THE MODERN DIESEL ENGINE

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THE origin of "Modern Diesel Development," was early in 1925 when several of the large manufacturing companies started experimenting in an attempt to produce a satisfactory Diesel for mobile and portable use.

The Diesel engine is probably the most economical known means of converting heat energy into power. This economy is inherent in the Diesel engine because of its fundamental principle of operation. It is expressed in practice by its ability to burn a lesser quantity of low-priced fuel than the conventional internal combustion engine. Low-priced fuel and less of it was the goal the manufacturers were striving to reach. Why had it not been reached before? Because the adaptations of the Diesel engine to mobile use presented very great difficulties on account of the limitations of space and weight, and the requirements of manufacture, service and use, as will appear from the story of the development of the engine. Therefore, a program of intensive and comprehensive research and development was launched by several of the larger manufacturers.

In considering why the subject of Diesel power was of such intriguing interest, it is appropriate that the question should first be answered: What is a Diesel engine? A Diesel engine is an internal combustion engine in which the fuel is ignited by the heat of compression. It is so named because the early development of this type engine had as one of its most active and successful proponents, Dr. Rudolph Diesel. Dr. Diesel, starting with the simple fact that compressing any body of air causes it to become heated, made computations which convinced him that if the compression were carried far enough, sufficient temperature would be produced to burn powdered or liquid fuels. For instance, if air be compressed to 375 pounds per square inch, the temperature of the compressed air will rise to 500 degrees F. If fuel be sprayed into such highly heated air, combustion will immediately take place.

The basic principle of the Diesel type engine can best be understood by comparing the action of a four-cycle Diesel engine with that of the four-cycle gasoline engine, with which most people are familiar. In both types of engines there are the same four strokes in the cycle, namely intake, compression, power, and exhaust. On the intake stroke, the gasoline engine draws in from the carburetor, a mixture of gasoline and air. The Diesel type engine has no carburetor, and draws in on this stroke only air. On the compression stroke, the gasoline engine compresses the combustable mixture to about 80 pounds per square inch. In the Diesel type engine, the air is compressed to a much higher pressure, upwards of 500 pounds per square inch. At this point, in the gasoline engine, the compressed mixture is ignited by an electric spark. In the Diesel type engine, the high compression produces sufficient temperature to ignite the fuel which is injected into the cylinder at this point. In both cases the burning of the fuel produces the power stroke.

On the exhaust stroke, the action of the Diesel type engine like that of the gasoline engine, is the scavenging of the combustion chamber.

The Diesel type engine, because of its high compression, turns more heat into power and wastes less in cooling water and exhaust gasses. High compression pressure of a Diesel provides (a) higher initial temperature in the cylinder at the beginning of the power stroke, (b) minimum area of cylinder surface exposed for absorption of heat by cooling water, (c) more complete expansion of burning gasses, resulting in much lower exhaust temperatures. The last item is best illustrated by the actual tempearture of the exhaust gasses, which is between thirty and forty per cent lower on the Diesel than on the gasoline engine. Approximate complete combustion is assured by the present of more air in the cylinder than is required by almost twice the maximum amount of fuel per stroke at full throttle.

The first Diesel type engine built and used commercially was put into service in the year 1898. Beginning in that year, one builder in the United States and a number of others in Europe, engaged in the manufacture of engines of this type. Most of the early installations were large marine and stationary units. They were very successful and accomplished their purpose; providing power at a very low fuel cost.

Such points of performance as involved skill in operation, and inconvenience and minor difficulties, were accepted as characteristic of Diesel type engines, and were so far overshadowed by the fuel economy that they were considered of very little importance. They were eagerly accepted and adapted to such use as marine service, pumping plants and electric power production, and ably handled the work to which they were assigned. The requirements of this type of service did not impose demands for any further development.

During the years since 1898 there have been, of course, constant improvements in the Diesel type engine and a constant increase in the range of sizes offered. Never in the United States however, had any intensive effort been concentrated on the production of a Diesel engine specifically intended for transport use.

For the purpose of research, Diesel type engines that were representative of the highest development in this

type were purchased in sizes within the range of the power requirements of mobile uses.

Broadly considered, all commercial internal combustion engines fall into two classifications, namely, Otto-cycle (the ordinary gasoline engine) and Diesel-cycle engines. The distinction between the two is mainly in the manner in which the fuel is handled. In the first type, the fuel is drawn into the engine along with the air, while in the second, air alone is drawn into the cylinder and the fuel is later introduced. For the purpose of considering the paths of development open to the experimenting companies, however, it is simpler to classify oil-burning engines into terms of ignition, namely: spark ignition, surface ignition and compression ignition. Each of the main classifications has various sub-classes, and some engines are very difficult to classify in a clear or satisfactory manner.

Those engines of the "Spark Ignition" type include low compression engines in which ignition of the fuel is effected by means of electric spark plugs. Such engines start on gasoline with spark ignition, and after starting, operate on fuel oil with electric spark ignition. The heat of the exhaust gasses is depended upon for aid in vaporizing the fuel. Such engines are mainly conversions from gasoline engines and represent hopes of being able to use low-priced fuels in engines designed for gasoline. Although almost innumerable attempts along this line have been made, none has been more than partially satisfactory. The principle disadvantage has been the very serious difficulty with lubricating oil contamination, due to low compression. Such engines also give poor variable load performance and can operate at idling speeds only for brief periods. Their power out-put, in relation to engine size is low. This type, for transport duty operating on Diesel fuels, lacked many of the desired qualities and was therefore eliminated from consideration in this field.

Next came a rather broad class of engines which, like the spark ignition type, are not Diesel engines. Sometimes they are incorrectly referred to as "Semi-Diesels." They are termed "Hot Bulb" or "Surface Ignition" engines. In this type, ignition of the fuel is not dependent upon high compression, but is effected by the plate or bulb in the combustion chamber. For starting it is necessary to apply heat by a torch, or other outside means, to the bulb or plate that assists ignition. After starting, the high temperature of this surface is maintained by the combustion process. Such engines, though they may perform satisfactorily at constant loads, are not suited for variable load service. Idling is usually very poor. Moreover, the principle of ignition employed in this type makes power output for a given weight much too low for satisfactory use as a portable power unit. In addition, there are the dangers and difficulties of employing externally applied heat for starting, and the impracticability of maintaining, under variable loads and speeds, sufficient temperature of the ignition element to insure combustion.

Coming then to the true Diesel type the engineers had a choice between air injection and solid injection of the fuel. This choice was an easy one, for air injection (blowing the fuel into the combustion chamber by a blast of compressed air) necessitated the employment of a pressure of approximately 1,000 pounds per square inch. Obviously, this could not be used on a portable power unit with the same excellent success as on large permanent units, due to the space and the added weight of the air compression unit and equipment required. The solid injection method was decided upon because of its simplicity of operation. This method consists, as the name indicates, of keeping the fuel in a solid stream up to the point of injection.

To perfect the development of a proper fuel injection and cumbustion system, there has been produced an engine which in the laboratories is nick-named "The rubber engine," not because of the material of which it is constructed, but because of the elasticity of its design. The entire cylinder assembly may be raised or lowered in relation to the piston, making possible quick changes in the compression ratio. The cam shaft position may be changed while the motor is in operation making possible quick changes in valve and fuel pump timing. Recognized by all Diesel Engineers as the most vital point in Diesel design, the problem of combustion requires very intensive study. One very important phase of the combustion problem is fuel injection. This phase of design has been very closely studied and, inasmuch as the injection valve is open for less than one hundredth part of a second, it has been a very great hindrance in the development of a high speed Diesel suitable for portable or mobile service. Apparatus has been designed by means of which it is possible to obtain the necessary rate of injection and combustion at all points along the discharge curve.

It is not possible, in this limited space, to give more than these few indications of the magnitude of this undertaking to develop a Diesel power plant that will be capable of rendering satisfactory service under the exacting demands made upon it when used to power trucks, buses and tractors. A wisely conceived plan of research, pursued with caution and patience is leading toward this goal.

These engines are being installed in tractors, trucks, and buses and put in the field in the hands of men who are wholly unfamiliar with Diesel engines and are proving very satisfactory as their users become better acquainted with their care and operation. A service organization maintained jointly by several of the leading manufacturers keeps a constant watch over every unit in any type constantly checking each unit and reporting any flaw or fault that they might find, in order that a more efficient Diesel may be developed.

Sad Case

An absent minded professor was walking down the street one day with one foot in the gutter and the other on the pavement. A friend, meeting him, said:

"Good afternoon, professor, and how are you?"

"I was very well, I thought, but now for the last ten minutes I've been limping."