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The jet propulsion with closed combustion type

Brief structure and main principle:

I have an idea of a new jet engine. （It evolves from my patent ZL 95237295.9）The combustion in current jet engine is under consistent high pressure created by compressor. A lot of energy out off from combustion chambers is used to drive turbine for compressor. But I know the efficiency of compressor is not high and the compressor is very heavy, its weight occupies 70% of total engine. Further the compressor also consumes about 2/3 proportion of total energy. My idea is to adopt closed combustion type to increase pressure. It consist of several same components cooperate to get stable propulsion. By the closed combustion, we can get high pressure easily. It also utilizes the advantage of closed combustion of mixture gas: **easily igniting, burning rapidly; easy to get high pressure.** On the other side I must overcome its weakness: the stress on some parts isn't consistent and regulate difficultly in different work condition. I have thought methods to solve them.
The main advantage is: **the new jet engine has more efficiency** than current jet engine.

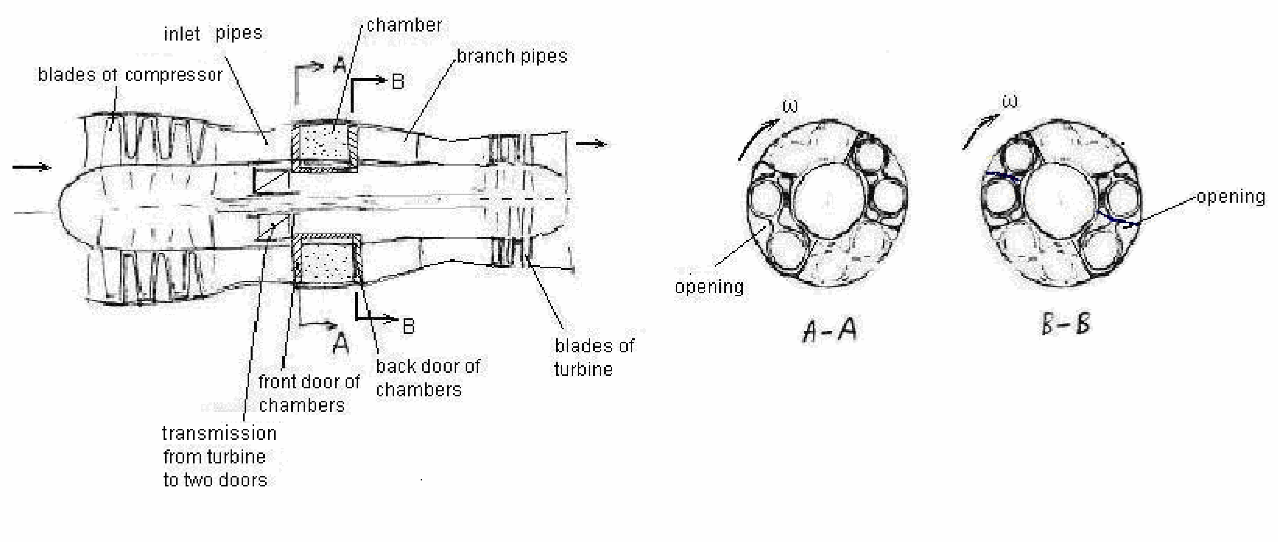


figure 1

Firstly I explain the **structure** in brief. （figure 1）

The left one is the section per axial, it show almost all main parts.
Another two pictures show the main parts: the front door and back door of the combustion chambers. two doors control and regulate work to complete combustion one by one. Anyone of combustion chambers sometimes sucks mixture gas; sometimes it the combustion happens inside it; sometimes gas exhausts from it. So the chamber sometimes is sealed by the two doors; sometimes it is open on both ends; sometimes it is open on one end. So the door has openings(slots) in it. The two doors rotate at same speed and co-operate each other.

As the amount of chambers, I draw 4 couples, actually it may be more. It depends on the utilization rate of space; parts strength; stable work and other factors.

There is blower/compressor in front of the chambers. The branch pipe, turbine install behind the chambers.

Now I state the work procedure.

Let us review the current jet engine's work procedure: the first step is that compressor suck air and increase the pressure to high level, the air enter combustion chamber, be mixed with fuel, burning, during the course the pressure remain consistent in chamber; after complete burning, gas goes out of chambers and drives turbine; turbine transmits the power to the compressor ahead; at last the gas utilizes the rest energy to accelerate itself to push jet engine.

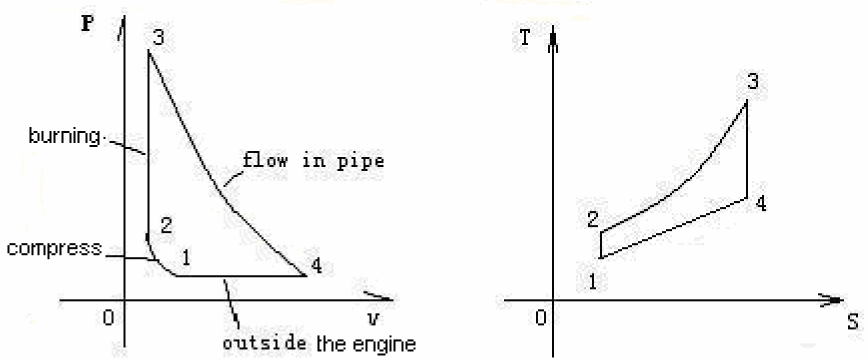
In my design: The first step of jet propulsion's work procedure is that the blower suck air and increase it to proper pressure, mix fuel as well; then through a pipe the gas enter the combustion chambers, after the front door and back door close, then burning inside chambers and the pressure increase rapidly, the back door open; the gas run into the branch pipes; then general pipe, there is a turbine afterwards to get power for the blower/compressor ahead. After the branch pipe the gases converge, flow out off the engine so as to give whole engine a consistent push force.

Upper I state two work courses, there is another course, at the end of the spouting course, the front door of chambers opens, and the fresh gas enters meanwhile drive/sweep the waste gas out off the chambers. So the chambers spout gas alternatively. All courses are controlled by chambers' front door and back door. In common case, there are always a couple of chambers at the same course. All chambers are arranged as a circle. The section shape of chamber is round or close to round.

One time combustion needs several milliseconds only to complete. Though it is so quick, if the rotary doors are driven by turbine, you should reduce the rotation speed from turbine to the valve. The speed of turbine is too high for doors because the combustion needs time. A transmission unit is needed from turbine to doors.

Working cycle analyses and efficiency (please see figure 2):

figure 2



$$\eta=\frac{C_v(T3-T2)-C_p(T4-T1)}{C_v(T3-T2)}=1-\frac{C_p(T4-T1)}{C_v(T3-T2)}=1-k\frac{(T4-T1)}{(T3-T2)}=1-k\frac{T1(T4/T1-1)}{T2(T3/T2-1)}$$

$$T2/T1=(P2/P1)^{\frac{k-1}{k}} \qquad T3/T4=(P3/P4)^{\frac{k-1}{k}}$$

SET: $U=P3/P2 \quad W=P2/P1$

$$T3/T2=U \qquad T1/T2=(P1/P2)^{\frac{k-1}{k}}=(1/W)^{\frac{k-1}{k}}$$

$$T3/T4=(P3/P4)^{\frac{k-1}{k}}=(P3/P1)^{\frac{k-1}{k}}=(U*P2/P1)^{\frac{k-1}{k}}=U^{\frac{k-1}{k}}(P2/P1)^{\frac{k-1}{k}}=U^{\frac{k-1}{k}}(T2/T1)\Rightarrow$$

$$T3/T2=U^{\frac{k-1}{k}}T4/T1 \Rightarrow U=U^{\frac{k-1}{k}}T4/T1 \Rightarrow T4/T1=U^{1/k}$$

$$\eta=1-\frac{k}{W^{\frac{k-1}{k}}}(U^{1/k}-1)/(U-1)$$

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regarding the current turbine-generater, a efficiency formular of typical jet: $\eta=1-\frac{1}{W^{\frac{k-1}{k}}}$

(This formulat is easy to be found in Engineering Thermodynamics book or technical handbook)

W=pressure after compressor ÷ pressure before compressor

W=3 ~ 10

Estimate the theoretic efficiency; compare the two types of engines: the current engine and I proposed.

Firstly I state some premises:

1. Because the efficiency of the current compressor and turbine in current turbo-generator is very high, the below calculation ignore the energy loss in them.

2. In below analyses I assume that the portion's efficiencies are same if they have the similar function component. Meanwhile I ignore some small loss during courses.

I set a sample example with data to explain, I assume the pressures are same before combustion in the two type engines.

for the current jet: efficiency=1-1/{W^[(k-1)/k]} （ *^N means the Nth power*）

W: the pressure rate in compressor or blower; I set: W=10, k=1.4, the theoretical efficiency of the current jet is 48.2%.

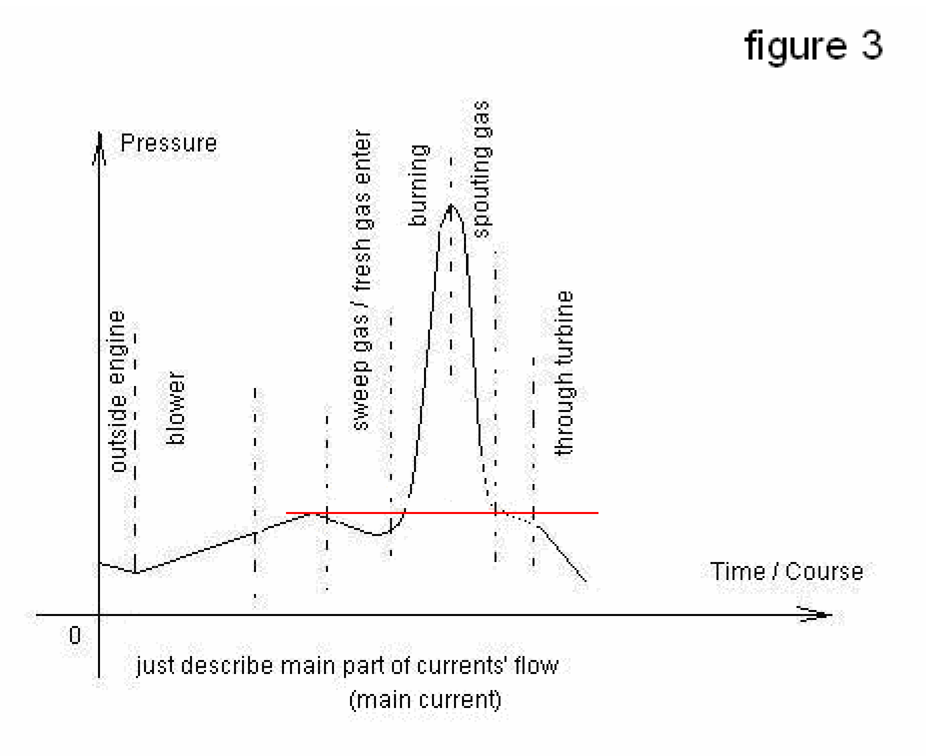
As to the new jet: efficiency=1-k*[u^(1/k)-1]/(u-1)/{w^[(k-1)/k]}

W is increase rate of gas pressure by blower. W=10; here U is the increase rate of pressure by combustion, here U=4.5;I input the data, you can see the theoretical efficiency of this closed combustion jet engine is 60%
The efficiency of the new type engine is higher than the current one by 25%.

In the example I have compare the efficiency of the two type of engine theoretically. Actually the compressor in the current engine consumes a lot of (about proportion of 2/3) energy from the burnt gas, the proportion in new engine will be much smaller (The date can be 1/4). Meanwhile the compressor's efficiency is not so high usually(the best is about 85%). So the new type of engine's actual efficiency is much higher than the current. The actual efficiency of the new type engine is higher than the current consistent pressure combustion type, expected by over 30%.

I try to explain why the new type of engine has more efficiency from another aspect, compared with current jet engine, the new engine uses up the same amount mechanical work and chemical energy but gets higher-pressure gas. The gas can make more work if its pressure is higher. So the new type engine has more efficiency.

The new engine can get higher-pressure gas because the gas pressure can increase further by the closed combustion course besides by the compressor that also is used in current jet engine.



The figure 3 shows the **gas pressure at different courses** (in different places), it is rough, and the exact details will is rather complicated. There might be a little mistake. Pay attention, the figure just shows main portion of the flow. The figures of temperature and gas velocity are more complicated,
Please pay attention, there is a red horizontal line inside the figure, it shows that the pressure at two places have some relation, against the relation the engine can't work orderly. It isn't precise in this figure.

Calculate the temperature before the turbine:

Pls see below figure 4:
The method also is used to calculate the temperature of each course. Under some condition, when the pressure

after compression is pretty high, reducing the pressure by combustion in some extent, the efficiency reduce a little, meanwhile the temperature before turbine reduce much, I state a example:

Set the temperature of outside air: 300K, k=1.4, set the pressure after compression/before compression α=7, the pressure after combustion/before combustion β=7.5, thus the temperature turbine 2206K; theory efficiency: η=60.2%; k=1.4, α=7, β=7, the temperature turbine 2100K, η=59.6%; k=1.4, α=7, β=6.5, the temperature turbine 1992K, η=58.9%; k=1.4, α=7, β=6, the temperature turbine1881K, η=58.2%; I change β by change in the volume proportion of fresh gas in each time or change of the concentration of fuel a little. In this example, η is reduced by 3%, the temperature before turbine decrease 400K.

As to the new type jet engine: (closed combustion type)

compression gas in blower/compressor(without cooling): $T_1/T_0=(P_1/P_0)^{(k-1)/k}$

combustion of mixture gas: $Q=C_v m \Delta T$ $\quad T_2 = T_1 + \Delta T$

Combustion under unvarying volume, pressure rises $T_2/T_1 = P_2/P_1$

The gas expands, flows, gets before the turbine, for convenience and some representative, I set the pressure before turbine same as it after compressor, so:

$T_2/T'_1 = (P_2/P_1)^{(k-1)/k}$

Set $\alpha = P_1/P_0 \quad \beta = P_2/P_1$

$T_2/T_1 = \beta$

$$T_1/T_0=(P_1/P_0)^{(k-1)/k}=\alpha^{(k-1)/k} \qquad T_2/T'_1=(P_2/P_1)^{(k-1)/k}=\beta^{(k-1)/k}$$

$$\frac{T_1}{T_0} \div \frac{T_2}{T'_1} = (\alpha/\beta)^{(k-1)/k} \Rightarrow \frac{T'_1}{T_0}\frac{1}{\beta} = (\alpha/\beta)^{(k-1)/k} \Rightarrow T'_1 = T_0\,\alpha\,\sqrt[k]{\beta/\alpha}$$

T_0 the temperature in outside air
T_1 the temperature after compression
P_1 the pressure after compression
P_0 the pressure in outside air
k
T_2 the temperature after combustion
T'_1 the temperature before turbine
P_2 the pressure after combustion

According to the formulation of efficiency I demonstrated before

$$\eta = 1 - \frac{k}{\alpha^{(k-1)/k}}(\beta^{1/k}-1)/(\beta-1)$$

α: the pressure after compressure /the pressure before compressure

β: the pressure after combustion/the pressure before combustion

figure 4

This example just reminds a phenomenon. The data to some parameters may not precise; actually they change in normal and very high temperature. Here I assume them unvaried. After all it is a good reference for you.

Feasibility and improvement solution:

When I firstly proposed the idea in my patent(That patent has been out of valid time), I didn't use the blower or compressor in my engine. Now I prefer to adopt the **blower/compressor** in engine before combustion after I think it over. It really has a lot of advantages.

1. Without the blower/compressor the engine may have difficulty to be started or on work in slow speed because it may not get enough air.
2. Increasing pressure of air before combustion can increase efficiency considerably.
3. Without compression before combustion, the size of chamber will be much bigger; sometimes the mixture isn't easily to be ignited.
4. Adopt compression before combustion, the engine easily to keep orderly work under a little variable situation.
5. If feasible we can add fuel in into air gradually to form mixture at the position of some portion of blower/compressor, maybe blades, or install additional device.
6. If increasing the pressure extremely high before combustion, the mixture gas might be ignited by itself. It is not safe under some case. So I have to improve the structure.

Later I have an idea. We can set the branch pipes in front of the chambers, there are a pairs or two pairs of the branch pipes(or relative space) that are corresponding to the chambers while the gas enter them. The **branch pipes rotate** with the front door, it won't cost much energy. Thus the gas before chambers always flows in high speed flow condition, Thus the gas is hard to burn, even though it will, it has entered the chambers when it burn.

The internal space of the front door becomes much large than the previous. We also can utilize the space install some devices to cool front door, separate the heat from gas by another air, is good for seal and so on.
Temporary I don't update the structure picture.

I think the biggest difficulties to realize the new type of jet engine are:
1. Some parts bear the unstable forces. I calculate and compare the several solutions to choose the best. I **change the force condition** from initial pulse force; let the parts bear pressure and pull forces alternately and the maximum magnitude of stress becomes smaller a lot. The trend of deformation became the smallest and the whole weight is the smallest. It also need to add a component, however the whole weight will be the lightest. I am not sure that the solution can be applied in each part has the situation.
2. To regulate the work procedure for high efficiency, safety, and economical is necessary but a little hard, but the jet have to work under many circumstances. The simple countermeasures are: 1. to set the **engine rotation speed within a certain range** while working. Out off the range the engine will be inefficient, even dangerous. 2. Sometimes we need to **change the proportion of fuel to air** to get different performance; the jet can work steadily without additional adjustment. Even though the volume of the fresh gas in once input changes, the jet also can work normally. 3. If necessary we can add openings or bypass on the general pipe.

As to the **components bearing the heat load in the type of jet**, I have some ideas:
1. Sometimes the chambers touch the burning gas in some position, but the rather higher temperature last a very short time. When the fresh gas enters the chambers, the chambers are cooled.
2. At some position in some components, such as inner side of the front door and back door of the chambers, they touch very high temperature gas all the time. I think out a solution: When the doors (round plates) will close, from their inner side, near the edge, discharge some fresh air to separate the burning gas to the inner side of the doors.
3. Some surfaces in some parts always touch very high temperature gas, but the stress isn't rather bad. I can choose proper structure and material on the surfaces to bear high temperature.

As to **ignite the gas in chambers,** I have three ideas. Each of them has weakness and advantage.
1. to install some instrument inside the chambers, ignite the gas at proper occasion.
2. to ignite the mixture gas at proper occasion by the burning gas from the previous chamber through the front door.
3. to ignite the fresh mixture gas by the burned gas in the same chamber at the beginning of the fresh gas entering the chambers. I think it is feasible at a certain frequency and proper original pressure.

Recently I have solution for idea 2: It is easy to realize, has enough energy to ignite the fresh gas, with small heat load to the components. The igniter is installed with the front door. Inside it the resistance wire is heated by electricity continuously or intermittently to get high temperature. A cavity inside the front door has two openings that can connect two chambers nearby at certain position. The fresh gas is ignited with flame in most case. When the front door turns to the position , through an opening of the cavity and by the gas pressure the flame will enter the chamber that just finish entering fresh gas, so the fresh gas in chamber begin to burn if they have proper condition.

In this new type of engine the **seal** is harder than the current engine, but I think it won't be very difficult. The seal in several places are by the flat surfaces, not a line. Personally I think the importance is to control the distance between two surfaces. Another aspect the extreme high pressure during these courses exist very short time. The flat surface is good to adopt a devise to control the gap of seal to get the good seal function.

In very thin tube or little gap the flame spreads much slower than it in normal space. The principle can be adopted in seal. The burnt gas with high pressure can also be filled in gap of seal to separate the flame, prevent the flame spreading inside.

The function of branch pipes behind the chambers:

When the burnt gases enter the turbine, keep their speed and pressure stable is important. It's good for efficiency and bearing load. It also can be realized. The initial condition just after combustion is same. By the branch pipes and a short time the gas from a pair of chambers has comparatively stable pressure and speed. Base on the feature, several pairs of chambers spout gas alternately and cooperate, we also can add a space behind branch pipes as buffer storage and to regulate gas before turbine, when the gas encounters the turbine, the condition is relatively stable.

Here we can see the function of branch pipes:

1. As buffer storage while the gas rush out off the chambers, to reduce the fluctuation.
2. The gas can flow in it even though the pressure in chambers isn't so high.
3. without the branch pipes, when a branch pipes spouts gas, the current will influence the sweeping gas from the branch pipes nearby. Installing the branch pipes; the course will help each other by the effect of suction.

A reader reminded me that the gas will **lost a little energy** when it runs from the branch pipes into general pipe due to the gases with different conditions from different pipes encounter. ---I admit.

It is hard to estimate that how much energy loss. What I can do is to analyze this waste's principle. I designed the branch pipes that make the gas in general pipe more stable than without the branch pipes. It has the effect of buffer storage that reduces the change of the gas condition because the gas's spouting is similar to impulse. 2. Fortunately the amount of gas from sweeping course (or the gas similar to the course) is much less than the amount of gas from the spouting course, so the loss is small. We also need to control the pressure and the direction of the velocity of gas from the different pipes, as well as the amount of the different gas.

When somebody designs the size and shape of branch pipes and general pipe actually, he should make the gas's condition spout from branch pipes varies as small as possible, and the gas stables at convergence before the turbine.

Somebody ever reminded me, the constant-volume combustion turbo-generator was proposed, devised and built many years ago. It has much weakness: the structure is too complicated, the efficiency is low. So it is replaced by constant-pressure combustion type later. (They think my engine is same to the constant-volume combustion type engine).

I replied to the query, though I call it "the closed combustion type.." my engine has different structure from those constant-volume combustion types engines definitely; meanwhile I always attempt to adopt the simplest mechanical action to realize the functions; If people who have learned the theory of combustion read the principle of my engine, they will know the combustion in my engine is not a common constant-volume combustion concept. Because the pressure and temperature rise to very high level rapidly in the combustion, **the spread speed of blaze is very high**; it is sonic or supersonic speed. Since the combustion spends little time, we needn't keep the doors of chambers closed until the combustion finish entirely. The solution is also very good for chambers to bear the varied forces. Thus the topic of the article seems not so accurate.

In recent years, in the world the fuel is always in short supply. So to study the efficiency is important. Meanwhile the level of manufacture and development new material improves quickly than before. It is more feasible and easier to realize the new jet than before. Another aspect, due to increasing carbon dioxide in atmosphere, globe warming become a big problem concerns everybody. I hope applying the new type of engine will slack up the trend.