The Flight of Paper Planes

Prefectural Kobe High School First grade Kano,Saeki,Shinohara,Doi,Hisamoto,Miyake

I. INTRODUCTION

We asked three questions about paper planes to our high school students, and 29 of them answered. As you can see Table 1, 68% of respondents have felt, “Playing with planes is boring because it flies a short distance.” And all of them answered, “If we had known how to make a plane which flies a longer distance, playing with a plane would be fun.”

So, we decided to study about the way to make a plane which fly a long distance.

Table 1 The result of the questionnaire which we conduct in our class (29 people answered)

Questions	Yes	No
Have you ever played with paper planes?	28	1
Have you ever felt boring because paper planes didn’t fly as long as you want?	19	9
Will you want to play with paper planes if you know how to make them fly longer distance?	29	0

II. OUTLINE

We thought that planes’ shapes are involved in the distance they fly and studied about their relations. Actually we launched planes, and understood the difference of each plane’s distance and studied the relation with the air pressure that is applied to the wing and its effect on trajectory when planes fly. We considered the characteristics of the plane which had the longer distance result.

III. HYPOTHESIS

We thought that the flight distance is influenced by the lift and reaction of the main wings. So we expect that large main wings let the plane fly longer distance.

IV. METHOD

In this study, we experiment in three ways with the Heso Plane, the Ika Plane, the Noshiika Plane, the Yari Plane, the Jet Plane, and the Guinness Plane which holds the Guinness World Record. (Figure 1, Reference 2 and 3)

Experiment 1; Measurement distance of each plane in the real world

By using launching pad (Figure 2) powered elastic energy, we launch planes and measure distance from launching pad to landing point. We launch planes from 109cm above the ground and give them an angle of attack of 40 degrees and initial velocity 4.78m/s .We measure the flight distance 50 times for each plane. We use kent paper (A4, 210g/m^2) to make a plane.

Experiment 2; Atmospheric pressure measurement around each plane with 3D thermo-fluid analysis software

We apply the wind to each plane in Flowsquare+ and measure the atmospheric pressure which works on the main wings. We thought that we could believe Flowsquare+ because it had been used in the Reference 1.

Experiment 3; Flight trajectory measurement of each plane

We think about trends of flight trajectory of each plane and make a figure of one trajectory witch follows the trend.

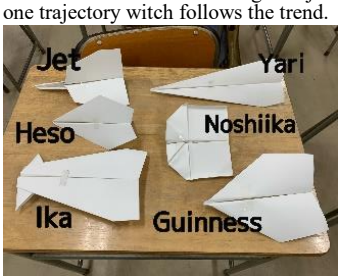

Figure 1 The shape of each plane

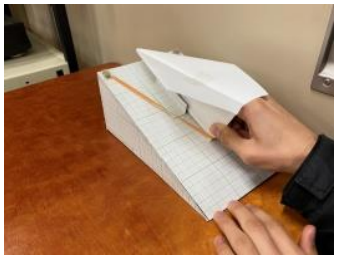

Figure 2 How to use the launch pad

V. RESULT

Experiment 1

The results are shown in Table 2.

Table 2 Measurement result of flight distance (m)

Name	Heso	Ika	Noshiika	Yari	Jet	Guinness
Maximum value	10.0	15.7	9.41	14.2	9.47	10.3
Minimum value	7.22	8.92	5.27	10.3	5.66	6.59
Standard deviation	1.5	2.5	1.5	1.5	1.0	1.3

Experiment 2

The air pressure became like Figure 3. The blue part has low air pressure. On the other hand the red part has high pressure. Therefore the force is generated from the red part to the blue part.

Gas speed became like Figure 4. In the blue part the gas speed is low, so air pressure is high. On the contrary, the pressure becomes smaller in the red part. Therefore, the power is generated from the blue part to the red part. (Only those used for consideration are listed)

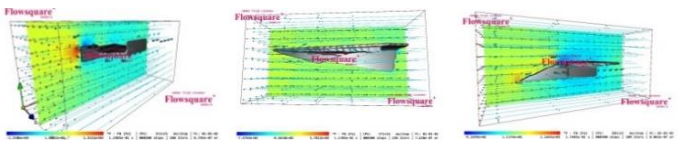

Figure 3 Measurement result of air pressure around each plane (From left to right Noshiika, Yari, Jet)

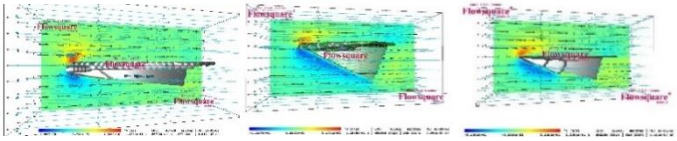

Figure 4 Measurement result of gas speed around each plane (From left to right Guinness, Ika, Heso)

Experiment 3

The result became like figure 5.

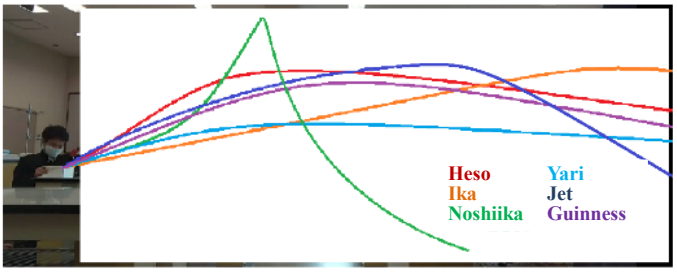

Figure 5 Trajectory during fright of each plane

VI. CONSIDERATION

We considered about the cause of the result of Experiment 1 from the result of Experiments 2 and 3 about each plane.

Ika

From Figure 4, the gas speed at the upper part of a point of Heso and Guinness main wing was about 1.00. But, Ika was about 2.00. So Ika’s speed was twice as fast as Heso and Guinness. In fact, many Ika’s launches just after we shot them. That's why there were variations in flying distance. Also, we thought the reason why Ika flew once at 15.7m is a large lifting power worked to the plane well.

Noshiika, Jet

From Figure 3 and 6, the front part of Noshiika's wing has an upward force, and the center part of Noshiika's wing has a downward force. Therefore, Noshiika faces upward. On the other part, the front part of Jet's wing has a downward force, and the center part of Jet's wing has an upward force. Therefore, Jet faces downward. Accordingly, Noshiika and Jet didn't fly a long distance.

Yari

From Figure 3, Yari's wing has little force. Therefore, Yari is free from unnecessary force, so it can make use of the launch pad force. Accordingly Yari flew a long distance.

Heso, Guinness

From Figure 4, these two types of planes have similar force. And from Figure 5, these flight paths are also similar. Therefore planes which make similar flow of gas fly in similar flight paths.

Each of the four types of planes with a long fright distance has a swell made by folding a piece of paper under the main wing. We thought that this is because the lift is made by changing the direction of the gas that hits from the direction of downward travel.

VII. SUMMARIZE

According to the consideration of Noshiika and Jet, if the pressure is strong or weak specifically at a part of the wing, a plane flies a short distance. And a plane flies a long distance by folding the paper to make swells under the wings.

It was a point for improvement that we couldn't find the reason of why Guinness didn't fly long distance.

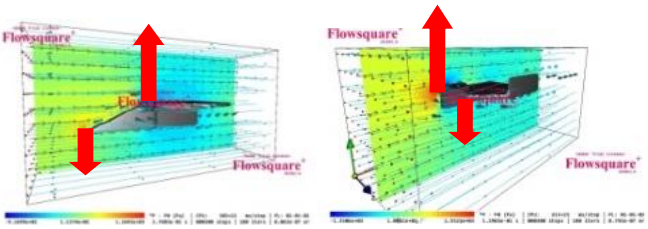

Figure 6 The force which works on planes (From left to right Jet, Noshiika)

VIII. REFERENCE

1.航空実用辞典 http://www.jal.com (As of 2021/1/26)
2.図解で簡単！紙飛行機 https://ikujist.com (As of2021/1/26)
3.紙飛行機の折り方 https://handmade3.jp (As of 2021/1/26)
4.Flowsquare+ https://fsp.norasci.com (As of 2021/1/26)
5.堤博貴・伊藤音矢 テクスチャ付きしゅう動面における潤滑油流れの可視化と摩擦特性に与える影響 日本機械学会関東支部総会講演会講演論文集 2016/3/10