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Ramjet Engine for Power Generation

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Abstract: **A method of power generation by using the ramjet engine. Ramjet structural components to provide inlet compression, the combustion chamber, and an outlet nozzle are provided at one or more circumferentially spaced locations along the periphery of the low aerodynamic drag rotor. Ramjet compression occurs by impingement of an inlet air stream between the rotating inlet structure and an adjacent stationary wall. The compressed air inlet stream provides oxygen for mixing with the fuel, such as natural gas, others suitable hydrocarbons, or hydrogen, which is supplied to the ramjet combustion chambers to produce expanding combustion gases.**

Such gases escape out through the nozzle formed between the rotating outlet structure and the stationary wall. The ramjet operates at supersonic velocities, and preferably in excess of mach 2.0, to produce shaft energy. The rotor rotates about an axis defined by an outlet shaft. The rotor acts as the structural member which transmits to the output shaft the thrust generated by the ramjets. Thermal and mechanical energy in escaping combustion gases may also be utilized to increase the overall efficiency of the ramjet engine.

1. INTRODUCTION

The air induced through the inlet at velocity V_{∞}, decelerated in the in diffuser, burned in the region where fuel is injected, and then blasted out the exhaust nozzle at very high velocity V_e. Such simple devices are called the Ramjet engine. The ramjet operates at supersonic velocities, and preferably in excess of mach 2.0, to produce shaft energy. The rotor rotates about an axis defined by an outlet shaft. The rotor acts as the structural member which transmits to the output shaft the thrust generated by the ramjets. Thermal and mechanical energy in escaping combustion gases may also be utilized to increase the overall efficiency of the ramjet engine.

2. TECHNICAL APPROACH

The invention relates to a high efficiency, novel ramjet driven rotary engine, and to a method for the generation of electrical and mechanical power with the engine, while minimizing emission rates of nitrogen oxides. More Particularize, the invention relates to the power plant driven by the ramjet engine, and to structures which are designed to withstand the extremely high tensile stress encountered in the rotating device with distally mounted ramjets operating at supersonic speeds. Power plants of that character are particularly useful for generation of electrical and mechanical power.

3. MASTER OF OBJECTIVE OF CONCEPT

A continuing demand exists for the simple, highly efficient and inexpensive thermal power plant which can reliably provide low cost electrical and mechanical power. This is because many electrical and mechanical power plants could substantially benefit from the prime mover that offered the significant improvement over currently practiced cycle efficiencies in power generation. This is particularly true in medium size power plants largely in the 10 to 100 megawatt range which are used in many industrial applications, including stationary electrical power generating units, rail locomotives, marine power systems, and an aircraft engines.

Medium sized power plants are also well suited for used in industrial and utility cogeneration facilities. Such facilities are increasingly employed to service thermal power needs while simultaneously generating electrical power all somewhat reduced overall costs. Power plant designs which are now commonly utilized in co-generating applications include (a) gas turbines, driven by the combustion of natural gas, fuel oil, or other fuels, which capture the thermal and kinetic energy from the combustion gases, (b) steam turbines, driven by the steam which is generated in boilers from the combustion of coal, fuel oil, natural gas, solid waste, or other fuels, and (c) large scale reciprocating engines, usually diesel cycle and typically fired with fuel oils. Of the currently available power plant technologies, diesel fueled reciprocating and advanced aero derivative turbine engines have the highest efficiency levels. Unfortunately, with respect to the reciprocating engines, at power output levels greater than approximately 1 megawatt, the size of the individual engine components required become almost unmanageably large, and as the result, widespread commercial use of single unit reciprocating engine systems in larger sizes has not been developed. Gas turbines perform more reliably than reciprocating engines, and are therefore frequently employed in plants which have higher power output levels. However, because gas turbine are only moderately efficient in converting fuel to electrical energy, gas turbine powered plants are most effectively employed in co-generation systems where both electrical and thermal energy can be utilized. In that way, the moderate efficiency of the gas turbine can in part be counterbalanced by using the thermal energy to increase the overall cycle efficiency.

Fossil fueled steam turbine electrical power generation systems are also of fairly low efficiency, often in the range of

30% to 40% on an overall net power output to raw fuel value basis. Still, such systems are commonly employed in both utility and industrial applications for base load electrical power generation. This is primarily due to the high reliability of such systems.

In any event, particularly in view of reduced governmental regulation in the sale of electrical power, it can be appreciated that it would be desirable to attain significant cost reduction in electrical power generation. Fundamentally, particularly in view of long term fuel costs, this would be most effectively accomplished by generating electrical power at the higher overall efficiency than is currently known or practiced.

4. DESCRIPTION WITH RESPECTIVE TO STAGES

I have now invented an improved power plant based on the use of a supersonic ramjet thrust module as the prime mover to rotate a power shaft. Then using this method to generate electrical power, the supersonic ramjet thrust module is directly or indirectly coupled with an electrical generator. By use of the secondary fuel feed arrangement, the power output of the ramjet thrust module can be turned down as necessary to maintain constant rotating velocity, such as is necessary in synchronous power generation apparatus, at minimal output loads. Throughout its operating range, the supersonic ramjet power plant has greatly increased efficiencies.

The designs incorporated into my power plant overcome four significant and serious problems which have plagued earlier attempts at ramjet utilization for efficient electrical power production:

First, at the moderate Mach number tip speeds at which my device operates (preferably, Mach 2.5 to about Mach 4.0), the design minimizes aerodynamic drag. This is accomplished by both reducing the effective atmospheric density that the rotor encounters, and by use of the boundary layer control and cooling technique. Thus, the design minimizes parasitic losses to the power plant due to the drag resulting simply from rotational movement of the rotor. This is important commercially because it enables the power plant to avoid large parasitic losses that undesirably consume fuel and reduce overall efficiency.

Second, the selection of materials and the mechanical design of rotating components avoid use of excessive quantities or weights of materials (the vast improvement over large rotating mass designs), and provides the particularly tensile strength where needed in the rotor, necessary strength, to prevent internal separation of the rotor by virtue of the centrifugal forces acting due to the extremely high speed rotor.

Third, the design provides for effective mechanical separation of the cool entering fuel and oxidizer gases from the exiting hot combustion gases, while allowing ramjet operation along the circumferential pathway.

Fourth, the design provides for effective film cooling of rotor rim components, rim strakes, including rim segments and ramjet thrust modules. This novel design enables the use of lightweight components in the ramjet combustor and in the ramjet hot combustion exhaust gas environment, including potentially combustible components such as titanium.

To solve the above mentioned problems, I have now developed novel rotor designs which overcome the problems inherent in the heretofore known apparatus and methods known to me which have been proposed for the application of ramjet technology to stationary power generation equipment. I have now developed a low drag rotor which has one or more enshrouded ramjet thrust modules mounted on the distal edge thereof. A number N of peripherally, preferably partially helically extending strakes S partition the entering gas low sequentially to the inlet to a first one of one more ramjets, and then to the second one of one or more ramjets, and so on to an Nth one or more ramjets.

The exhaust gases exiting from each of the one or more ramjets is effectively prevented from “short circuiting” by returning to the inlet side of subsequent ramjets. Downstream from the ramjet exhaust area, and extending until just before the inlet to the next of the one or more ramjets, the prevention of bypass of the cool entering fuel air mixture is effectively accomplished by the design of my one or more ramjet thrust modules, as it is preferred that the exhaust gases from each ramjet be expanded to approximately atmospheric pressure, so the strakes S merely act as the large fan or pump to move exhaust gases along with each turn of the rotor. The radial dimension at the start of each individual air receiving radically proximal wall determines the distance over which that air receiving chamber operates for compression, and thus determines the pressure of air delivered at the exit of the particular boundary layer cooling outlet orifice.

Attached at the radial end of the rotor are one or more of the at least one ramjets, each ramjet preferably having an enshrouded thrust module construction. Fuel injected into the inlet air stream is thus well mixed with the inlet air before arriving at the ramjet engine combustion chamber. The power generated by the turning shaft portions may be used directly in mechanical form, or may be used to drive an electrical generator and thus generate electricity. The operation of my ramjet engine may be controlled to maintain synchronous operation, i.e. vary the power output from the ramjet, while maintaining constant speed shaft operation. The heat transfer fluid may be utilized for convenient thermal purposes, or for mechanical purposes, such as for driving the steam turbine. `Ultimately, the cooled combustion gases are exhausted to the ambient air.

Finally, many variations in the air flow configuration and in provision of the fuel supply, secondary fuel supply, and in providing startup igniters, may be made by those skilled in the art without departing from the teachings hereof. Finally, in addition to the foregoing, my novel power plant is simple, durable, and relatively inexpensive to manufacture.

4.1 Ram jet power generator

The side elevation view of a combined cycle plant

Which uses my novel ramjet driven rotor as a prime mover, provide as shown in combustion with an electrical generator and steam turbine. It is modified partial cross-section view of the novel power plant, which shows the details of the cooling system, and the annular valve, and varying position of strakes as the rotor turn about its axis of rotation.

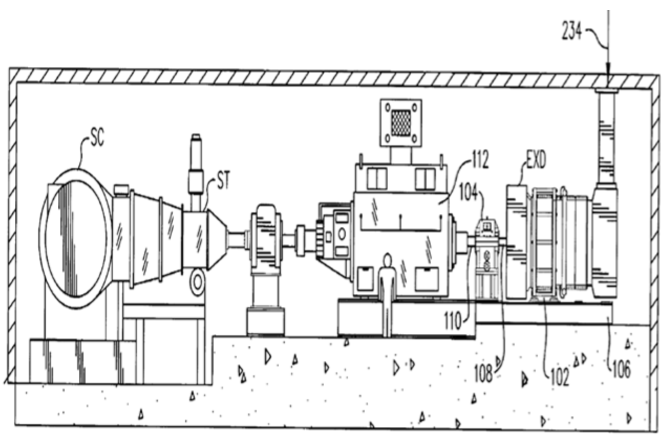

Fig. 1 Ramjet engine power generator

5. IMPORTANT FEATURES

From the foregoing, it will be apparent to the reader that one important and primary object of the present invention residues in the provision o f a novel ramjet powered engine which can be cost effectively used to generate mechanical and electrical power.

More specifically, an important object of my invention is to provide a ramjet driven power generation plant which is capable of withstanding the stress and strain of high speed rotation, so as to reliably provide a method of power generation at high efficiency.

Other important but more specific objects of the invention reside in the provision of power generation plants as described in the preceding paragraph which the high efficiency rates; i.e, they provide high heat and high work outputs relative to the heating value of fuel input to the power plant. It connections with a proceeding object, provide lower power costs to the power plant operator and thus ultimately to the power purchaser that was presently the case; Allow the generation of power to be done in a simple, direct manner; It is the minimum of mechanical parts; Avoid complex subsystems; Require less physical space than many existing technology Power plants; are easy to construct, to start, to operate, and to service; Cleanly burns fossil fuels; in conjunction With the just mentioned object, results in fewer negative environmental impacts than most power generation facilities currently in use; The rotating element With the minimal distally located mass structure, and Which is thus able to Withstand the stresses and strains of rotating at a very high tip speeds; and Which provides for operation With minimal aerodynamic drag.

One feature of a present invention is the novel high strength rotor structure. In one design, the high strength steel inboard sections are provided with high strength spokes that at their distal end suspend the rotating rim that has enshrouded ramjet thrust modules integrated therein. The unique structure enables operation at a rotational speeds above stress failure limits of many conventional materials, While simultaneously providing for adequate cooling of a rim and ramjet structure, that order to maintain material integrity, at a high temperature operating conditions. In another design, the carbon berg epoxy composite disc are provided, Which simplexes the overall construction While providing an Abundance of strength, While still providing the ventilated positive cooling system design to maintain structural integrity of a rotor, and of a rim and ramjet structure.

Another feature of the present invention is the use of the enshrouded ramjet design. In this design, the stationary, peripheral Wall which surrounds the ramjet functions as part of the ramjet thrust module. This unique design enables use of a minimal rotating mass at the high design tip speeds, there is enabling the rotor to be designed with lower strength materials and a higher margin of safety With respect to overall tensile strength requirements for a given ramjet

Operational Mach number. Still another important feature of a present invention is the use of strakes to partition of the ramjet inlet air from the ramjet exhaust gas. This elegant design feature assures that exhaust gases are directly removed from the engine, and that only the amount of inlet air necessary for combustion in the ramjets is required to be provided. Other important objects, features, and additional advantages of my invention Will become apparent to those skilled. Ages of my invention Will become apparent to those skilled in the art from the foregoing and from the detailed description Which follows and the appended claims, in conjunction.

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