# **The Eisfeld auto-ignition engines and their development.** *By Gustav Eisfeld.*

Two types of auto-ignition engines have so far been deemed suitable for model plane propulsion, the Diesel with pressure pump and injector, and the auto-ignition with carburettor and variable compression.

The development of the Eisfeld auto-ignition engines began in 1937. The engine which was built at this time had a capacity of 15 ccm, a compression ratio of 22:1, an adjustable injection pump and needle injector. It ran on regular gasoil.
Development of this engine was halted in view of the prevailing much better ease of manufacture and greater reliability of the spark ignition engines of the time.

Since the beginning of the war, problematic availability of dry batteries and the poor performance of wet batteries for model engine usage were the motivation for renewed interest in the development of a model diesel engine. The engine shown in fig.#1 with injection pump and injector was built in 1942. The research engines were of 3.7 ccm and 7.3 ccm. They ran on commercial diesel fuel. Compression ratio was 23:1 and the pump pressure was 300 Atmosphere. A number of injector configurations were tested, with needles or plain. The outcome of the difficult and extensive tests was that the plain injector was the most suitable.
In comparison with spark-ignition engines, they ran surprisingly smoother and the power was significantly higher. Thanks to the fine adjustment provision, the rpm could be altered within very wide limits. After air purging and initial hand pumping, one-flip starts could be obtained. The tests showed that the engines were practical for model airplane flying, especially so because the operating weight including pump and injector was comparable to that of spark ignition engines even excluding the battery.

However, the manufacture of the pump and injector required high precision which can only be attained through industrial means. Firtehr development and manufacture of these engines is not possible due the ongoing war.
It was repeatedly noticed that model spark ignition engines with compression ratios of 6:1 would continue to run some time after the ignition was shut off; also that hot engines could be brought to life. This realisation was motivation to develop a carburettor auto_ignition engine. Tests in 1939 and 1940 had failed to perform starting from cold. The tests were therefore interrupted.

In 1942, research on high compression carburettor engines - in parallel with the Diesel pump/injector engines - was resumed. After promising preliminary tests, a range of midlle and short stroke research engines was built. Performance-wise, the short stroke engines proved to be comparable with the midlle stroke. In view of the smaller bulk and lower weight, advantage must be given to the short stroke design - see fig.#2.
Engines were made in the following sizes: 0.5ccm - 45g, 1.0ccm - 85g, 2.5ccm - 190g, 5ccm - 330g, 6ccm - 380g, 10ccm - 570g. (Weights include airscrew)

The engines use reverse flow scavenging with a flat piston and single-side exhaust. Compression ration is 20:1 and can be adapted as required operating conditions thanks to the adjustable contra-piston. The carburettor with adjustable needles has proven itself quite satisfactory. Suitable fuels are the well-known mix of turpentine, kerosene and ether, or the alternative turpentine/gasoline mix. The turpentine/gasoline mixes nedd more compression and yield lower output power. Starting is easily obtained by hand flipping. Power is significantly higher compared to spark-igintion engines of the same capacity, although less than that of diesel injection pump engines. Fig.#3 shows short stroke engines in the sizes 0.5, 1.0, 2.5 and 6 ccm.

The development of  the engines spread over a long time. The result of the research proved the practical suitability of the carburettor auto-ignition engine for model airplane flying and the performance advantage over the gasoline engines. The effective power of the engines is shown in Fig.#4. The 6 ccm engine yields 0.33 HP. The power to weight and power to capacity is shown in Fig.#5. The weight per HP is higher for the smaller engines, from 0.93kg/HP for 10 ccm to 1.98 kg/HP for 0.5 ccm. The power per liter is held within narrow limits, from 54 HP/liter for the 0.5 ccm to 58 HP/liter for the 10 ccm.

Fuel consumption of the carburettor auto-ignition engines is generally largely higher than that of the gasoline or the Diesel/injection pump counterparts. The cause of this higher consumption is likely the small proportion of kerosene actually burnt, most of it being ejected with the exhaust gases. Fig.#6 shows fuel consumption versus capacity.

As a consequence of the higher power of the carburettor auto-ignition engine compared to the gasoline engine, a higher thrust is obtained from the airscrew; thrust versus engine capacity is shown in fig.#7. The rpm at which these figures were measured are: 0.5ccm - 9500 rpm, 1.0ccm - 9000 rpm, 2.5ccm - 6700 rpm, 5ccm - 6500 rpm, 6ccm - 6500 rpm, 10ccm - 6000 rpm.

Firther development was extended to robustness and running qualities. Because of the higher compression and instantaneous combustion with very high peak, special dimensioning of the parts must be done, for a useful lifetime.

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