Development and Fabrication of Liquefied Nitrogen Draw Pump

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1.Purpose

Most conventional LN2 turbine pumps are very expensive large scale devices in which their motor parts have been established in room temperature. The device we are currently developing has its entire drive part contained within the LN2 and compared to other conventional devices,it is smaller, lighter and less costly.

2. Motor

We consider the durability in the whole liquid nitrogen,and used a brushless DC motor (that has no contact surface) and miniaturized by a power supply circuit. In addition, we use a bearing of low temperature use. As the result, the durability largely improved.

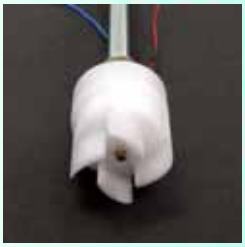
Voltage	7	[V]
Ampere	0.18	[A]
turns	2200	[rpm/V]

Pic1. Motor

3. Turbine Blade

Adding to the production of a low cost device, the shape of several types of screws were tested as shown below.

★ the thing which it is easy to be comparatively available
★ the thing that processing is easy
①A handmade turbine (pic2)
②A turbine blade of a CPU fan (pic3)



Pic2. A handmade turbine

Pic3. A turbine blade of a CPU fan

Work (W_E) which a turbine (a motor) gave liquid nitrogen is

$$W_E = N\times\{\int(2\pi r)d\,dr\}\,\rho g$$
$$= N\,\pi\,\rho g\,n\,d\,(r_2^2 - r_1^2)$$
$$= 7.94\times10^{-2}\quad [J\cdot s^{-1}] \quad \cdots \quad (3\text{-}1)$$

In addition, theoretical flow quantity (J) which is calculated

$$J = 9.83\times10\text{-}2\ [l\cdot s^{-1}] = 5.90\ [l\cdot m^{-1}] \quad \cdots \quad (3\text{-}2)$$

N	Number of blade	(= 7)
n [cps]	turns	(= 256)
d [m]	Thickness of a blade	(= 6×10^{-3})
r_1 [m]	The blade inside diameter	(= 11×10^{-3})
r_2 [m]	The blade outside diameter	(= 19×10^{-3})
ρ [kg·m^{-3}]	Liquid nitrogen density	(= 8.07×10^{2})

4. Shape of Cover

The internal shape of the case greatly influences pressure loss. We produced it and tested several kinds shape with aluminum from a problem in processing.

Than the energy income and expenditure

$$W_E - \rho Vg - 8\nu J/\pi a^2 = 0 \quad \cdots \quad (5\text{-}1)$$

It suppose to be column form for simplification of a calculation, and assume it $V = \pi a^2 h$

$$h = N\,n\,d\,(r_2^2 - r_1^2) / a^2 - 8\nu J / \rho g\,(\pi a^2)^2 \qquad 6.45\text{m}$$

ν	[10^{-6}m^2·s^{-1}]	LN_2 viscosity
a	[m]	Cover inside diameter (= 20×10^{-3})
V	[m^3]	Volume
h	[m]	lift

Pic4. Motor Case

Pic5. Motor Case (inside)

5. Conclusion

As a result of our testing, an approximate lift of 60cm was produced by energy loss due to a resistance, such as a bearing of a motor of a case.

Pic6. result

★Future obstacles to overcome:
・Plan optimization of case shape including motor.
・Continue to run and calculate discharge.
・Miniaturise to the degree to fit it in a compact container.
・As well as nitrogen, improve by utilizing LHe, LH2 with attention to fuel purposes.