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Air Powered Vehicle

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***Abstract*: A Compressed-air engine is a pneumatic actuator that creates useful work by expanding compressed air. A compressed-air vehicle is powered by an air engine, using compressed air, which is stored in a tank. Instead of mixing fuel with air and burning it in the engine to drive pistons with hot expanding gases, compressed air vehicles (CAV) use the expansion of compressed air to drive their pistons. They have existed in many forms over the past two centuries, ranging in size from hand held turbines up to several hundred horsepower. For example, the first mechanically-powered submarine, the 1863 Plungers, used a compressed-air engine.**

Keywords: compressed air engine

I. Introduction

A. Air Compressed Engine

a) The first compressed-air vehicle was devised by Bumpers, a patent for a locomotive being taken out in England in 1828. There were two storage tanks between the frames, with conventional cylinders and cranks. It is not clear if it was actually built. (Knight, 1880).
b) The first recorded compressed-air vehicle in France was built by the Frenchmen Andraud and Tessie of Motay in 1838. A car ran on a test track at Chaillot on the 9th July 1840, and worked well, but the idea was not pursued further.

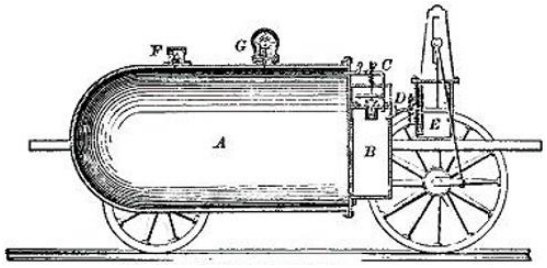

Fig. 1. Parsey's compressed air engine

c) In 1848 Barin von Rathlen constructed a vehicle which was reported to have been driven from Putney to Wandsworth (London) at an average speed of 10 to 12 mph.
d) At the end of 1855, a constructor called Julienne ran some sort of vehicle at Saint-Denis in France, driven by air at 25 atmospheres (350 psi), for it to be used in coal mines.
e) Compressed air locomotives were used for haulage in 1874 while the Simplon tunnel was being dug. An advantage was that the cold exhaust air aided the ventilation of the tunnel.
f) Louis Mékarski built a standard gauge self-contained tramcar which was tested in February 1876 on the Courbevoie-Etoile Line of the Paris Tramways Nord (TN), where it much impressed the current president and minister of transport Maréchal de MacMahon. The tramcar was also shown at the exhibition of 1878 as it seemed to be an ideal transport method, quiet, smooth, without smoke, fire or the possibility of boiler explosion.
g) The compressed-air locos were soon withdrawn due to a number of accidents, possibly caused by icing in the pipes of the brakes, which were also worked by compressed air.
h) In Louis Mékarski built a standard gauge self-contained tramcar which was tested in February 1876 on the Courbevoie-Etoile Line of the Paris Tramways Nord (TN), where it much impressed the current president and minister of transport Maréchal de MacMahon. The tramcar was also shown at the exhibition of 1878 as it seemed to be an ideal transport method, quiet, smooth, without smoke, fire or the possibility of boiler explosion.

B. Discussion

After twelve years of research and development, Guy Negre has developed an engine that could become one of the biggest technological advances of this century. A French engineer by profession, he has designed a low consumption and low pollution engine for urban motoring that runs on compressed air technology (Fig. 2). The CATS (Compressed Air Technology System) "air car" from Motor Development International is a significant step for zero-emission transport, delivering a com-pressed air-driven vehicle that is safe, quiet, has a top speed of 110 km/h and a range of 200 km. Costing next to nothing to run, the Zero Emission Vehicle (ZEV) range - which includes a pickup truck and van - was released in 2005. Guy Negre is the head of Research and Development at Moteur Development International (MDI) cars, where the Zero Emission Vehicle (ZEV) prototype has been in production since 1994. The two-stroke engine is powered by compressed air stored in tanks at about 150 times the pressure in car tyres. The ex- pansion of the compressed air drives the pistons to create movement, replacing the burning of fossil fuel in a conventional engine. In an air-refilling station (currently unavailable as service stations have not been fitted yet) it is estimated to take between three and four minutes to refuel. At home, with a 220V plug, it takes three and a half hours.

CAT vehicles have significant economic and environmental advantages. With the incorporation of the energy (compressed air + fuel) the CAT Vehicles have increased their driving range to close to 2000 km with zero pollution in cities and considerably reduced pollution outside urban areas. Also, the application of the MDI engine in other areas, outside the automotive sector, opens a multitude of possibilities in nautical fields, cogeneration, auxiliary engines, electric generators groups, etc.

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Compressed air is a new viable form of power that allows the accumulation and transport of energy. MDI is very close to initiating the production of a series of engines and vehicles. The company is financed by the sale of manufacturing licenses and patents all over the world. Table-I lists the technical specifications of the vehicle.

II. Engine Working

Approximately 90m^3 of compressed air is stored in fibre tanks in the vehicle. The engine is powered by compressed air, stored in a carbon-fibre tank at 30 MPa (4500 psi). The tank is made of carbon fibre in order to reduce its weight. The engine has injection similar to normal engines, but uses special crankshafts and pistons, which remain at top dead centre for about 70 degrees of the crankshaft's cycle; this allows more power to be developed in the engine. The expansion of this air pushes the pistons and creates movement. The atmospheric temperature is used to re-heat the engine and increase the road coverage. The air conditioning system makes use of the expelled cold air. Due to the absence of combustion and the fact there is no pollution, the oil change is only necessary every 50,000 km.

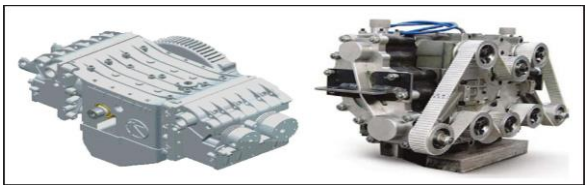

Fig. 2. Compressed air engine

A. Distribution and Valves

To ensure smooth running and to optimize energy efficiency, air engines use a simple electromagnetic distribution system, which controls the flow of air into the engine. This system runs on very little energy and alters neither the valve phase nor its rise.

No clutch is necessary. The engine is idle when the car is stationary and the vehicle is started by the magnetic plate, which re-engages the com-pressed air. Parking maneuvers are powered by the electric motor. The P04 engine is equipped with patented variable-volume butts and a dynamic variable-volume volumetric reducer. The engines can be equipped with and run on dual energies - fossil fuels and com-pressed air - and incorporate a reheating mechanism between the storage tank and the engine.

This mechanism allows the engine to run exclusively on fossil fuel, which permits compatible autonomy on the road. While the car is running on fossil fuel, the compressor refills the com-pressed air tanks. The control system maintains a zero-pollution emission in the city at speeds up to 60 km/h.

B. Articulated Con-Rod

The MDI con-rod system allows the piston to be held at Top Dead Centre for 70o of the cycle. This way, enough time is given to create the pressure in the cylinder. The torque is also better, so the force exerted on the crankshaft is less substantial. Fig. 4 shows the articulated connecting rod and the drive train.

C. Gear Box

Gear changes are automatic, powered by an electronic system developed by MDI. A computer which controls the speed of the car is effectively continuously changing gears. The latest of many previous versions, this gearbox achieves the objective of seamless changes and minimal energy consumption. Its steering wheel is equipped with a 5kW electric Moto alternator. This Moto alternator connects the engine to the gearbox. It has 22 many functions. It supports the CAT's motor to allow the tanks to be refilled. It starts the vehicle and provides extra power when necessary as an alternator it produces brake power.

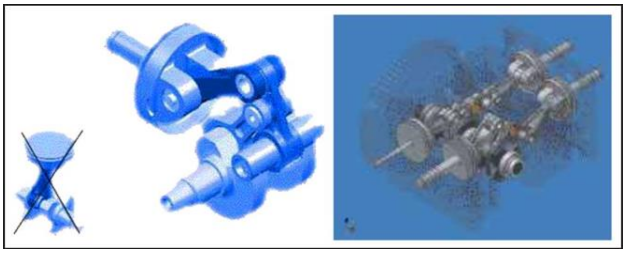

Fig. 3. Articulated connecting rod and drive train

Additional features of the MDI car

a) Light-weight: The vehicle has a fiberglass body, which makes it a light, silent urban car. The car's body is tubular, and is held together using aerospace technology. It can reach speeds up to 220 km/h (even though the legal limit is 120).
b) It does not have normal speed gauges. Instead, it has a small computer screen that shows the speed.
c) Its electric system is also revolutionary. MDI has bought a patent that is bound to reduce the importance of electrical systems in all cars. The trick consists in using a small radio signal. The system makes the car 20 kilograms lighter and consider-ably quieter.
d) In the single energy mode, MDI cars consume less than one euro every 100 km (around 0.75 euros), that is to say, 10 times less than gasoline-powered cars.
e) Its driving range is close to twice that of the most advanced electric cars (from 200 to 300 km or 8 hours of circulation). This is exactly what the urban market needs where, 80 per cent of the drivers move less than 60 km a day.
f) The recharging of the car will be done at gas stations, once the mar-ket is developed. To fill the tanks, it will take about 2 to 3 minutes at a price of 1.5 euros. After refilling, the car will be ready to drive 200 kilo meters. The car also has a small compressor that can be connected to an electrical network (220V or 380V) and will recharge the tanks completely in 3 or 4 minutes.
g) Because the engine does not burn any fuel, the car's oil only needs to be changed every 50,000 km.
h) The temperature of the clean air expelled from the exhaust pipe is between 0 and -15 degrees and can be subsequently channeled and used for air conditioning in the interior of the

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car.

i) Advanced features such as GSM telephone systems, GPS satellite tracking systems, programmes for delivery people, emergency systems, Internet connections, voice recognitions, map presentation and traffic information can be incorporated.
j) Regarding security, the seatbelt system is different from what is known. One part of the belt is anchored to the floor of the car, like traditional cars. The other part of the belt, instead of being attached to the side of the car, is also anchored to the floor of the vehicle. This helps to secure the bodies of the driver and passengers in the case of a collision.
k) There are no keys - just an access card that can be read by the car from your pocket.

III. Safety Features of the Air Car

TABLE I
TECHNICAL SPECIFICATIONS OF A MINICAT VEHICLE

		Mono-energy	Dual-energy 2	Dual-energy 4
Length	m	2.65	2.65	2.65
Width	m	1.62	1.62	1.62
Height	m	1.66	1.66	1.66
No. of seats	-	3	3	3
Luggage compartment volume	Dm^3	500/700	500/700	500/700
Weight	Kg	550	520	540
Engine	-	41P03	41P01	41P01/4
Power	c v	25	25	50
Max. speed	Km/h	110	125	140
Urban range (zero pollution)	Km	140/150	50	50
CO_2 emission in urban use	g/Km	0	0	0
Non-urban range	Km	80	1650	1500
Non-urban consumption (petrol)	litres	-	1.8	2
CO_2 emission in non-urban use	g/Km	0	35	40
Price (from) taxes included	€ 9200			

The CATS air tanks store $90m^3$ of air at 300 bars of pressure (four tanks have a capacity of 90 litres, and they store $90m^3$ of air at a pressure of 300 bars), just like tanks already used to carry liquefied gases on some urban buses. That means that the tanks are prepared and certified to carry an explosive prod-uct: methane gas. In the case of an accident with air tank breakage, there would be no explosion or shattering because the tanks are not metallic but made of glass fibre. The tanks would crack longitudinally, and the air would escape, causing a strong buzzing sound with no dangerous factor. It is clear that if this technology has been tested and prepared to carry an inflammable and explosive gas, it can also be used to carry air. In order to avoid the so-called 'rocket effect' (air escaping through one of the tank's extremities causing a pressure leak that could move the car), MDI made a small but important change in the design. Where the valve on the bus tanks are placed on one of the extremities, MDI has placed the valve in the middle of the tank reducing the 'rocket effect' to a minimum.

IV. Conclusion

The technology of compressed air vehicles is not new. In fact, it has been around for years. Compressed air technology allows for engines that are both non-polluting and economical. After ten years of research and development, the compressed air vehicle will be introduced worldwide. Unlike electric or hydrogen powered vehicles, com-pressed air vehicles are not expensive and do not have a limited driving range. Compressed air vehicles are affordable and have a performance rate that stands up to current standards. To sum it up, they are non-expensive cars that do not pollute and are easy to get around in cities. The emission benefits of introducing this zero emission technology are obvious. At the same time the well to wheels efficiency of these vehicles need to be improved.

V. Future Scope

Tata Motors has signed an agreement with Motor Development International of France to develop a car that runs on compressed air, thus making it very economical to run and almost totally pollution free. Although there is no official word on when the car will be commercially manufactured for India, re-ports say that it will be sooner than later. The car - MiniCAT - could cost around Rs. 350,000 in India and would have a range of around 300 km between refuels. The cost of a refill would be about Rs. 90. In the single energy mode MDI cars consume around Rs. 45 every 100 km. Figure 6 shows the proposed air car for India. The smallest and most innovative (three seats, minimal dimensions with the boot of a saloon), it is a great challenge for such a small car which runs on compressed air. The MiniCAT is the city car of the future.

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