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Chapter 1 : Gas turbine - Wikipedia

As a professional engineer, I have a tremendous appreciation for equipment theory and technical details but I also need to satisfy the practical aspect. The text was purchased partly due to the term "practice" being included in the title.

The compressor used in gas power plant is rotating type. The air at atmosphere pressure is drawn by the compressor through a filter which removes the dust. The rotary blades in the compressor push the air through the stationary blades to raise its pressure. Thus air with high pressure is available at compressor output. A regenerator is a device which recovers the heat from the exhaust gases to heat the air from the compressor. The exhaust is passes through regenerator before releasing it to the atmosphere. Several numbers of tubes are nested in a shell of the compressor. The compressed air passes through these tubes and exhaust gases from the gas turbine passes through the shell side which transfers heat to the compressed air. In this way compressed air heated by the exhaust gases which is an effective usage of waste gasses. This is one of the important components of the gas power plant where the high pressure air from the compressor is entered in it via regenerator. The air from regenerator is quietly heated which is not adequate to drive the gas turbine. Only hot air with high pressure can only drive the gas turbine. So in combustion chamber the compressed air is heated up to high temperature F. The heat is added to the air by burning oil which is injected through a burner in to the chamber at high pressure. The heated air with high pressure is then applied to gas turbine after it attains suitable temperature. This is heart component of the gas power plant. The hot air with high pressure and temperature is passed through gas turbine. The gases are expanded on the gas turbine blades which causes the rotation of blades to the intended mechanical work. After expanding, the exhaust gases with the temperature about F are applied to the regenerator. Alternator is directly coupled with the gas turbine same as in the case of steam power plant. Alternator converts the mechanical energy of the turbine in to electrical energy. The output generated electrical energy is then passed to the grid through a generator transformer, isolators and circuit breakers. The starting motor is placed to start the compressor before starting the plant. This works as the initial driving component for the compressor. The starting motor is coupled to the same shaft of the gas turbine for this purpose. Once the gas turbine starts rotating, some part of the mechanical energy is used to drive the compressor and the starting motor is turned off. The starting motor is driven by the batteries. Advantages of Gas power plant: The design of gas power plant is simple compared to steam power plant as that it does not require boiler and its auxiliaries. Occupies less space and size compared to the steam power plants where the boiler and feed water arrangement is not needed. Initial and Operation costs are lower compared to all other plants. Gas turbines are simple in construction compared to steam turbines and the maintenance of them is also less. It requires less water compared to steam power plants where the condenser is required. It can be started with less time from cold conditions. Disadvantages of Gas turbine Power Plant: The efficiency and net output power is less because some amount of mechanical power is used to drive the compressor. Initial external power is needed to drive the compressor until the plant starts generating.

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The "Trotting Horse Lamp" Chinese: When the lamp is lit, the heated airflow rises and drives an impeller with horse-riding figures attached on it, whose shadows are then projected onto the outer screen of the lantern. The Chimney Jack was drawn by Leonardo da Vinci: Hot air from a fire rises through a single-stage axial turbine rotor mounted in the exhaust duct of the fireplace and turning the roasting spit by gear-chain connection. Jets of steam rotated an impulse turbine that then drove a working stamping mill by means of a bevel gear , developed by Giovanni Branca. Ferdinand Verbiest built a model carriage relying on a steam jet for power. A patent was given to John Barber , an Englishman, for the first true gas turbine. His invention had most of the elements present in the modern day gas turbines. The turbine was designed to power a horseless carriage. The patent shows that it was a gas turbine and the drawings show it applied to a locomotive. Teleshov , a Russian aviation pioneer. A gas turbine engine designed by Berlin engineer, Franz Stolze , is thought to be the first attempt at creating a working model, but the engine never ran under its own power. Sir Charles Parsons patented the idea of propelling a ship with a steam turbine, and built a demonstration vessel, the Turbinia , easily the fastest vessel afloat at the time. This principle of propulsion is still of some use. Sanford Alexander Moss submitted a thesis on gas turbines. His design used a small turbine wheel, driven by exhaust gases, to turn a supercharger. The Armengaud-Lemale turbine engine in France with a water-cooled combustion chamber. Holzwarth impulse turbine pulse combustion achieved kilowatts. Nikola Tesla patents the Tesla turbine based on the boundary layer effect. Working testbed designs of axial turbines suitable for driving a propellor were developed by the Royal Aeronautical Establishment proving the efficiency of aerodynamic shaping of the blades in Having found no interest from the RAF for his idea, Frank Whittle patented [13] the design for a centrifugal gas turbine for jet propulsion. The first successful use of his engine occurred in England in April Following the gas turbine principle, the steam evaporation tubes are arranged within the gas turbine combustion chamber; the first Velox plant was erected in Mondeville, Calvados, France. Gas turbine reign in the sky begins. Together, these make up the Brayton cycle. Brayton cycle In a real gas turbine, mechanical energy is changed irreversibly due to internal friction and turbulence into pressure and thermal energy when the gas is compressed in either a centrifugal or axial compressor. Heat is added in the combustion chamber and the specific volume of the gas increases, accompanied by a slight loss in pressure. During expansion through the stator and rotor passages in the turbine, irreversible energy transformation once again occurs. Fresh air is taken in, in place of the heat rejection. If the engine has a power turbine added to drive an industrial generator or a helicopter rotor, the exit pressure will be as close to the entry pressure as possible with only enough energy left to overcome the pressure losses in the exhaust ducting and expel the exhaust. For a turboprop engine there will be a particular balance between propeller power and jet thrust which gives the most economical operation. In a jet engine only enough pressure and energy is extracted from the flow to drive the compressor and other components. The remaining high-pressure gases are accelerated to provide a jet to propel an aircraft. The smaller the engine, the higher the rotation rate of the shaft s must be to attain the required blade tip speed. Blade-tip speed determines the maximum pressure ratios that can be obtained by the turbine and the compressor. This, in turn, limits the maximum power and efficiency that can be obtained by the engine. In order for tip speed to remain constant, if the diameter of a rotor is reduced by half, the rotational speed must double. For example, large jet engines operate around 10, rpm, while micro turbines spin as fast as , rpm. This, in turn, can translate into price. More advanced gas turbines such as those found in modern jet engines or combined cycle power plants may have 2 or 3 shafts spools , hundreds of compressor and turbine blades, movable stator blades, and extensive external tubing for fuel, oil and air systems; they use temperature resistant alloys, and are made with tight specifications requiring precision manufacture. All this often make the construction of a simple gas turbine more complicated than a piston engine. Moreover, to reach optimum performance in modern gas turbine power plants the gas needs to be prepared to exact fuel specifications. Fuel gas conditioning systems treat the natural gas to reach the exact fuel specification prior to entering the turbine in terms of pressure, temperature, gas composition, and the related wobbe-index. Thrust bearings and journal bearings are a critical part of a design. They are hydrodynamic oil bearings or oil-cooled rolling-element bearings. Because of the stresses of operation, turbine materials become damaged through these mechanisms. As temperatures are increased in an effort to improve turbine efficiency, creep becomes more significant. To limit creep, thermal coatings and superalloys with solid-solution strengthening and grain boundary strengthening are used in blade designs. Protective coatings are used to reduce the thermal damage and to limit oxidation. These coatings are often stabilized zirconium dioxide -based ceramics. Using a thermal protective coating limits the temperature exposure of the nickel superalloy. This reduces the creep mechanisms experienced in the blade. Oxidation coatings limit efficiency losses caused by a buildup on the outside of the blades, which is especially important in the high-temperature environment. The microstructure of these alloys is composed of different regions of the composition. A uniform dispersion of the gamma-prime phase â€” a combination of nickel, aluminum, and titanium â€” promotes the strength and creep resistance of the blade due to the microstructure. The addition of these elements reduces the diffusion of the gamma prime phase, thus preserving the fatigue resistance, strength, and creep resistance. Flow is left to right, multistage compressor on left, combustion chambers center, two-stage turbine on right Airbreathing jet engines are gas turbines optimized to produce thrust from the exhaust gases, or from ducted fans connected to the gas turbines. Gas turbines are also used in many liquid fuel rockets , where gas turbines are used to power a turbopump to permit the use of lightweight, low-pressure tanks, reducing the empty weight of the rocket. Turboprop engines[edit] A turboprop engine is a turbine engine that drives an aircraft propeller using a reduction gear. Turboprop engines are used on small aircraft such as the general-aviation Cessna Caravan and Embraer EMB Tucano military trainer, medium-sized commuter aircraft such as the Bombardier Dash 8 and large aircraft such as the Airbus AM transport and the 60 year-old Tupolev Tu strategic bomber. Aeroderivative gas turbines[edit] Diagram of a high-pressure film-cooled turbine blade Aeroderivatives are also used in electrical power generation due to their ability to be shut down and handle load changes more quickly than industrial machines. They are also used in the marine industry to reduce weight. In its most straightforward form, these are commercial turbines acquired through military surplus or scrapyard sales, then operated for display as part of the hobby of engine collecting. The simplest form of self-constructed gas turbine employs an automotive turbocharger as the core component. A combustion chamber is fabricated and plumbed between the compressor and turbine sections. Several small companies now manufacture small turbines and parts for the amateur. Most turbojet-powered model aircraft are now using these commercial and semi-commercial microturbines, rather than a Schreckling-like home-build. Industrial gas turbines for power generation[edit] GE H series power generation gas turbine: They are also much more closely integrated with the devices they powerâ€” often an electric generator â€”and the secondary-energy equipment that is used to recover residual energy largely heat. They range in size from portable mobile plants to large, complex systems weighing more than a hundred tonnes housed in purpose-built buildings. However, it may be cheaper to buy electricity than to generate it. Therefore, many engines are used in CHP Combined Heat and Power configurations that can be small enough to be integrated into portable container configurations. Gas turbines can be particularly efficient when waste heat from the turbine is recovered by a heat recovery steam generator to power a conventional steam turbine in a combined cycle configuration. They can also be run in a cogeneration configuration: Another significant advantage is their ability to be turned on and off within minutes, supplying power during peak, or unscheduled, demand. Since single cycle gas turbine only power plants are less efficient than combined cycle plants, they are usually used as peaking power plants , which operate anywhere from several hours per day to a few dozen hours per yearâ€”depending on the electricity demand and the generating capacity of the region. In areas with a shortage of base-load and load following power plant capacity or with low fuel costs, a gas turbine powerplant may regularly operate most hours of the day. The power range varies from 1 megawatt up to 50 megawatts. The majority of installations are used within the oil and gas industries. Oil and Gas platforms require these engines to drive compressors to inject gas into the wells to force oil up via another bore, or to compress the gas for transportation. The same companies use pump sets to drive the fluids to land and across pipelines in various intervals. Compressed air energy storage[edit] Main article: Compressed air energy storage One modern development seeks to improve efficiency in another way, by separating the compressor and the turbine with a compressed air store. In a conventional turbine, up to half the generated power is used driving the compressor. In a compressed air energy storage configuration, power, perhaps from a wind farm or bought on the open market at a time of low demand and low price, is used to drive the compressor, and the compressed air released to operate the turbine when required. Turboshaft engines[edit] Turboshaft engines are often used to drive compression trains for example in gas pumping stations or natural gas liquefaction plants and are used to power almost all modern helicopters. The primary shaft bears the compressor and the high-speed turbine often referred to as the Gas Generator , while a second shaft bears the low-speed turbine a power turbine or free-wheeling turbine on helicopters, especially, because the gas generator turbine spins separately from the power turbine. This arrangement is used to increase power-output flexibility with associated highly-reliable control mechanisms. Radial gas turbines[edit] Main article: Various successors have made good progress in the refinement of this mechanism. Owing to a configuration that keeps heat away from certain bearings the durability of the machine is improved while the radial turbine is well matched in speed requirement. Microturbine Evolved from piston engine turbochargers , aircraft APUs or small jet engines , microturbines are 25 to kilowatt turbines the size of a refrigerator. External combustion has been used for the purpose of using pulverized coal or finely ground biomass such as sawdust as a fuel. In the indirect system, a heat exchanger is used and only clean air with no combustion products travels through the power turbine. The thermal efficiency is lower in the indirect type of external combustion; however, the turbine blades are not subjected to combustion products and much lower quality and therefore cheaper fuels are able to be used. When external combustion is used, it is possible to use exhaust air from the turbine as the primary combustion air. This effectively reduces global heat losses, although heat losses associated with the combustion exhaust remain inevitable. Closed-cycle gas turbines based on helium or supercritical carbon dioxide also hold promise for use with future high temperature solar and nuclear power generation. A key advantage of jets and turboprops for airplane propulsion - their superior performance at high altitude compared to piston engines, particularly naturally aspirated ones - is irrelevant in most automobile applications.

Chapter 3 : Gas Turbine for Power Generation- Introduction

Norman Davey is the author of The Gas Turbine - Theory and Practice - Illustrated (avg rating, 1 rating, 0 reviews, published), Wall Painting I.

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The basic gas turbine cycle is illustrated (PV and T-s diagrams) in Figure 5. A comparison can be drawn between the gas turbine's operating principle and a car engine's.

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Chapter 9 References Aircraft Gas Turbine Engine Technology written by Irwin E. Treager ISBN Glencoe/McGraw-Hill This is the best gas turbine title that I have ever come across and I consider it to be my.

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