Study of gas turbines and development of an experimental gas turbine at Montana State College
by Diyonis V Demirdjoglu

A THESIS Submitted to the Graduate Committee in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering
Montana State University

Abstract:
The Gee Turbine , after the Invention of Steam engine by James Watt in 1776, followed by Otto’s Internal Combustion engine in 1876 and Parson’s and De Level’s steam Turbine in 1885, is the fouirth type of prime mover invented, backed with experience of long years. The experience gained with Diesel engines since 1895 and the final retouching of steam turbines, form the backbone of modern , constant pressure combustion gas turbine.

Gas turbines known from the time of Hero of Alexandria , 130 B.C. , and the conventional wind mill, entered the family of prime movers quite recently, although different patents on gas turbines start from the time of John Barber of England in 1791. Its successful development la closely associated with the use of high temperatures and the realization of an efficient compressor, hence the progress gained in this field must be directly attributed to the combined efforts of Metallurgists and Aerodynamista.

The inherent simplicity of its design in many respects, ideally adapts the gas turbine for certain classes of service, and it is toward this ends that its present development is being directed.

STUDY OF GAS TURBINES

&

DEVELOPMENT OF AN EXPERIMENTAL GAS TURBINE

AT MONTANA STATE COLLEGE

by

DIYONIS V. DEMIRDJOGLU

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D. V. Demiroglu

ABSTRACT

The Gas Turbine , after the invention of Steam Engine by James Watt in 1776, followed by Otto's Internal Combustion Engine in 1876 and Parson's and De Laval's Steam Turbine in 1885, is the fourth type of prime mover invented, backed with experience of long years. The experience gained with Diesel Engines since 1895 and the final retouching of steam turbines, form the backbone of modern , constant pressure combustion gas turbine.

Gas turbines known from the time of Hero of Alexandria , 130 B.C. , and the conventional wind mill, entered the family of prime movers quite recently, although different patents on gas turbines start from the time of John Barber of England in 1791. Its succesful development is closely associated with the use of high temperatures and the realization of an efficient compressor, hence the progress gained in this field must be directly attributed to the combined efforts of Metallurgists and Aerodynamists.

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INTODUCTION

Gas Turbine is the newest and most promissing addition in the family of prime movers. Man's ambition to invent a power generating unit simple and efficient with as many less wearing parts, starts from the time of Hero of Alexandria, who had as followers innumerable inventors without any appreciable success up to the present time. And it is logical for one to inguire why, since the Gas Turbine had so much time and effort devoted to its development , it had so little success.

Mechanical Engineers are very familiar with Carnot Cycle which states in a simle expression, the best that can possible be done in the conversion of heat energy into mechanical energy. The efficiency which is given by Carnot's formula can not be carried out in any actual engine due to inherent mechanical losses in any one, but it is of great value as a criterion of the maximum result approachable.

The mathematical derivation of Carnot's formula is very simple. As it is well known, the efficiency of any power generating unit , is given by the ratio of output over input, or net work over heat supplied. So, we have

$$\text{Eff.} = \frac{Q_2 - Q_1}{Q_2} = \frac{T_2 - T_1}{T_2}$$

From the above expression ,it is clearly seen that to improve the efficiency of any engine, even that of the ideal Carnot, either T_2 (maximum temperature in the cycle), must be too high or T_1 (lower temperature in the cycle) must reach the absolute zero i.e. -460 F. Since the second condition is impossible in this world we live under existing conditions, much effort has been devoted in raising T so that we will have a higher obtainable efficiency.

The superiority of internal combustion engine over the steam unit lies on this fact. In the I.C. engine for a fraction of a time, we have a very high temperature raise, a case which can not exist in a steam turbine or engine; there some parts of the cycle are continuously at the maximum temperature of the cycle and metals can not stand high temperatures as those encounterdd in the internal combustion engines.

Due to the fact, as it will be seen in the later part of this Thesis, in the Combustion Gas Turbine, the type to attain commercial significance up to the present time, we must have contimuous high temperatures, all attempts of the earlier designers and inventorsfailed due to the inability of the existing materials to withstand the high temperatures necessary to produce suitable high efficiencies. An other important obstacle to the early inventors was the lack of a compressor of adequate efficiency to make the cycle feasible.

The theoritical part of this thesis , deals with the history, the thermodynamic principles , the types and the latest development in the Gas Turbine field, while the experimental one, explains the devolopments done in the Mechanical Engineering Laboratories of Montana State College in transforming an aviation turbosupercharger to an open cycle simple gas turbine plant.