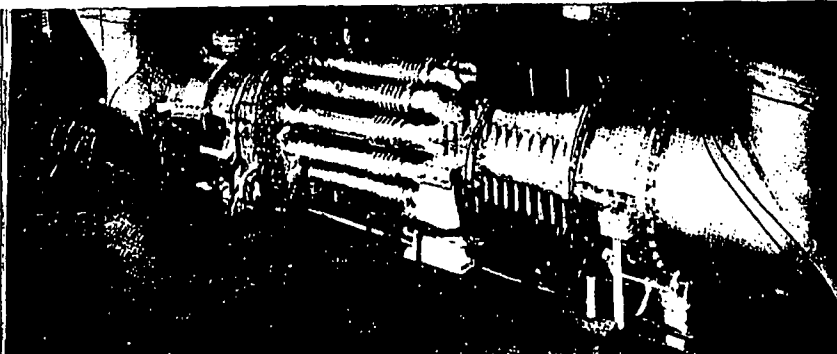




GAS TURBINE ON TEST STAND (l to r) dc generators, reducing gear, air inlet, compressor, combustors, gas turbine, shaft

1350-F 2000-Hp Gas Turbine Runs On Test Stand for Over 1000 Hours

A YEAR AGO Westinghouse announced an experimental 2000-hp land gas turbine, (POWER, Jan 1947, pp 98-9, 102). Tests run since, while incomplete, have gone far enough to confirm the hopes of its originators. Subsequent experience gives substantial evidence of eventual success for industrial and transportation use.

In more than 1000 hr of tests, performance has been essentially in accord with design predictions. Operation under all types of loading and up to the design temperature has caused no objectionable distortion and no serious creepage. Difficulties have not been fundamental and can be readily corrected in new designs. On the whole, experimental evidence points to the soundness of the general design.

Test Results. The turbine, on test since August 1, 1946, has operated about 1000 hr, of which more than 850 hr have accumulated since July 9, 1947. Evaluating performance of the unit and its components took 300 hr. Remainder of the time was used in simulating the more severe operating cycles expected in actual service.

Accurate over-all performance has been established by reliable measurements of power output, fuel flow, speed, air-inlet temperature and atmospheric pressure. Over-all fuel rate at full load of 0.78 lb per bphpr corresponds to a

Experimental unit generates full load at 16.7% thermal efficiency with 19,500-Btu-per-lb fuel oil. Maximum output developed equalled 2220 hp with 48-F inlet air to the compressor.

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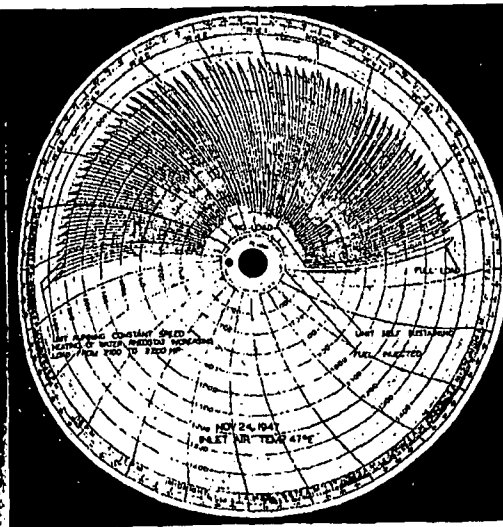
thermal efficiency of 16.7%, based on the fuel having a heating value of 19,500 Btu per lb. Maximum output developed has been 2220 hp when operating with an air-inlet temperature of 48 F.

Test Procedure. Evaluation of component performance has been difficult. Many changes in instrumentation and laborious heat-balance calculations were made to achieve the desired results. Compressor performance was established by measuring air flow, inlet and discharge pressures and temperature rise. Adiabatic compression efficiency varied from 80 to 86% over the entire speed and load range.

To determine turbine efficiency in a complete plant without a dynamometer between compressor and turbine requires accurate measurement of inlet and exhaust temperatures and pressures. Of these, temperature of the

combustion gas as it enters the turbine is particularly difficult to measure. Three methods were used: (1) direct measurement, using specially designed, shielded-type temperature probes (2) calculation, taking combustion efficiency as 95%, measured air and fuel flow, measured combustion inlet temperature and neglecting all losses (3) calculation, using the measured turbine exhaust pressure and temperature, measured inlet pressure and turbine work being determined by heat-balance calculation.

Turbine efficiency, obtained by using the temperature recorded by direct measurement, gave least reliable results, while the second and third methods were quite consistent and in close agreement. Turbine efficiency varied from 84 to 86% over the operating range. This is about 2 points lower than that obtained with earlier test results and

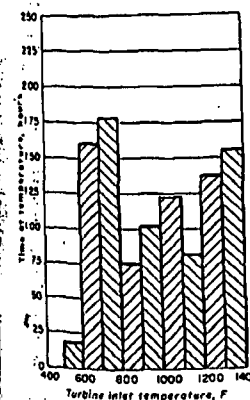


TEMPERATURE RECORD OF CYCLIC TESTS run on unit simulating short-run locomotive service. Turbine is alternately run at full and no load for 5-minute periods

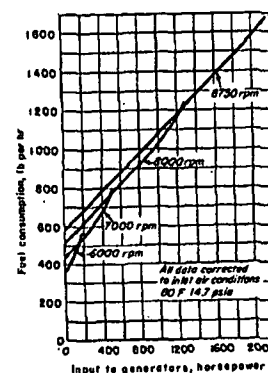
is caused by the increased radial tip clearance found necessary for rapid changes in loading.

Combustion efficiency, using specially designed air-atomizing nozzles, found by heat-balance calculations, varied between 94 to 96%. These values agree closely with those of combustion tests at our research laboratories.

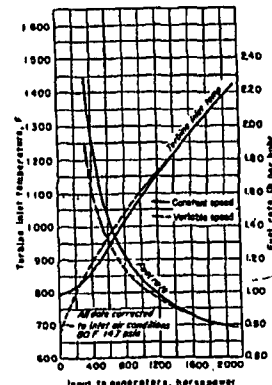
Operating Cycles. The unit has been started from a cold standstill condition 350 times and has undergone several thousand rapid load cycle changes from no load to full load. Loading and unloading cycle tests have proved its load-response characteristics. Probably the most severe load cycle will be in locomotive service where loading and un-



TURBINE HAS RUN at various loads up to Mar. 15, 1948 as temperatures show



FUEL INPUT INCREASES with load and speed, no-load fuel about 1/3 full load



RIISING TEMPERATURE with increasing load causes sharp reduction in fuel rate

loading is continuous. This corresponds to rapid temperature changes of 600 to 700 F on turbine and combustor, turbine-inlet temperature being 1350 F at full load and 600 to 750 F at no load.

To simulate locomotive operation, the unit ran at full load 30 min, then was immediately unloaded and run 30 min at no load, whereupon load was re-applied in 10 to 20 sec and the cycle repeated. This cycle was then changed to limit the loaded and unloaded time to 10 min instead of 30. To accelerate the program, a further change to 5 min was made when tests established that this time was sufficient to heat and cool parts subjected to rapid temperature variation. Chart at left shows typical load cycle run.

Starting. The unit starts easily, one generator being used as a motor. Time required is a function of starting power available. When this power is limited to a maximum of 35 kw, the unit can start in about 2 1/2 min. With a maximum of 80-kw starting power, it runs in 1 min. With 20 kw the time is 8 min. When the rotor reaches 15% speed the acetylene igniters are turned on and at 25% speed the fuel is injected. Starting power is shut off at the end of 1 1/2 min and the unit reaches a stable self-sustaining speed in about 2 1/2 min. A gas turbine of this type can operate at full capacity 10 min from the time starting is initiated, or even less if necessary.

Troubles and Remedies. During the early test weeks the compressor inlet and exhaust ducts were equipped with