Section 2. Transport

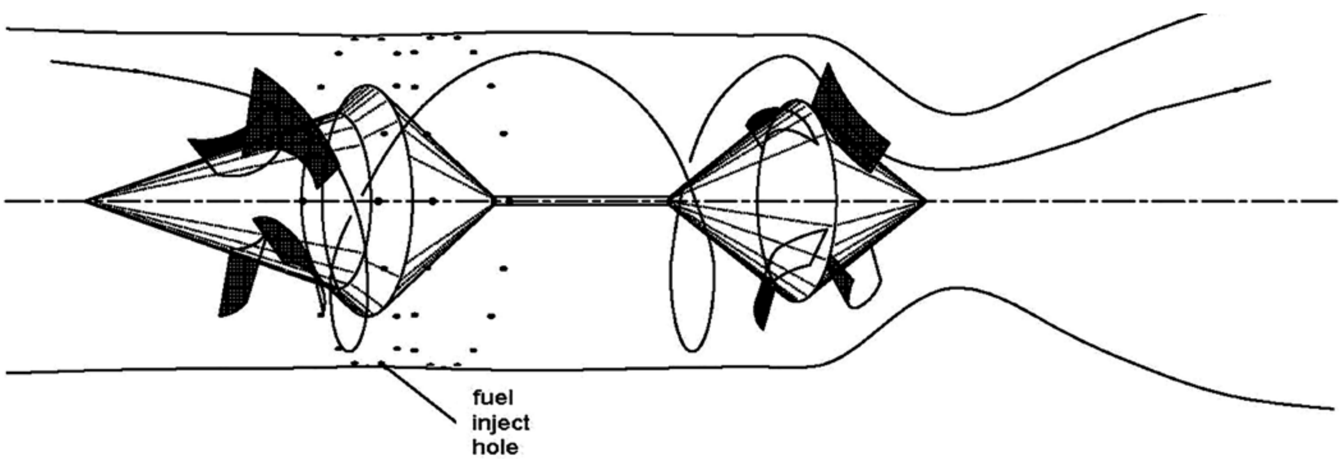
https://doi.org/10.29013/EJTNS-23-2-18-22

Gao Heng Wei,
ChaoYang, Beijing, China

THE HYPER-SONIQUE VORTEX RAMJET PROPULSION

Abstract. Apply an artificial spinning vortex in the engine, a new kind of ramjet could be made out to work from M1 to M10 by centrifugal force in theory. This efficient method can provide high quality push power for many types of supersonic vehicles. The compress course has been solved under some simplifies in this article too. Although it is simple, it's a way to have a look at the result of this special engine until more accurate solution is get.

Keywords: supersonic, vortex, spin, ramjet, engine.



Drawing 1. Concept design of spinning ramjet

The key difficulties for ramjet working would be overcomed by this amazing method: Flow through (a set of) fixed fan(s) or twisted tunnel(s), the air entering the engine with high speed (esp. M1 ~ 10) can form an exciting spinning vortex, and compress the peripheral part into high pressure and high density. This would create perfect condition for the air combine with the fuel injected into the combustor (see the drawing 1, please).

After burning, another (set of) fixed fan(s) or twisted tunnel(s) would lead the gases get rid of the spinning state back to common line flowing again. Then the gasses accelerate in an De Laval nozzle to reach its top speed and rush out the end of the engine finally.

In both of the courses the gasses return to common line flowing and accelerating in the Laval nozzle, the engine would get the power of pushing force and the more faster of the air entering, the more efficient it can works well!

Like all of the supersonic cases, some shock waves would occur besides the engine's structures, esp. near the edges of the blades of the front fixed fan(s). However, its disturbance to the engine would be secondary – since it's just a boundary surface of sudden change of the fast-flowing state (eg. the state of speed etc.). So, in order to simplify, it will be ignored the influence of the shock waves in this article.

The most urgent question is about the effects of spinning compress: Could it has a too low or too high pressure, density, flowing speed and temperature?

To answer this, the following part would simplify the spinning course and establish a set of equations for solving.

Because of the engine is designed for supersonic working, the velocity of the gas is rapid, and in comparison of this, the speed of heat transferring appears slowly. Based on this fact, the first hypothesis can be given: The fluid in spinning could be thought as adiabatic – The temperature's change would be caused by the pressure's work only:

$$Nd\left(\frac{i}{2}kT\right) = -pdV \qquad (1)$$

Moreover, the work pdv would cause the gass(es)' kinetic energy increasing. When it is the only way:

$$Nd\left(\frac{1}{2}mv^2\right) = pdV \qquad (1')$$

Combine with (1) and (1') can get:

$$d\left(\frac{i}{2}kT\right) = -d\left(\frac{1}{2}mv^2\right) \qquad (2)$$

Overall consider of the fluid's mechanics equation, the constancy of the number of particles and the gas' state function, the equations set (ref. 1) for spinning would be gained as:

$$\begin{cases} \text{momentum:} & nm\dfrac{v^2}{r} = \dfrac{dp}{dr} & (3) \\ \text{number:} & d(nV) = 0 & (4) \\ \text{state:} & p = nkT & (5) \\ \text{adiabatic:} & Nd\left(\dfrac{ikT}{2}\right) = -pdv & (1) \\ \text{energy:} & d\left(\dfrac{ikT}{2} + \dfrac{1}{2}mv^2\right) = 0 & (2) \end{cases}$$

Next is the main steps of a way to solve the set of equations, and its solution result:

Step 1: From (4) get: $\dfrac{dV}{V} = -\dfrac{dn}{n}$ (6)

Step 2: Take (6) and (5) into (1), and note that $n = \dfrac{N}{V}$. Sign:

$$C_1 = \frac{n_0}{T_0^{\frac{i}{2}}} \qquad (7)$$

The footnote 0 represent the original state (or the start state). Then could solved out:

$$n = \left(\frac{n_0}{T_0^{\frac{i}{2}}}\right) T^{\frac{i}{2}} = C_1 T^{\frac{i}{2}} \qquad (8)$$

Step 3: From (2) could get: $\dfrac{i}{2}kT + \dfrac{1}{2}mv^2 = C$

(C is a constant) (9)

Step 4: From (9): $mv^2 = 2C - ikT$ (10)

Then take (10), (8) and (5) into (3), it could be solved out at the end:

$$T = T_0 + \frac{mv_0^2}{ik}\left[1 - \left(\frac{r_0}{r}\right)^{\frac{2i}{2+i}}\right] \qquad (11)$$

The total solution result is:

$$\begin{cases} T = T_0\left\{1 + \dfrac{mv_0^2}{ikT_0}\left[1 - \left(\dfrac{r_0}{r}\right)^{\frac{2i}{2+i}}\right]\right\} & (11) \\ n = n_0 (T/T_0)^{\frac{i}{2}} & (8) \\ p = p_0 (T/T_0)^{\frac{i}{2}+1} & (12) \\ v = v_0 \left(\dfrac{r_0}{r}\right)^{\frac{1}{1+2/i}} & (13) \end{cases}$$

Especially, from the above result could still get the limit values of the spinning compression (when $\frac{r}{r_0}$ is little enough):

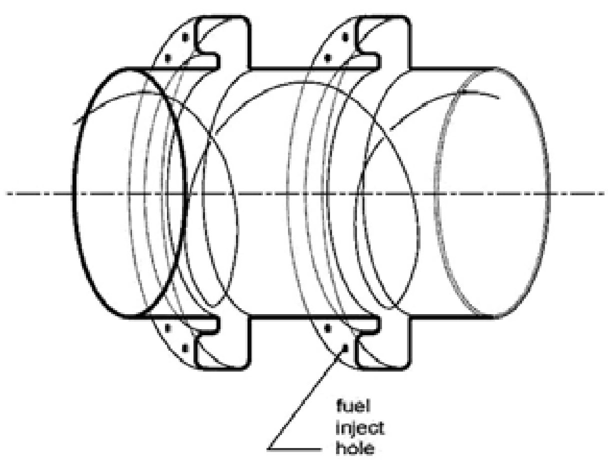
$$\begin{cases} \frac{T}{T_0}|_{\max} = 1 + \frac{mv_0^2}{ikT_0} & (14) \\ \frac{n}{n_0}|_{\max} = (1 + \frac{mv_0^2}{ikT_0})^{\frac{i}{2}} & (15) \\ \frac{p}{p_0}|_{\max} = (1 + \frac{mv_0^2}{ikT_0})^{\frac{i}{2}+1} & (16) \\ v|_{\min} = 0 & (17) \end{cases}$$

The following table is some calculation results under the standard atmosphere condition for an engine with the structure character of $\frac{r_0}{r} = \frac{1}{2}$ in different altitude and speed (the flowing along the axis is overlooked):

Table 1.

$\frac{r_0}{r} = \frac{1}{2}$, $\frac{v}{v_0} = 0.6095$, air molecule $m = 29 \times 1.667 \times 10^{-27}$ kg, $k = 1.380649 \times 10^{-23}$ J/K, i=5

H km	a_0 m/s (Sound velocity)	T_0K	ρ_0 kg/m³	p_0 10^5Pa	M_0 1.	v_0 m/s	v m/s	T K	ρ kg/m³	p 10^5Pa
0	340.	288.15	1.225	1.013	1.			339.2	1.841	1.792
3	328.58	268.65	0.9091	0.7011	3.			696.3	9.836	19.66
6	316.43	249.15	0.6597	0.4718	4.			954.2	18.94	51.87
10	299.46	223.15	0.4127	0.2644	4.5			1022.	18.55	54.44
20	295.07	216.65	0.08803	0.05475	6.			1596.	12.97	59.44
32	303.13	228.65	0.01323	0.00868	8.			2822.	7.077	57.30



Drawing 2.

Improved combustor.

In fact, this spinning compression engine isn't perfect, even though the streamlines in it are helicoid. Compare to the common flow through the engine directly, it has just lengthened the time of gasses staying in the engine several times – secα times, α is the angle between the flow speed vector and the axis line. It's still a very short period for the fuel's complete burning in the combustor with so high-speed flowing, much more of the fuel would be wasted.

To solve this problem, an efficient improved combustor could be used – it's just needs to make out one or some 'circular groove(s)' on the column surface of the combustor (see Drawing 2, please.) – which can be called as 'stationed ring(s)', and inject the fuel from the bottom or innermost space of it.

By this method, except few particles escape out through diffusion, most of the fuel injected in the groove(s) would spin there round and round until takes chemical reaction with the air rush in or diffuse inside.

Since the oxidizing agent of the engine comes from the air in the atmosphere, the total propulsive agents consuming rate of the engine would be much less than the rocket engine to produce same pushing force, let the relative specific impulse raise to near 5000.S as many air engines done. For the same reason, the craft's take-off weight to transport an unit mass of the effective load would be reduced to ~ 1/10 in the same time.

So the spinning engine could provide for a huge amount of supersonic air-space crafts an efficient kind of pushing power and save much weight for them.

Conclusion:

The solution result (formulas: (8), (11), (12), (13)) and the calculation examples all shows that: 1. The speed reducing rate of the air in the bottom of the combustor is decided by the r_0/r only. 2. If the velocity of the flight could be controlled well on different altitude, then the temperature and the pressure can be kept in fair range of the structure's material bearing ability. 3. The engine can work to a high M count (~10) finally.

Acknowledgement

To thanks: Cai Yuan Pu, Yang Gui Fen, Gao Yu Ying, Cai Feng Zheng, Wei Zhen Hua, Cai Feng Ying, Pei Feng Yun, Yang Zhen Guo, Aunt Mrs. Pei, Pei Xin Chi, Pei Yu Hua, My First Uncle, My First Aunt, Gao Yu Mei, My Second Aunt, Gao Yu Cong, Liu Zun Qing, Zhang Jing Liang, Liu Man Tang, Gao Heng Xue, Zhang Jie, Gao Heng Ge (Jane Yifei Gao), Wei Ning, Wei Wei, Zhang Zhen Jiang, Wei Liang, Xu Bao Jun, Wei Zhen Zhong, Liu Shu Qin, Wei Zhen Rong, Xu Yuan Gong, Wang Ya Lin, Wang Shu Gui, Lao Xie, Yue Quan, Mrs. Yue Quan, Mrs. Shi, Yang Lian Zhong, Wei Bing, Wei Yan, Wei Xin, Wang Gang Feng, Bi Guan Zheng, Uncle Sun, Mrs.Song, Mr. Liu, Mrs.Liu, Liu Jian Suo, Guo Zhi Chun, Wang Fu Chun, Lao Pi, Xu Bao Min, Zhang Xue Liang, Lao Li, Lao Ma, Mrs.Lao Ma, Mr. Dong, Xiao Wang, Jia Zhen He, Zhang Gui Zhen, Uncle Lao Jin, Mrs.Lian Hong, Mr. Li, Jia Yu Xuan, Peng Zu Jia, Li Tian You, Qiao Ming, Mrs.Feng, Jia Shu Min, Sun Gui Zhen, Mrs.Ma, Lao Gu, Lao Zhang, Zhang Wei Hong, Zhou Lan Xiang, Wang Jian, Xue Yi Sheng, Xu Yun Xia, Zhou Jia Lin, Zhou Guang Wen, Feng Yin Jiu, Wu De Long, Yang Min Zhen, Geng Li Xia, Ma Qi Min, Ding Qin Zhi, Li Qun Zhi, Pang Kun, Yu Yang, Zheng Run Xiang, Zheng Wen Xiang, Wang De Zhu, Mr. Du, Aunt Wang, Zhang Wen Bin, Wu Yan Qing, Ms. Liu, Xiao Jin, Mr. Lan, Li Xing Qun, Yan Dian Yuan, Qiao Chang Li, Sun Ji Tong, Zheng Wei Dong, Xong Shi Jie, Li Shuo Xin, Shen Du, Huang Wei, Wang Li, Yan Shi Ling, Yan Zhao Fu, Professor Zhou Hui Zhong, Professor Wu Wen Zheng, Teacher Xu Ning Yuan, Teacher Xue, Teacher Deng, Teacher Lan, Teacher Li Wen Li, Teacher Zhang Ying, Teacher Gu, Teacher Liu Shu Fang, Yuan Dong, Li Qi, Song Jin Song, Wang Wei, Shao Ying Cui, Cui Yu Ling, Wang Bin, Mr. Hu, Zhang Xuan, Xia Qiang, Luo Tao, Zhu Yun Yin, Cao Jian Wu, Chen Qi, Hu Yue Gui, Hu Jian He, Li Bao Fang, Xiao Zhi Yuan, He You Qing, Zhang Heng, Yang Hong, Hou Ji Yei, Chen Chi, He Yan, Li Dong Shun, Li Dong Ren, Li Dong Yi, Liu Ya Wen, Fu Qiang, Fu Liang, Wang Xue Qiang, Zhou Chun Fa, Zhang Wan You, Liu Kun, Ms. Liu, Liu Hong Xia, Li Ming

Ming, Uncle Gao Li Cheng, Uncle Cao, Xian Xin, Teacher Wang Shu Fen, Aunt Mrs. Wei, Aunt Mrs. Shi, Aunt Mrs. Huang Yun Xia, Aunt Mrs.Qiu, Aunt Mrs. Yang, Feng Ming, Peng Qi Gui, Mrs.Guo, Mrs.Jiang, Mrs. Jia, Mrs.He, Mrs.Gao, Mrs.Wang, Mrs Ma, Ms. Zhu, Lao Xu, Lao Deng, Mrs.Liu, Lao Zhao, Lao Wang, Mr. Zhang, Mrs.Wang, Mr. Li, Mr. Ju, Mr. Wang, Mrs.Xu Wen Zhen, Xu Jing Long, Mrs.Ma Dong li, Mr. Fu, Mr. Wan, Mrs.Yu, Uncle Yan, Uncle Zhang, Uncle Li Chang Feng, Uncle Liu, Zhao Jin Ling, Zhao Mei Ling, Meng Xian Rui, Mr. Li Sheng, Mr. Zhang Yu, Mr. Zhang Yin Jiang, Mr. Zhi Chun He, Mrs. Liu Shu Fang, Mr. Xiao Wang, Li Jie, Mr. Wu Xiao Fang, Mr. Wu Jian Qiang, Xiao Wang, Mr. Wang, Mrs Lian Hong, Sun Jian Jun, Mrs.Shu Xiu Ling, Mrs.Ma Dong Li… and all the persons used support to me.

References:

1. Gao Heng Wei. The Field's General Dynamic Equation And Some Applications. Young Scholars Journal No. 4–5.2021. URL:https://doi.org/10.29013/YSJ-21-4.5-39-42 Czech Republic. © Premier Publishing s.r.o.