AN INVESTIGATION INTO THE POSSIBILITY OF USING STEAM ENGINES FOR VEHICLE PROPULSION

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يقدم المقال عرضاً لبعض المحاولات السابقة لأستخدام الآلات البخارية في تحريك السيارات كبديل لآلات الاحتراق الداخلي التي تنتج غازات عادمة تلوث الهواء .

وكمساهمة في دراسة امكانية تحويل آلات الاحتراق الداخلي لكي تعمل بالبخار جرى تحويل ثلاث آلات مختلفة واختبرت عند ظروف مختلفة ، وتبين انه بالامكان تحويل آلات الأحتراق الداخلي لتعمل بالبخار ، غير أن ذلك يؤدي الى الحصول على قدرة وكفاءة منخفضتين عما يمكن الحصول عليه قبل التحويل .

ونعتقد انه بالأمكان تطوير هذه الفكرة بالمزيد من البحث مع دراسة استعمال بديل لبخار الماء في انتاج الطاقة ، مما سيعطي الفرصة للاستفادة من تطور آلات الاحتراق الداخلي بالاضافة الى امكانية استخدام انواع اخرى من الوقود غير منتجات البترول .

Abstract

A survey of previous trials to use steam for vehicle propulsion instead of internal combustion engines with attendant possible reduction in the air pollution, is given. In continuation of similar work done previously by others, the author converted three I.C. Engines to run with steam. The engines ran perfectly with steam but the power output and the efficiencies obtained were lower than the original values. The idea requires more research using either steam or an alternative medium.

1. INTRODUCTION

A vapour cycle machine has two possible advantages; (a) it may avoid, because of its steady state combustion, much of the pollution associated with the I.C. engine, (b) it can be self starting against load, and may have no need for clutch and gear box. However during the past seventy years the steam engine has been neglected, while the I.C. engine has been developed to a state of superb mechanical reliability.

When one looks back at the early steam engine, it was noisy, smelly, extremely heavy, dangerous, inconvenient, slow starting, bulky, inefficient, and had a high steam consumption. Nowadays, the ability to manufacture stronger, lighter metals permitting high temperatures and pressures, and smaller, fewer moving parts, combined with an effficient condenser, also the use of other more suitable working mediums may greatly help the steam technology [1,2,3,4]. The steam engine was first applied to road automobiles by the French engineer Cugnot in 1769. His car ran for 15 minutes at a speed of 3 m.p.h. as it was limited by a small type boiler. By 1900, the steam car had developed so far as to attain a speed of 75 m.p.h. In the 1930's, one or two statisfactory steam cars were in service. The steam motor car was externally indistinguishable from a gasoline engine motor car, it was quiet in operation, flexible and also cheap to run as far as fuel was concerned. However, the use of steam engines was confined to the heavy class of transportation.

Because of the existing problem of air pollution, several countries have imposed a limit on the exhaust emissions of I.C. engines. As a result, various ideas were explored for moving a vehicle.

An exercise in steam car design was done by R.M. Palmer [1], who used the Rankine cycle and kept in mind the basic requirements needed in a passenger vehicle. Palmer prefered to use a single acting engine rather than a double acting one, as the latter involves the use of piston rods and glands, which would not stand the high pressure and high engine speed. The output of the engine was controlled by varying the cut-off ratio or by throttling or by both. The engine produced 40 kw, sufficient to attain a speed of 80 m.p.h.

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Palmer concluded from his design that the engine does not constitute a problem but the main point is to design it so as to use the most suitable condition of steam with the appropriate boiler and condenser.

Another important example of the use of steam power is a steam bus, which was designed in U.S.A. as a prototype to study experimental techniques. The steam generator was designed without a drum. The engine had three-cylinders, double acting with compound expansion, producing 143 kw at 2100 r.p.m., using steam at 454°C and 60 bar. The following advantages were obtained :

1 - Low weight (compared with 6 cylinder diesel engine). 2 - Low emissions. 3 - Simple system. 4 - Good road performance. Two minutes were needed to develop sufficient steam to move from cold, and three minutes to achieve full steam supply. Once on the road the vehicle started in 30 seconds.

The third exercise was that more than six steam engines were designed specifically for vehicle propulsion. They are now in various stages of development (4). Some have been road tested and proved successful.

One of the tests on the emissions of a steam plant for vehicle propulsion proved positive as its emissions were 30 to 40 p.p.m., which is not far from the limit of 23 p.p.m. put for the I.C. engines of 1975. This low steam plant emission is the result of continuous combustion released from acceleration and deceleration.

2. SCOPE OF PRESENT INVESTIGATIONS

In continuation of similar work the author successfully converted three petrol engines to work with steam. The engines were :

I - A Morris "Minor" B.M.C. 1000 c.c. 4-cylinder Engine*

The following modifications were carried out : (a) A 0.508 mm thickness was taken off the cylinder bores to avoid engine seizure that occurred when the engine was first used. (b) The engine cam shaft was modified , so that the engine would work as a two-stroke engine.

On testing the engine, finally, it ran perfectly with a satisfactory lubrication. The output power was measured at different inlet steam pressures. The original maximum power of this engine is estimated to be 30 kw.

II - An Opposed Cylinder 203 c.c. Two-Stroke Engine

Again various alterations were made. A valve to distribute the steam to both cylinders at the same time was designed and assembled to the engine. The original maximum power of this engine is estimated to be 7.5 kw.

Several sets of tests were carried out at different inlet steam pressures and at different admittance angles: 0°, 5°, 10° 15° before T.D.C.

III - A Single Cylinder Alternator Engine

This was a 36 c.c., four stroke, single cylinder engine used to drive a small generator attached to the output shaft of the engine. The original maximum power of this engine is estimated to be 746 watts.

3. EXPERIMENTAL RESULTS

The engines were tested under different conditions of load, speed, steam inlet pressure and admittance angle. In each case the power, torque, specific steam consumption, thermal and mechanical efficiences were determined. An example of the type of results obtained is given for the 1000 c.c. B.M.C. engine.

The B.M.C. 1000 c.c. Engine

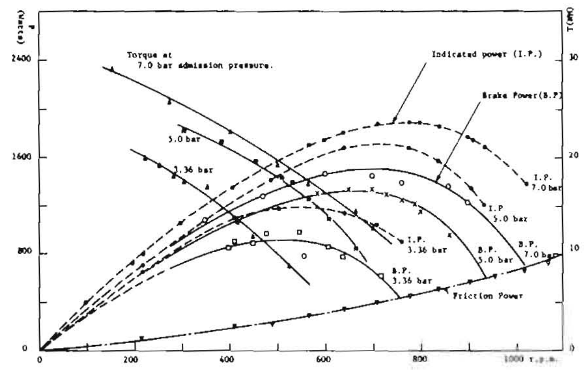
According to the calculations, the figure given was obtained for different dry saturated steam, the inlet pressure ranging from 3.36 bar to 7.0 bar. Maximum torque obtained was 3 NM at 160 r.p.m. The figure shows also the power-speed diagram for different steam pressures. From the figure we deduce:

1. Maximum power output was about 1400 watts at about 700 r.p.m. which is considered low if compared with its original output.
2. High mechanical efficiency, about 87% max. was reached.
3. Low thermal efficiency, (1.9% max.) at 1400 r.p.m.
4. Engine speed was high when at no load.

The Opposed Cylinder Engine

Similary the results for this engine were obtained using dry saturated inlet steam with pressures of 6.0, 8.0, and 8.75 bar and at different steam admission timing of 0°,5°,10°,15°, B.T.D.C. Similarly, the

The engine had overhead valves, and was estimated to have run over 50,000 miles on the road.



Torque and Power vs speed Diagram for Different Steam Pressures, For the B. M. C. 1000 cc Engine.

results obtained from the opposed cylinder engine showed that:

1. Maximum mechanical efficiency was 70%.
2. Low thermal efficiency (2.9% max.)
3. The engine produced maximum power when steam was admitted at 10° before T.D.C.

The Alternator Engine

Experiments were performed at different dry saturated inlet steam pressures of 1.0, 1.36, 2.5 and 3.36 bar, and the voltage, amperes, and speed were obtained. From the results we deduce:

1. On running the engine at a constant speed of 1700 r.p.m. it produced an output power of 22 watts.
2. Maximum power output is 24 watts at 1500 r.p.m. and 3.36 bar inlet steam pressure.

4. CONCLUSIONS

Several ideas were introduced to overcome the many problems, such as the seizure of the B.M.C. engine, and the piston lubrication. All these modifications were extremely sound, and the engines ran with steam without trouble, but low power output was obtained. It should be noted that the main reasons for low power output and low thermal efficiencies are the high back pressure and the initial condensation of the steam in the cylinders.

The opposed cylinder two stroke engine was quieter than the B.M.C. engine but both were far below the original noise level of a similar I.C. Engine.

It is unlikely that these converted engines will produce high power output unless some major alterations are made to the system.

Much heat was rejected and lost, this was indicated by the low thermal efficiences.

The author believes however that if the steam engine receives the same attention as the I.C. engine, it may reach a stage where it can be a successful alternative power plant for cars. The main points to be noted are : the use of high pressure superheated steam and low back pressure. It is also worthwhile using another working medium which could be more suitable than the conventional steam.

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