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GAS ENGINE ECONOMY

by the

TEMPERATURE of COOLING WATER.

Anything that has to do with the economical operation of a gas engine to-day is of great interest to thousands of people who use gasoline either for pleasure or for work.

In working up this thesis, most of my time was taken in fixing the engine for use. A six horse-power "MOGUL" engine was used during the tests. This engine was loaned to the University by the International Harvester Company, and care had to be taken not to damage or radically change too many parts of same.

PREPARATIONS.

The cylinder-head had to have a hole bored in it and a tapered, threaded tube about 6" long threaded into this hole. A ½" elbow was placed on the outside end of this tube and an indicator attached.

A reducing motion was put on the engine in a very unique way. A hole was bored and tapped in the fly-wheel hub and a 2¾" cap-screw with a sleeve the proper length screwed into it. The wooden skid which formed the engine base was used as the support for the long rocker arm of the motion. While this arrangement was of a temporary nature, it answered the purpose very well.

The regular belt pulley was used as a brake-wheel and cooling water was kept in it by putting a wooden flange inside of it. A water-pipe from the city main furnished a convenient supply which could be regulated by a valve.

Ordinarily the engine was cooled by water circulating by boiling; the water flowing thru the water-jacket and then over an inclined screen for cooling it. As I had to vary the temperature of this cooling water, this system was disconnected and a connection made with the city supply. The intake was regulated by means of a valve and the outlet-pipe arranged so that the water could be discharged into a tank. One thermometer was placed in a tee on the inlet-pipe, while another was placed similarly on the outlet-pipe.

A brake had to be made for the 14" pulley, and, although the simplest type I could devise was used, after the pulley and friction surfaces had worn smooth, a better prony brake could not have been wanted.

The tank for fuel on this type of engine is fitted to the skid, and a force-pump used to raise the gasoline to the carburetor. I couldn't find a way to accurately measure the amount used at first, but by disconnecting the tank and weighing it before the start and then taking it off and weighing it again after the test, a very accurate method was found.

A gravity system for feeding could not have been used, as a return-pipe carried all surplus fuel from the carburetor back to the tank, thus making this method impossible.

THE TEST.

In order to see where the best adjustment for the spark and carburetor was, for the load used, a run of a half hour was made before every test. The action of the engine with different adjustments was noted and indicator cards taken with the spark in different positions. As the engine was run on fuel from an auxiliary tank until the test started, the regular tank was filled, weighed and connected ready for use, and when the test started the auxiliary supply was shut off and the regular needle-valve was opened to the pt. already determined. This caused no trouble and the engine didn't stop running. The load was kept constant for all the runs and with the carburetor feeding the same only the speed was variable. By regulating the valve on the water-line, any temperature desired up to about 210° could be obtained. While the average temperature for each run, was used, I found that by changeing the valve and leaving it alone the temperature would soon become constant, especially at the lower temperatures.

As the speed was the important thing to get, during the test a continuous counter was connected to the reducing motion and the readings were taken with great care. No trouble was experienced at any time with this device and I believe the speed taken was as correct as could have been obtained.

Altogether five tests were made, two on kerosene and three on gasoline. In both of those using kerosene as fuel, the engine refused to work at any temperature much below 170° or 180°, and I changed to gasoline so as to get a lower temperature. All tests showed a slightly increasing power as the temperature of the jacket-water went higher, but only the one recorded in this report showed anything like a smooth curve. This was due to the gripping effect of the brake, caused by the paint that was on the fly-wheel.

"INCREASING the THERMAL EFFICIENCY of the GASOLINE ENGINE."

-C. E. Sargent, Chief Eng., Lyons-Atlas Co.

Before the time of automobiles, gasoline was a drug on the market and the price was correspondingly low. Therefore the fuel consumption of the early engine was given but a passing thought, while simplicity, looks, individualism and, sometimes, price were the dominant factors discussed. The result is that the automobile engine of today is a wonderful machine, in spite of the fact that its thermal efficiency is low. With the cost of gasoline steadily increasing, the problem with engineers is, how to get more power from the same amount of fuel.

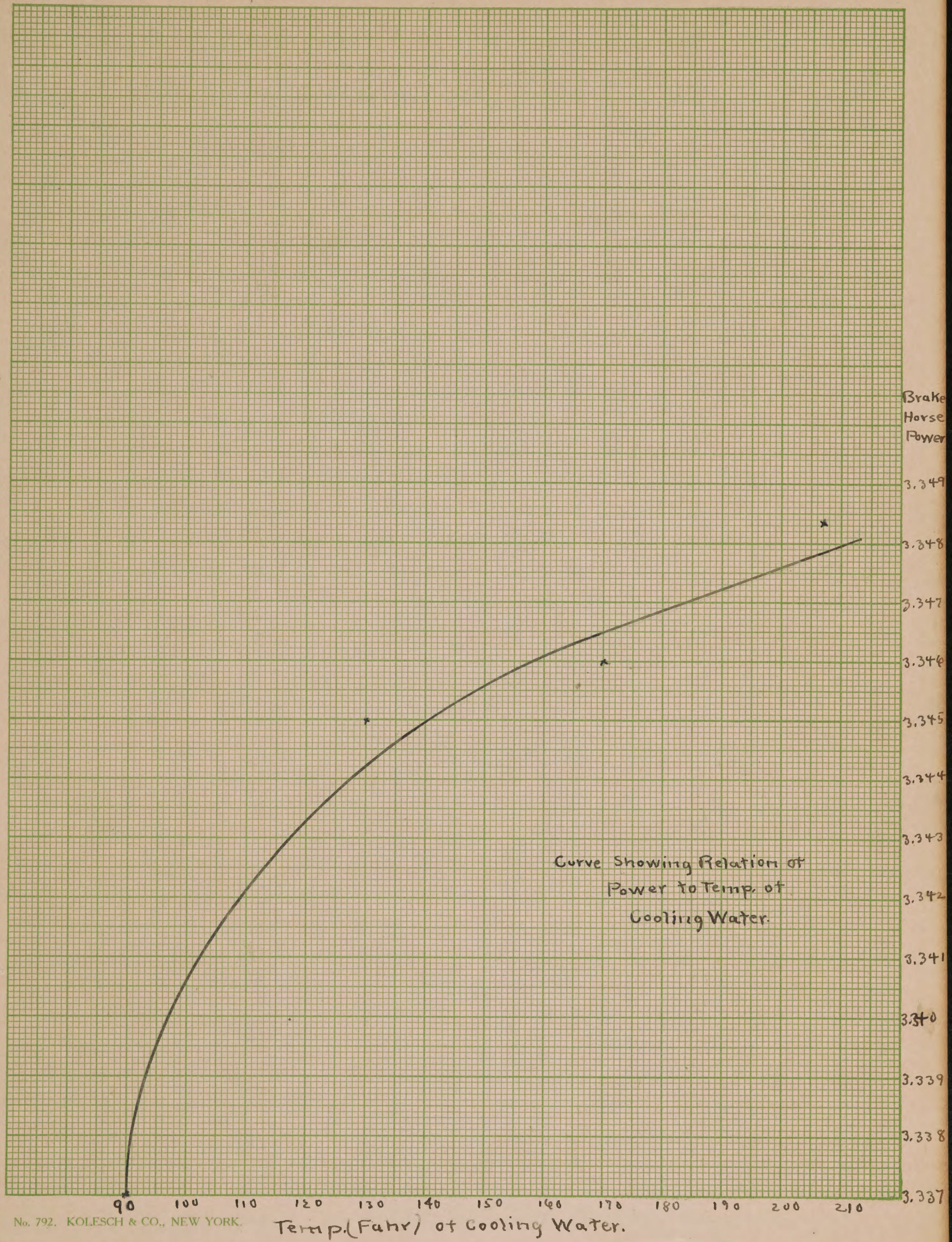
Out of the 100% of heat supplied, 20% is converted into work and 80% is lost or rejected in friction, cooling water radiation and exhaust. To convert more heat into work, it will be necessary to decrease one or more of the losses. So far as decreasing the friction is concerned, good engineering has lowered same until little can be expected from this source.

The loss of heat to the water-jacket depends on the difference in the temperature between the burning gases and the cylinder walls, the time the cylinder walls are exposed to the heat of the flame and the surface exposed.

If the temperatures were nearly the same, there would be no difference and therefore no loss, but this is of course out of the question for proper lubrication.

The time per working stroke, in which the difference of temperature exists, is cut down by high speed; herein lies the advantage of high piston speed in an engine of this type.

Therefore, the possibilities of increasing the thermal efficiency of automobile engines by decreasing the jacket losses lies in having a high temperature cooling system, high piston speed, a minimum surface per unit of volume and a compression that is as high as possible.



No. 792. KOLESCH & CO., NEW YORK.

Sample of 6 H. P. MOGUL GASOLINE ENGINE for determining the

Most Efficient Temperature for Cooling Water.

Time	Load	R. P. M.	Temp of Cooling H_2O	Brake H. P.	Gasoline per H.P.hr.	Exhaust
2.25	17#	5685	148	3.3462	1.23#	Clear no smoke
2.30	"	7753	178			
2.35	"	9860	180			
2.40	"	1495	170			
2.45	"	3958	172			
Aver.		413.5	169.6			
2.50	"	6018	182	3.3452		
2.55	"	8084	186			
3.00	"	0151	186			
Aver		413.4	184.6			
3.05	"	2230	204	3.3484		
3.10	"	4306	206			
3.15	"	6368	210			
Aver.		413.8	206.6			
3.20	"	8424	90	3.3371		Slightly Hazy
3.25	"	0489	90			
3.30	"	2548	90			
Aver.		412.4	90			
3.35	"	4618	130	3.3450		Slightly Hazy
3.40	"	6684	130			
3.45	"	8752	130			
Aver.		413.4	130			

THE NEED of a SUBSTITUTE for GASOLINE.

While many improvements in the construction and operation of the gasoline engine may cut down the expense of operation, yet it seems that a substitute will have to be found. In the case of the automobile, better carburetion has doubled the mileage that was obtained five years ago. Constant temperature has helped, while the greatest recent improvement is the small high-speed engine.

The increased cost of gasoline is more than likely due to a shortage and, unless some substitute is found, the price will continue to rise. Gasoline shortage is due to three things: (1) Increase in consumption in the United States. This increase amounted to 25% last year over the 1914 figures. (2) Increase in exports, 1915 exceeding 1914 by 1,500,000 barrels. (3) Decrease in amount of crude oil obtained from certain large oil fields.

POSSIBLE SUBSTITUTES.

The market, at present, affords three possible substitutes, namely: Kerosene, Alcohol and Benzol. The result of tests with each will be shown under their respective heads.

KEROSENE

While not enough gasoline is being obtained from the crude oil to keep up with the demand, large quantities of kerosene are being stored up for future use. This is due to the fact that kerosene is to-day a drug on the market. A small amount is being used in stationary engines but the automobile has never been very successful in its use. Since, in order to use the low grade fuels, the conditions must be nearly constant, the flexibility that has made themotor-car so popular cannot be obtained from kerosene. In the automobile, conditions are changeing all the time: the temperature of the engine varies between wide limits and the load is constantly changeing. Even if all these difficulties were overcome the important question of how to start a cold engine on kerosene would have to be fought out.

Many experiments have been made to determine the possibilities of using low-grade fuels. Nearly all of these have shown that they can be used under proper conditions, but that it is difficult for the ordinary motor-car user to get satisfactory results from non-volatile fuels. Clogging up takes place when the engine is too cold. The engine which I used in the test will use kerosene, but upon trying to change the temperature while using this fuel, the engine choked up and refused to run when the temperature of the cooling-water was 170°. Good results were obtained only when the water was actually boiling.

The difficulty of starting the engine is perhaps one of the greatest. This requires gasoline or the use of some outside heating device to vaporize the fuel. These seem to be the only alternatives, with perhaps the one exception of some device that actuallyignites the fuel while in the carburetor. Tests as recorded by P. S. Tice in Motor Age show that a temperature of from 170 to 250 degrees Fahrenheit, depending on the richness of the mixture, is necessary with kerosene, the higher temperatures being required for leaner mixtures. These tests also indicate that the fuel consumption decreases as the temperature increases.

The results of such tests also showed that Kerosene can be used in starting direct if a suitable device is provided to vaporize the mixture. This construction would complicate the design and would cause more or less trouble to the ordinary motor-car user.

If gasoline is used for starting, a separate tank must be supplied for the starting fuel, again complicating things. The kerosene could be used only after the engine was very hot, and then gasoline would have to be used again when the engine was idling. Of course if an outside source were used for heating the fuel, this use of gasoline would not be so important.

A special type of carburetor must be used. It may be necessary to heat the air so it will vaporize the kerosene more readily and prevent condensation. Direct heating, if carried too far, would cause pre-ignition and this would show that some regulating device was necessary. The introdiction of a slight quantity of water vapor with the fuel is of great importance. While experimenting on the engine in the laboratory, I found that the amount of water necessary varied with the load. When a heavy load was being carried, the engine required a great deal more water than when a smaller load was used. The man from the International Harvester Co. informed me that when their big kerosene tractors were plowing, "they seemed to nearly run on water". This, of course, is exaggerated, but a kerosene engine must have a small amount of water injected with the fuel. Its beneficial effects are recognized and some device for this purpose will have to be attached to the automobile. This water slightly reduces cylinder heat, delaying or prolonging the combustion, somewhat reduces the maximum cylinder pressure while keeping up the expansion curve or increasing the mean effective pressure. In other words, it fattens out the indicator diagram, which shows as a result a greater work area. Water vapor in proper proportion gives greater fuel economy, longer life to the engine and causes less carbon to be left.

ALCOHOL.

When looking through the list of possible substitutes for the expensive gasoline, we naturally look to alcahol as a solution. Alcohol is a substance that can be produced in unlimited quantities, that cannot be controlled by any group of manufacturers, and its source of supply is cheap and plentiful. Unfortunately however, even if there were no government restrictions concerning its production, it offers no present relief, owing to the fact that for economical use an entine reconstruction of motor-car engines would be necessary. Instead of 65 or

70 pounds compression, for efficient alcohol burning 150 to 175 pounds are required. This, of course, eliminates it as a fuel for the 2,000,000 motor-cars already in use. Engines could be produced that would run as efficiently on alcohol as on gasoline, but the horse-power would be proportionately less as the heat units per pound of gasoline are to that of alcohol. If used in the present engines, fully 50% would be wasted, thus making it too expensive altogether. Many rumors have been heard about the use of alcohol as a motor fuel by the Germans, but the truth as to this will never be known until the war is over.

BENZOL (Extracts from Motor Age)

The prevalent use of benzol in Europe as a motor fuel has led some to expect relief from this source. This hydro-carbon(C_6H_6), which is a by-product of coke, although slightly less volatile than even gasoline of the lower grade now in use, never-the-less serves well as a motor-car fuel, it being possible to start on it with the ordinary carburetor and to use it as gasoline is used without any difficult adjustments. Benzol, however, can be obtained in this country in limited quantities only. There is no general or present means of distribution such as exists with gasoline or would exist with kerosene if it were used as a common motor-car fuel.

Approximately 14,000,000 gallons of benzol were produced in the coke ovens of the United States in 1915, with a probable output for 1916 of 22,000,000 gallons. Unfortunately, this possible fuel is selling at the present time for 75 cents a gallon and not lower than 65 cents in 1000 gallon lots and is in ever-increasing demand in the manufacture of dyes, explosives and carbolic acid.

A ton of coal now yields, by the present process about two gallons of benzol. The amount of coal used for coke manufacture annually averages about 70,000,000 tons, which means a possible annual production of benzol of 3,000,000 barrels. Although the supply of coal available is practically unlimited, benzol would have to be in general use as a fuel for some time before it would be manufactured for fuel purposes alone in excess of the amount produced as a by-product of the coke industry. As long as the war continues benzol will be in great demand and therefore offers no present relief. It can, however, be produced to sell for even less than the present price of gasoline and did sell at such prices but a few years ago; it may be considered as a possible future source of part of the fuel supply.

CONCLUSION.

In conclusion, I may say that I find the results obtained in my test moderately satisfactory, considering the equipment that had to be used. At any rate, I gained valuable experience in the machine shop, in pipe-fitting, concerning which I knew previously absolutely nothing, and learned much from the reading that I found on the subject. It is my opinion that a much greater increase of power would be shown on a high grade engine and with an exact method of measuring the brake horse-power.