavior while honoring efficient energy use across the board, and especially in the road transport sector.

- Wind energy seems to be at the threshold of becoming the least-cost-technology for electricity generation. But other technologies for renewable energy are still more expensive than electricity from paid-off thermal power plants. And with mass production renewable electricity will be much cheaper than power from ever more expensive natural gas or nuclear. Therefore this tariff system should be applied for all renewable technologies with no or very low externalities and with good potential for cost regression by mass production and further technical improvements.
- Models should be developed which apply guaranteed feed-in-tariffs for electricity imports, too. This can give access to cheap primary resources for mutual benefit of export and import countries. The energy system on the long run need not be more expensive than the old fossil way of doing things up to now.
- Massive long distance HVDC electrical power transmission will promote energy security and access to least cost production areas from renewable sources. Such schemes work for all industrialized regions of the world. Instead of a one-way supply structure from the power plant to the user, the electrical power grid of the future will be a multi-way network with electrons moving back and forth at different times to balance local or regional supply and demand.
- To a certain extent production of electrical power needs to be done locally — for security reasons and for protection of essential life line services, to balance between locally produced energy and cheap imports. A standard for mandatory use of renewables in situ by every household or business might be an incentive for more security, for controlling efficiency of electricity use (minimizing stand-by-losses for example) and for reducing costs.
- Managing these energy flows economically requires price signals by real-time tariffs so the system can optimally use the generating capacity. Modern information technology could help to manage demand side and to improve the match between production and consumption of electricity in time. This will reduce the requirements for stand-by capacity to follow peaks in demand and reduce overall costs. Storage and time management of electrical energy is critical for the stability and robustness of a grid depending on solar and wind as dominant primary power sources.
- Where storage is nevertheless needed it is best provided locally near the point of use. Imagine that by 2050 every house, every business, every building and every car has its own local electrical energy storage device, an uninterruptible power supply capable of handling the entire needs of the owner for 24 hours. Based on yesterday's lead-acid storage batteries, a 100 kWh electrical energy storage for a typical apartment house would require a small room and cost over $ 20,000. But it is possible to shrink the size of such installations and to drop cost. Super capacitors may provide a better solution.
- Energy will be produced where it is cheapest and most available in terms of capacity and time. Therefore we should stop subsidies for non-renewable energy that do not cover their cost. We need a strong foothold in government action — this time not for subsidized nuclear energy or coal, but for correct pricing and for a strong power transmission system.
- Zero emissions building technology is readily available. Stringent standards should be enacted for all energy-consuming products, standards analogous to electrical safety standards but aimed at wasteful use of energy.
- Last but not least: Start research efforts devoted to harvest and distribute energy from renewable sources, to systems for efficient energy storage with superconducting magnets, super capacitors, advanced batteries, compressed air, and to practicable methods for converting biomass into synthetic liquid hydrocarbon energy carriers.

2.4 Economic Impacts:

High-energy prices aren't going to go away. The effect on the economy is going to be ruinous. Here some of the key issues getting affected by the rising prices are discussed ahead:

JOBS: Mark Zandi, chief economist at Economy.com says that the oil spike has, "already cut a half point from the top line of GDP growth in the last year. And that translates into about 500,000 lost jobs."

TECH: Oil prices are one reason that a million fewer personal computers will be bought this year around

the world. Consultants at The Gartner Group recently forecasted that the U.S. economy's soft patch and the run-up in oil prices would cut back on purchases.

RETAIL: In early August, Wal-Mart announced that high oil prices were hurting its sales. The major airlines are all reporting sizable reductions in earnings due to the high cost of fuel. The list of companies hurt by higher transportation costs goes on and on.

INTEREST RATES: The noted Wall Street economist Henry Kaufman says that price increases will begin to filter through the economy and that the situation will encourage the Federal Reserve Board to continue with a steady rate climb.

Higher oil prices have come before every recession since World War II, with the exception of 1960's recession. You know who gets hurt the most in a recession or when oil prices rocket up: the middle class and retirees. You know what? The wealthy crowd doesn't even sweat it. According to Sung Won Sohn, chief economic officer of Wells Fargo bank, wealthy people spend only 1.7 percent of their income on oil related purchases. That leaves you and me – who need to get to work each day and heat our homes – holding the bag. That means more and more people will be forced to spend their precious retirement accounts or savings merely to get by.

3.0 ALTERNATIVE FUELS FOR AUTOMOBILES

Many research works are being carried out to find the alternative to fossil fuel. Apart from the non-conventional energy such as Photocell battery operated vehicles, hydrogen cell, wind mill operated power generating device and its storage capacitors, **C**ompressed air operated vehicle, Bio diesel and Di-methyl Ether are also being used as an alternative to fossil fuel.

3.1 Bio-Diesel: Biodiesel is a renewable fuel obtained from vegetable oils, animal fats, and recycled cooking oils. Biodiesel offers many advantages:

- It is renewable.
- It is energy efficient.
- It displaces petroleum derived diesel fuel.
- It can be used in most diesel equipment with no or only minor modifications.
- It can reduce global warming gas emissions.
- It can reduce tailpipe emissions, including air toxics.
- It is nontoxic, biodegradable, and suitable for sensitive environments.
- It is made in the United States from either agricultural or recycled resources.
- It can be easy to use if you follow these guidelines.

Biodiesel can be used in several different ways such as use 1% to 2% biodiesel as a lubricity additive, which could be especially important for ultra low sulfur diesel fuels (ULSD, less than 15 ppm sulfur), which may have poor lubricating properties. It can blend 20% biodiesel with 80% diesel fuel (B20) for use in most applications that use diesel fuel. It can even use it in its pure form (B100) with take proper precautions. The word biodiesel in this report refers to the pure fuel—B100—that meets the specific biodiesel definition and standards approved by ASTM International. A number following the "B" indicates the percentage of biodiesel in a gallon of fuel, where the remainder of the gallon can be No. 1 or No. 2 diesel, kerosene, jet A, JP8, heating oil, or any other distillate fuel. The use of Bio diesel are tested for various parameters and blending of Bio Diesel up to 18-20 % is found most efficient for the running of the vehicle and also pollution limits due to hydrocarbon (HC), Carbon-mono oxide (CO) and nitrogen (NOx) are found well within the emission limits prescribed by EPA in 1995.

3.2 Dimethyl Ether: Demonstration on Dimethyl Ether while carried out it was found that CO emission is lower than Propane and n-butane over a broad range. No production from DME is less than or similar to Propane & n-butane. DME burns with a non- luminous flame & flame is much compact. It is also noticed that oxygen blending 4 % wt in the fuel blend and it is observed that the emissions can be reduced by as much as 28 % when compared with premium diesel.

3.3 Hydrogen Cell Vehicle: Hydrogen gas does not occur naturally in the Earth's atmosphere and the gas must be artificially produced. Currently hydrogen used in the manufacture of ammonia is produced by reacting steam with methane. Hydrogen may also be extracted from fossil fuels by using fuel `reformers'. Both these processes produce pollutants. They can not be used to generate the gas for storing electrical energy. Therefore the most practical method of generating hydrogen is the electrolysis of water. This process is about 65% efficient and because of this hydrogen will always be more expensive than the energy used to produce it.

One of the main problems of using hydrogen in vehicles is storing the gas. Hydrogen is highly flammable and this raises many safety issues. However, hydrogen is less hazardous than petrol as the gas dissipates quickly and will not cause prolonged fires.

The simplest method of storing hydrogen gas is by compressing the gas and storing it in cylinders. However, cylinders are bulky and make transporting the gas costly. Hydrogen may also be stored as a liquid, but this requires it to be cooled down to 20 K. The energy required for this process is large and this reduces the energy efficiency of this method to about 25%.

Hydrogen can be bound to solid metals, and because the process is reversible, it can be used to store the gas. Certain metals absorb hydrogen and can be used to transport it. Unfortunately, the mass of hydrogen stored is very small compared to the mass of the metal. As the **metals used are expensive this method is also very costly.**

3.4 Photo Cell, Wind Mill and Compressed Air: Non conventional energy is the source available in nature and do not effect imbalance in atmospheric ecology. Worldwide uses are being made for electric photocell to generate electric power and power so generated are utilized to be stored in batteries ,which finally gives power to use for light, run small electric motors and in US photo Cell car has also been developed to run on roads emission free. A research works are also going on to make cluster of photo cell operated device to generate power which can be utilized in many ways.

Similarly wind mills are being used very effectively for irrigation as well as power generation, where high velocity air is running in atmosphere, due to geological conditions.

Sterling air engine was developed in 1790-1810, but due to its limitation much work was not carried out. Keeping in view of fire problems in Coal mines and other volatile places where high flammable fuel like fossil fuel vehicles are not advisable, compressed air engine operated vehicle are normally started to use. Thus in 1979 to 1998 much work was not carried out, with limitation.

4.0 COMPRESSED AIR AS AN ALTERNATIVE

India is developing country. Still per capita income of average person is very low to meet out the minimum requirement of person. Maximum population of country is still living in villages. There transport is still either bi-cycle or Motor Bike. Current hike of fossil fuel is going tremendously high up to 30-40 % every year. With this pace up to 2010 prices may go double than what is today and by 2030-40, it may fetch to Rs.1000 per litre. A time will come when common person would not be able to purchase fuel to even run the Motor-Bike. It is not only due to rate of increase of vehicles in India. It is worldwide problem that 80 % of fossil fuel is being consumed in transport with increasing mobility of persons to day and daily consumable materials are being transported through Road Transport. Thus it is need of day to explore possibility of alternative for fossil fuel to make environment free from emission & make children healthy. With high rate of consumption of fossil fuel it also necessary to make sustainable energy or in other words of our Hon. PRESIDENT of INDIA Dr. APJ Abdul Kalam make INDIA energy freedom by 2030, which he has spoken in his speech on the eve of 14th Aug.'2005 of Independence day.

From the last two decade lot of researches are being made to tap down air freely available in atmosphere at high compression, which can easily be stored in cylinders with little modified design. This compressed air can be used to run combustion engine with mixture of gas which gets fire at compression

stroke at TDC. Compressed air helps for fire stroke when ignition is given. Thus efficiency of IC engine gets improved and without all running four stroke cycle it runs two stroke cycles. Guy Nigre-a French scientist developed the engine and claims that it is zero Pollution and given demonstration in Aug.'2004.Similarly, Quasiturbine is also developed to run on radial cycle where all four strokes take place in one complete 360 degree. A compressed air quasi turbine car was demonstrated in Oct'2004. These engines are basically running with use of compressed air and gas.

4.1 Principle

For compressed air engine, High Air Pressure is the driving force for prime-mover at ambient temperature. So far worldwide researches are being carried out for various alternative for fossil fuel and compressed air is also considered one of the source, but air engine so far developed have been declared running on use of compressed air and gasoline.

4.2 Availability

Air is natural source and available freely in atmosphere, which can be stored after compressing it to desired pressure such as 90- 150 psi. This is the only source which can be stored at very high pressure and can be retained without any loss after lapse of passage of time, which can drive so many domestic appliances such as vacuum cleaner, mixy and pumps, running Power generator when electric power is off instead of using inverter to have clumsy arrangements of battery etc.

4.3 Influence on Environment and ecology

Compressed air may be definitely as an alternate for running light vehicle, which is presently creating emission due to use of fossil fuel and imbalances to ecology, ultimately effects public health hazard. It will have no effect on ecology if all the alternate transports will get run on compressed air.

4.4 Sustainability, Economics and Advantages

Compressed air is most sustainable. It has no volatility or temperature or much weather effect .Once compressed air is stored through compressor, it will be available at any time without any loss of Pressure. Thus sustainability of compressed air will much be beneficial to other available alternate of fossil fuel. Battery needs constant maintenance even for charging & discharging cycle. Hydrogen Cell is very costly due to its storage problems. Wind Mills, photo Cells are also need some storage device may be high bank capacitors or batteries, which will need constant and recurring expenditures on its up keep.

4.5 Present Developments of compressed air engines for Light Vehicles

Korean inventor "Beau de Rocha" (Otto) developed zero pollution cars using Quasiturbine with a set of 14-engines parameters and disclosed on Sept'2005 using gasoline. [6.2.10]

"Guy Negre", a French Scientist , in 1998 developed compressed air- 4- cylinders engine run on air and gasoline, claims zero pollution cars and got 52- patents registered since 1998 to 2004.The car was demonstrated in Oct.'2004 publically.[6.2.9]

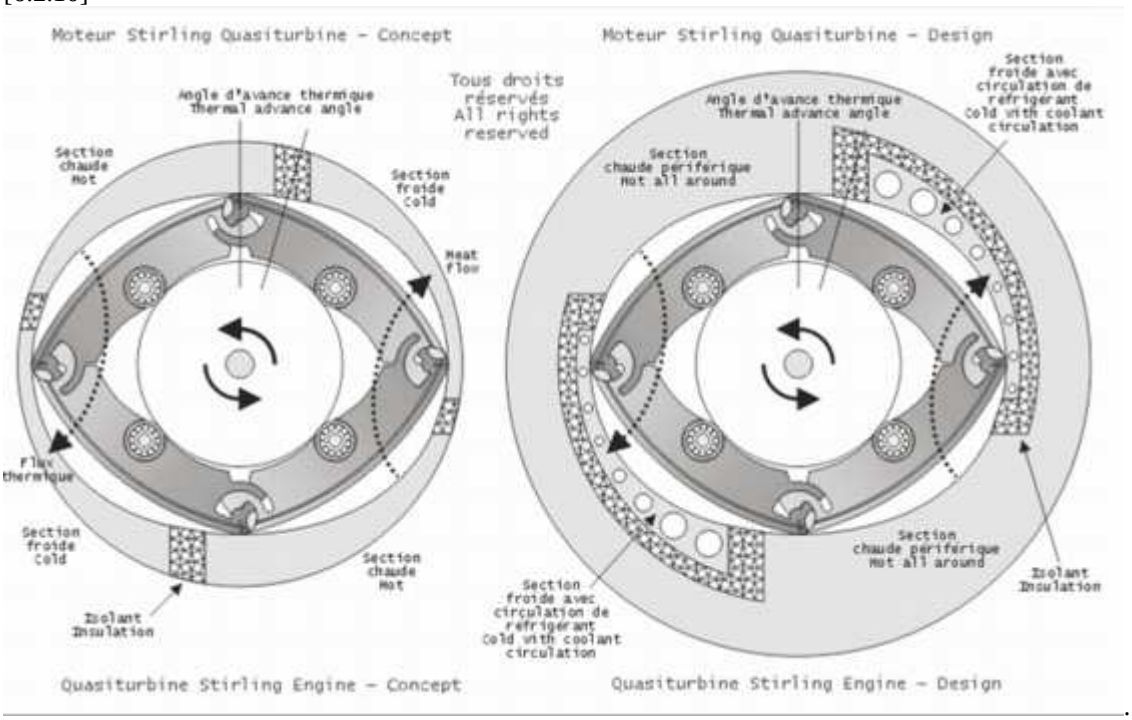
"E.J. Honton" an USA based inventor in April'2004 presented the Hydrogen Fuel Cell Car at 15th Annual US Conference & Hydrogen Expo, USA and projected the scope of its market in different country. [6.2.8]

5.0 CURRENT USES OF AIR ENGINES

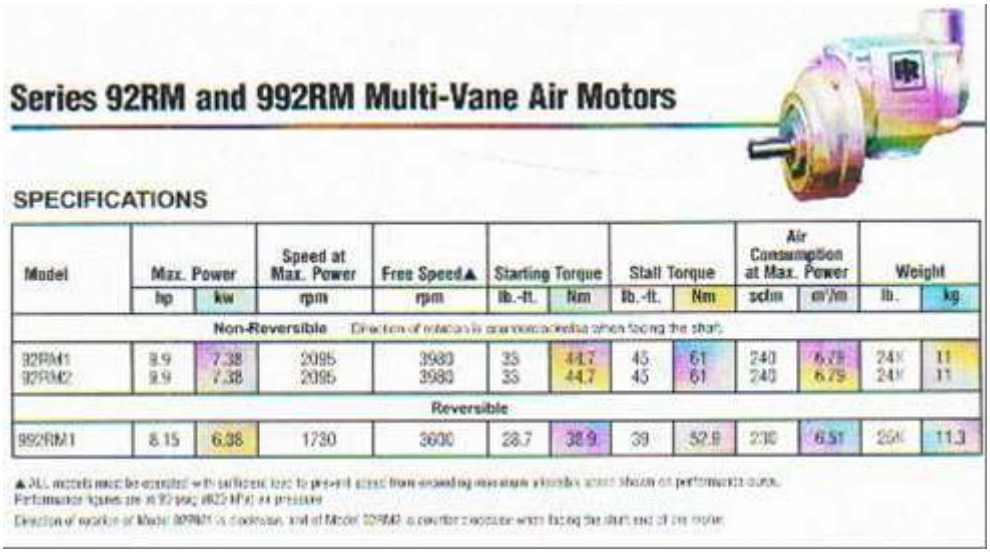
Compressed Air Engines as indicated here are not exactly as to what is being proposed. Some of the successful designs of air motor are discussed here.

5.1 Rotary Hot air Motor (Quasiturbine)

How it Works: The Quasiturbine engine, the four strokes of a typical cycle de Beau de Rochas (Otto) cycle is arranged sequentially around a near oval, unlike the reciprocating motion of a piston engine. In the basic single rotor Quasiturbine engine, an oval housing surrounds a four-sided articulated rotor which turns and moves within the housing. The sides of the rotor seal against the sides of the housing, and the corners orotor seal against the inner periphery, dividing it into four chambers [6.2.10]



5.2.1 Industrial Air Motor



Series 92RM and 992RM Multi-Vane Air Motors

SPECIFICATIONS

Model	Max. Power hp	Max. Power kw	Speed at Max. Power rpm	Free Speed▲ rpm	Starting Torque lb.-ft.	Starting Torque Nm	Stall Torque lb.-ft.	Stall Torque Nm	Air Consumption at Max. Power scfm	Air Consumption at Max. Power m³/m	Weight lb.	Weight kg
Non-Reversible Direction of rotation is counterclockwise when facing the shaft.												
92RM1	9.9	7.38	2095	3980	35	44.7	45	61	240	6.79	24½	11
92RM2	9.9	7.38	2095	3980	35	44.7	45	61	240	6.79	24½	11
Reversible												
992RM1	8.15	6.38	1730	3600	28.7	38.9	39	52.9	230	6.51	25¼	11.3

▲All models must be operated with sufficient load to prevent speed from exceeding maximum allowable speed shown on performance curve.
Performance figures are at 90 psig (620 kPa) air pressure.
Direction of rotation of Model 992RM1 is clockwise, and of Model 92RM2 is counterclockwise when facing the shaft end of the motor.

5.2.2 Pneumatic Air Motor

5.3 PROPOSED AIR MOTOR / ENGINE

Present objective is to develop an **air engine** having a torque of 10.45 Nm or 6.85 HP to 7.50 HP at 5500 to 7500 rpm which will be suitable for a motorbike. Various steps involved in the development of engine are as given below. A cylinder of compressed air is proposed to be designed to have minimum requirement of 30 Min running at initial stage and to have maximum pressure of 200 PSI. The cylinder should have a aesthetic shape to get installed properly to motor bike. Air motor with double inlet and exhaust have been taken into consideration to produce high rpm to match 7500-800rpm.Cylinder must produce constant pressure so that motor torque should not get reduced at low volume of compressed air. Thus a spring loaded baffle is proposed to be installed into the cylinder. The engine / air motor is proposed to be designed with spring loaded vanes to maintain regular contact with elliptical bore of motor/ engine, to produce optimum torque. Above air motor is proposed to meet out the all minimum parameters of motor bike to have efficient and fossil fuel free running and compressed air must be utilized as a substitute to fossil fuel.

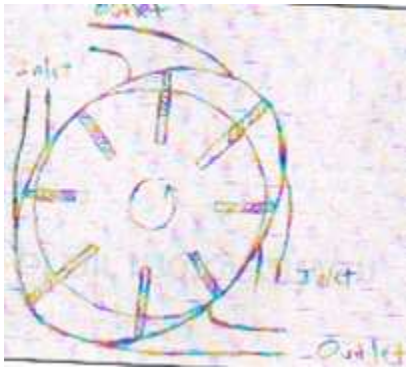
· Create the 2-d technical drawing and fabricate the 3-d models of parts.

· Design and make the compressed air storage cylinder, springs for the vanes etc.

· Update the test protocol and test setup as desired and assemble the motor and test setup.

· Run the performance test and record data and analyze the data and prepare the final setup

Design model for proposed Air motor / Engine



Hand Sketch of Air Motor

5.4 CONCLUSION: In view of the enormous potential of air as working fluid an engine is being designed to run on compressed air. Compressed air motor will be run using compressed air contained in a portable cylinder mounted on the motorbike. If test run is successful then it is going to be best alternate to the fossil fuel driven engine.

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