PROVISIONAL PATENT APPLICATION

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FOR

CAVITATION ENGINE

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CAVITATION ENGINE

FIELD

[0001] The present disclosure relates to a cavitation engine. More particularly, the disclosure relates to a cavitation engine structure that enables improved efficiency.

BACKGROUND AND SUMMARY

[0002] Improvement is desired in the construction of engines or the like that generate steam.

[0003] The disclosure advantageously provides a cavitation engine configured to produce superheated steam. The cavitation engine includes a pre-heated impact chamber configured to receive injected fluid, such as hyperbaric water, injected at supersonic velocities and in a manner to maximize the formation of bubbles in the injected fluid. The impact chamber is configured to interact with the injected fluid to promote cavitation of the injected fluid and generate very high pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Further advantages of the disclosure are apparent by reference to the detailed description when considered in conjunction with the figures, which are not to scale so as to more clearly show the details, wherein like reference numbers indicate like elements throughout the several views, and wherein:

[0005] FIG. 1 is a perspective view of a cavitation engine according to the disclosure.

[0006] FIG. 2 is a frontal view of the cavitation engine of FIG. 1, with a portion cutaway to show internal details.

[0007] FIG. 3 is a cross-sectional view taken along line A-A of FIG. 2.

[0008] FIG. 4 is a detailed view of a portion of FIG. 3.

[0009] FIG. 5 is a top view of the cavitation engine of FIG. 1.

[0010] FIG. 6 is a bottom view of the cavitation engine of FIG. 1.

[0011] FIG. 7 is a transparent perspective view of the cavitation engine of FIG. 1.

[0012] FIG. 8 is a transparent frontal view of the cavitation engine of FIG. 1.

[0013] FIG. 9 shows various cross-sectional and detailed views of the cavitation engine of FIG. 1.

[0014] FIG. 10 is a parts list of the cavitation engine of FIG. 1.

[0015] FIG. 11 is a graph showing operation of a cavitation engine according to the disclosure.

DETAILED DESCRIPTION

[0016] With reference to the drawings, the disclosure relates to a steam engine, and in particular to a cavitation engine. The cavitation engine produces superheat steam by injecting hyperbaric water at supersonic velocities into a specially configured, heated impact chamber configured to promote cavitation of the injected water and generate very high pressure that can be used to generate electricity or otherwised harnessed as an energy output. The impact chamber is initially pre-heated to 375 degrees F. Once the engine is operating, the energy supplied for the pre-heating may be ceased, as the temperature of the impact chamber will remain above 375 degrees F due to the operation of the engine.

[0017] Cavitation refers to the formation of vapor cavities in a liquid. The vapor cavities are characterized as small liquid-cavitation-free zones in the nature of bubbles or voids that are the consequence of cavitational forces acting upon the liquid. Cavitiation occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. When subjected to higher pressure, as in the case of the cavitation engine according to the disclosure, the voids implode and generate an intense shockwave and high pressure.

[0018] In accordance with the disclosure, when the injected water collides with the impact chamber wall a shock wave occurs and the water is shattered and instantly transformed into superheat steam. The cavitation engine has substantially improved efficiency as compared to conventional steam engines, such as conventional external combustion Rankine Cycle steam boilers.

[0019] It has been observed that the angle of incidence and the proximity of the impact surface wall are critical to the functioning of the cavitation engine of the disclosure. The type of electronic piezo fuel injector utilized to eject the water fraction preferably has injector orifices oriented at such an angle to the impact chamber surface as to produce a nearly perpendicular trajectory. This geometry is shown in the cross-sectional views of the impact chamber, such as FIGS. 2-4. This geometry desirably produces very high water hammer pressure during collision of the water fraction

[0020] In this regard, the timing, distance and geometry of the impact module are critical in desired operation of the engine system and the production of heat. The engine system operates with pressures between 15000 - 28000 psi and a variety of injector orifice diameters. The pressure and orifice determine the degree of cavitation in the injection stream. The distance to the impact surface is desirably between 0.150 - 0.450 inches. It has been observed that greater distances will tend to dissipate the injection stream and the vapor bubbles present in the stream will be lost. It is important that the water injection, which is saturated with cavitation bubbles, impact the surface with maximum force so that the water hammer pressure crushes the bubbles and releases the energy associated with the bubble collapse.

[0021] The incidence of impact is also very important. The funnel like curvature of the chamber as shown in the drawings is designed to yield a nearly 90 degree angle of incidence when coupled with the 15 degree angle of the impacting water injection jet. The pressure and orifice size also affect the velocity of the water. The velocity of the water directly affects the shock wave at the impact surface and the resulting water hammer pressure within the droplet containing the vapor nano bubbles.

[0022] Fuel injectors are configured to create cavitation bubbles at the orifice so as to maximize fuel atomization, dispersion and corresponding surface area for complete combustion. Fuel injectors for injecting diesel fuel have been observed to be suitable. It is desirable to maximally collapse these bubbles to obtain the greatest heat energy, which is a function of the cube of the bubble ratio (Radius expanded/Radius collapsed) and product of the pressure ratio.

[0023] It is believed that this is why the heat observed during operation of the engine is so intense. In this regard, it is believed that an oxyhydrogen covalent separation occurs where temperatures in excess to 3000 C are required to get 50% disassociation. The impact water hammer pressure drops off exponentially as the distance from the injector orifice increases. The angle of impact also affects the impact pressure. Placing the injector close to the impact surface makes no sense from a combustion engineering view point, but in our case it is important.

[0024] The timing of the injections also affects the operation of the engine. The water is desirably injected as a discrete pulse. This pulse width controls the volume of water injected. The number of injections per second controls the amount of steam production per hour in pounds of steam/hour. All of this requires an instant response to all of the sensors. Accordingly, the impact chamber temperature is controlled to manage the output steam temperature required by the water prime mover, such as a turbine, rotary expander, reciprocating steam engine etc. Controlling the volume of steam produced per second will affect the rotation rate of a steam engine which in turn may be driving a generator or other device. The computer control system monitors and adjusts injection rates and volumes, impact chamber temperatures, generator rpm and output pressure.

[0025] As noted above, it is believed that cavitation is responsible for the heating which occurs within the impact chamber. Cavitation occurs within the orifice of the fuel injector nozzle when the local flow pressure drops below the vapor pressure of the liquid. As the pressurized and compressed water expands through the orifice the liquid accelerates. The flow streamlines contract as the liquid ejects from the nozzle and according to the Bernouilli principle this causes a reduction in the local static pressure which can become lower than the vapor pressure of the water leading to extensive cavitation bubble formation. These cavitation bubbles are ejected from the nozzle at supersonic velocity into the impact chamber. When they collide with the impact surface they are crushed from the pressure.

[0026] Additional cavitation bubbles form as the fluid ejection fraction travels towards the impact surface as the ambient pressure within the impact chamber is significantly less than the pressure of the exiting water. The distance from the injector orifice is critical to the operation of the system and must be between .150 and .450 inches or the cavitation bubbles will dissipate before hitting the impact chamber wall.

[0027] The water hammer shock wave pressures encountered as the water droplet hits the impact surface can be well in excess of 275 MPa (Mega Pascals). This pressure is more than enough to crush any vapor bubbles which have been formed. The energy released when this phenomena occurs can be in excess of 30,000 degrees K (Kelvin). Since these temperatures are well in excess of that required to obtain molecular hydrogen and oxygen separation in water (temperatures above 3000 degrees C result in 50% molecular separation) a significant portion of the water separates and subsequently combusts releasing heat energy in excess of the hydraulic and heat energy used to accelerate the water to the impact target.

[0028] In a preferred embodiment, the engine includes banks of eight impact chambers arrayed together. Special ceramic insulation is used to separate the injector body from the impact chamber to minimize heat loss. The primary loss of heat is through steam exiting from the pressure relief valve. The steam exiting the pressure relief valve is superheat steam and can be used to drive a reciprocating steam engine or a rotary expander type turbine.

[0029] The rotational speed of the steam engine or rotary expander is controlled by adjusting the flow of superheat steam from the cavitation engine. This steam output flow is adjusted by varying the injection rate (Injections/second) of the individual impact chambers. As additional output power is required, the number of impact chambers used and the injection rate per chamber are varied in real time, according to demand.

[0030] A specially` designed high pressure triplex water pump system is used to provide high pressure water (> 20,000 psi) to the common rail manifold supplying the fuel/water injectors. The speed of the pump and thus the pressure is regulated by controlling the power flow to a DC electric motor. A control computer monitors the common rail manifold pressure and adjusts the pump speed to maintain this pressure. To minimize power consumption the pump is only run on demand for feedwater to the injectors.

[0031] An injector control module is used to supply the 140 V DC power required to fire the piezo type fuel injectors. A central control computer controls the impact chamber electric heaters, the impact chamber injection rate, the feedwater temperature and the cyclical rotation rate of the prime mover (steam engine, steam turbine) driving the power generators.

[0032] A cavitation engine according to the disclosure was successfully operated and yielded the pressure results shown in FIG. 11. The engine utilized for the results shown in FIG. 11 utilized a single injector and a single impact chamber. No relief valve was provided and an Omega pressure transducer was utilized to obtain instantaneous pressure readings. Because of the pressures generated, it is difficult to continuously operate the engine due to failure of seals. Thus, tests were kept short (1-2 seconds) while efforts are being made to improve the longevity of the seals.

[0033] For the purpose of example, for the operation of the engine for the results shown in FIG. 11, the impact chamber was initially pre-heated to 375 degrees F using an electrical heater, and then power to the heater was turned off once the pre-heating was accomplished. The pre-heated sealed impact chamber and expansion chamber of the engine were under 3 cubic inch, and the feed water was 160 degrees F. After two seconds of operation, resulting in 10 injections (5 injections per second), the impact chamber was heated to 575 degrees F and produced pressure of 1340 PSI. In another test of 3 seconds (5 injections per second), a pressure of 1,950 psi was achieved before the seal failed.

[0034] The results have also been observed to differ based on the salinity of the water. In this regard, it was observed that cavitation increased with seawater (4% salt solution) as compared to fresh water.

[0035] The foregoing description of preferred embodiments for this disclosure has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments are chosen and described in an effort to provide the best illustrations of the principles of the disclosure and its practical application, and to thereby enable one of ordinary skill in the art to utilize the disclosure in various embodiments and with various modifications as are suited to the particular use contemplated.

THE CAVITATION ENGINE ACCORDING TO THE DISCLOSURE IS FURTHER DESCRIBED BELOW.

1. A cavitation engine configured to produce superheat steam. The cavitation engine includes a pre-heated impact chamber configured to receive injected fluid, such as hyperbaric water, injected at supersonic velocities and in a manner to maximize the formation of bubbles in the injected fluid. The impact chamber is configured to interact with the injected fluid to promote cavitation of the injected fluid and generate very high pressure.

2. The cavitation engine of the preceding paragraph, wherein the injected fluid is injected using injector orifices oriented at such an angle to the impact chamber surface as to produce a nearly perpendicular trajectory.

3. The cavitation engine of the preceding paragraph, wherein the impact chamber has a funnel-like curvature that provides a substantially 90 degree angle of incidence of the impacting water injection jet.

ABSTRACT

A cavitation engine configured to produce superheat steam. The cavitation engine includes a pre-heated impact chamber configured to receive injected fluid, such as hyperbaric water, injected at supersonic velocities and in a manner to maximize the formation of bubbles in the injected fluid. The impact chamber is configured to interact with the injected fluid to promote cavitation of the injected fluid and generate very high pressure.