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Research Article

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Analysis of the CFD study of skiing curve slide way phase pneumatic freestyle athletes

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ABSTRACT

In order to study and analyze the aerials freestyle athletes in the curve slideway stage of the aerodynamic characteristics, the parameters for the calculation of aerodynamic characteristics using the introduction of the speed of time. By analysis of the CFD method using the technique of Chinese aerials of freestyle skiing athlete Xu Mengtao. The results show that: in the curve slideway, the lift is very small, can be neglected, but because of the relatively large resistance can't be ignored. When self gravity resistance and athletes of the tangential component is overlapped, sliding speed athletes will decay rapidly. In addition, in order to improve the athlete's movement in the left platform stability. Athletes should be kept away from the vortex region is formed in the slope and vertical wall corner off the platform.

Keywords: Freestyle Athletes; Curve Slideway; CFD

The aerial of freestyle skiing is the Winter Olympics standing event. Xiaopeng Han, Chinese athlete won the gold medal of the event in the 20th Turin Winter Olympics and achieve the gold medal zero breakthrough about snow events in history of the Winter Olympics. Aerial of freestyle skiing is composed of slipping, taking off, launching turn and falling to the ground. In the game, athletes take off from the height of about 4m platform and complete a series of turn in falling process after launching the height of about 15m and finally land in 37° slope stably. The granding of freestyle skiing aerials is mainly based on the completed quality of launching turn and landing phase. So the related research both here and abroad more concentrated upon the launching turn and landing phase and there is little attention to slipping and taking off phase. A perfect taking off can provide enough launching height and stability for completing launching and turn and slipping stage is the key to guarantee the perfect taking off. In slipping stage, athletes will shift their position from stances like horse riding step to jumping position, straight up arms and the body upright. As shown in Fig.1 (in the curve slideway, athletes basically keep the position shown in Fig.2). It plays an important role in completion a high-quality taking off to control slipping phase, especially the aerodynamic characteristics in the curve slideway period. There are no perfect reports here and abroad because of the bad environment, experimental means and testing technology limited. With the rapid development of computer hardware and software technology, CFD has become complex fluid flows, even the main methods and means of study on the fliud-structure heat and mass transfer. In this essay, adopt the concepts and methods of CFD to study the aerodynamic characteristics of Chinese freestyle skiing aerials athletes in the curve slideway period, so it will reach a basis for simulating of motion process of athletes slipping stage.

1. Athletes three-dimensional entity model and CFD model

The athlete materialization model has been restricting the freestyle skiing slip stage the bottleneck of the aerodynamic characteristics for CFD study. According to the theory of reverse modeling, the Application of Laser Scanning Technology Mengtao Xu in the Three-dimensional Human Body Model in our country, the windward surface projection area of athletes is 0.676935m^2) ,get up to more than 20 points of point cloud data, In the 3D design software

integrated by small plane modeling, to repair the broken surface and materialization process set up the three-dimensional entity model of the athletes(Athletes surface is divided into 87 seamless connection surface). As shown in Fig.2.

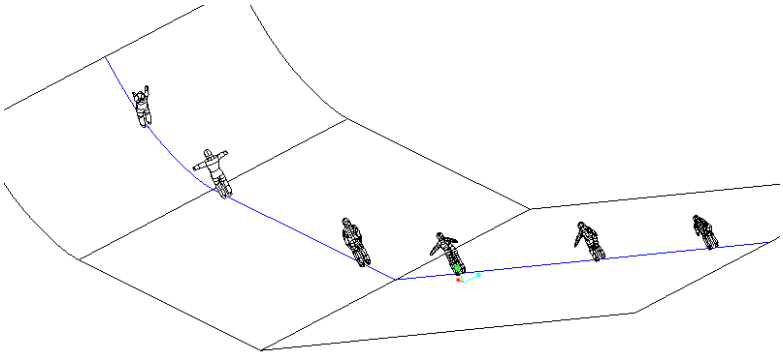


Fig.1 Athletes posture slideway evolution diagram

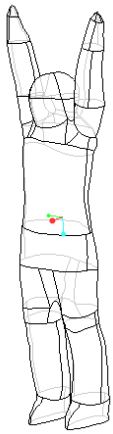


Fig.2 athletes physical model

The freestyle skiing slope is consisted by plummeting, straight and curve segments. The curve equation of curve segment is little detailed reported in the literature at home and abroad. According to the measured results by polynomial fitting to get the help of ramp curve equation for the curve segment:

$$y = a_1 + a_2 x + a_3 x^2 + a_4 x^3 + a_5 x^4 + a_6 x^5 \qquad \text{(Formula 1)}$$

Type in:

$$a_1 = 0; a_2 = 4.4\times10^{-2}; a_3 = 1.3\times10^{-5}; a_4 = 5.4\times10^{-8}; a_5 = -1.6\times10^{-11}; a_6 = 1.6\times10^{-15}$$

Finally, using 3D design of insert/merge and inheritance function module, the space model of athletes about the flow field around was established（for save computational cost, in addition to the ways of plummeting）.Seen from Fig.3, slide for the athletes to the section curve of 6.752 m at the time of the flow field around the space model（point of curvature radius of 3.09 m, at that point slide tangent plane and horizontal plane Angle is 117.291 °）.

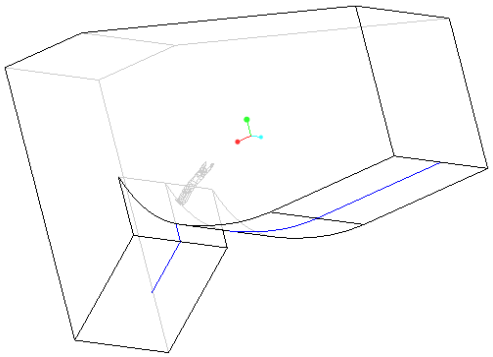


Fig.3 CFD computing model

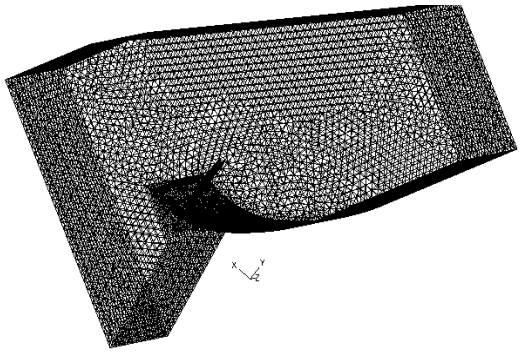


Fig.4 Schematic diagram of grid division

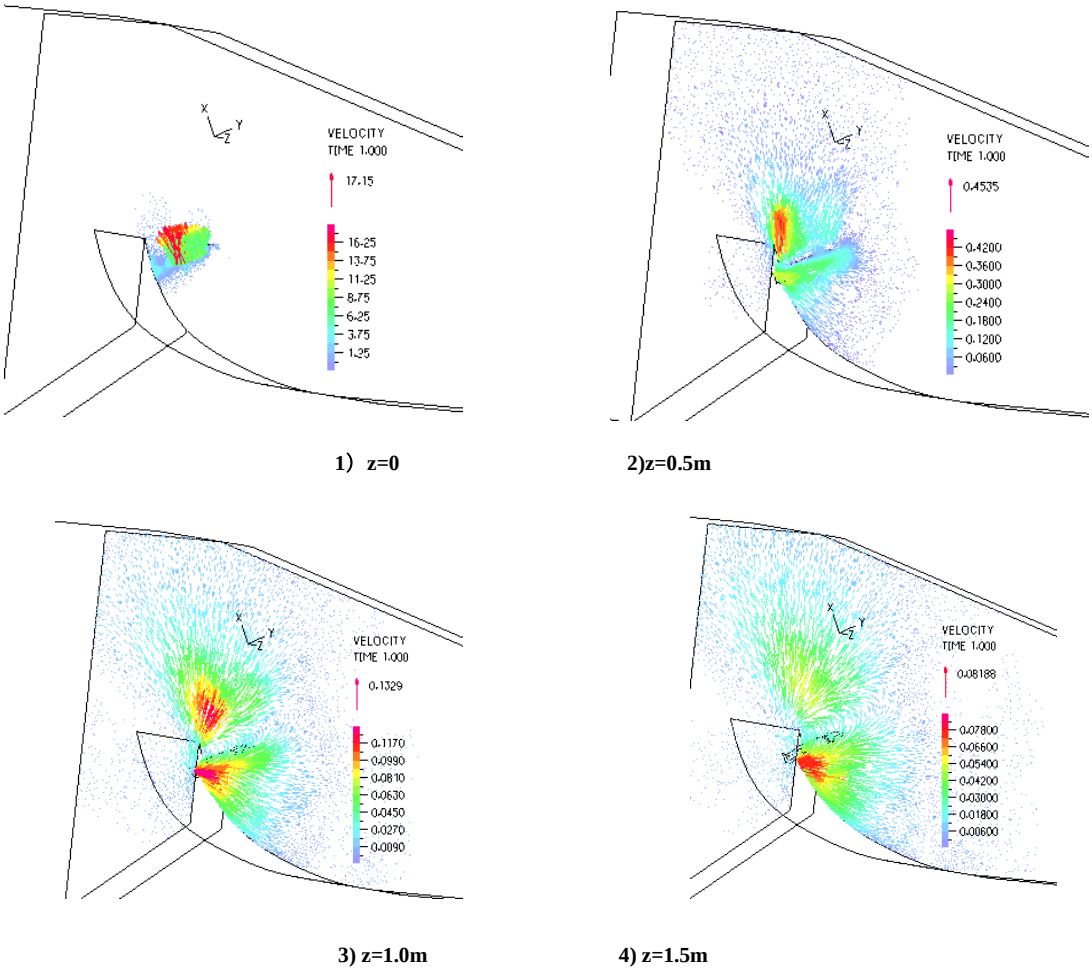
2. CFD simulation research

The air power is applied to the pressure and friction force of athletes, the resultant force can be obtained by solving the flow field around athletes. Because of the complicated shape and large athletes sliding speed, so the flow field around the athletes will be for the turbulent flow field. In a variety of turbulence model chose k—ω SST turbulence model, the finite element method to solve the turbulence model equations. Seen from Fig.3 and Fig.4, the flow field around a space model of meshing（more than 320,000 is divided into four nodes tetrahedron element）after the meshing diagram. Considering the close to the player within the boundary layer on the surface of the larger velocity gradient and the uneven surface of the athletes, meshing specially in athlete encryption is on the surface of the grid. Athletes in the program and ski slopes were defined as not penetrate the surface of the wall (including athletes for mobile wall surface), The rest of the surface is the surface of the open (consistent with the actual).Assumes that the environment

temperature is 20 temperature below zero, the air density and dynamic viscosity were 1.395kg/m^3、1.62×10^{-5}Pa·s. And the difference of linear slide athletes in the translation is that in the curve track athletes are turning around its instantaneous center. The instantaneous center is changing the curvature of the curve track centre.

RESULTS AND DISCUSSION

The circle flow field around an athlete was calculated at the angular velocity of 6,7,8,9,10,11,12 degrees / sec. Fig.5 shows the number of longitudinal profile velocity distribution when the angular speed of 8 degrees / sec (where the longitudinal profile of z = 0 and athletes' median coincide plane vertical plane).



1) z=0 **2)z=0.5m**

3) z=1.0m **4) z=1.5m**

Fig.5 Longitudinal velocity vector diagram

Seen from Fig.5, velocity distribution in each longitudinal profile showed a non-uniform characteristics , although athletes' sliding speed is large, the walls except snow road are open, so that the air volume flow rate that the athletes taking around are minimal in terms of sliding speed .When the athletes near the end of the chute, influenced by player driven, it will form air flowing in the same direction with athletes' sliding speed in the region of a space that athletes will participate in and form eddy current in the upcoming slopes and Angular domain vertical walls .

Fig.6 and Fig.7 shows the curves equations which are about the relationship between athletes lift and drag obtained by polynomial fitting and the sliding speed.

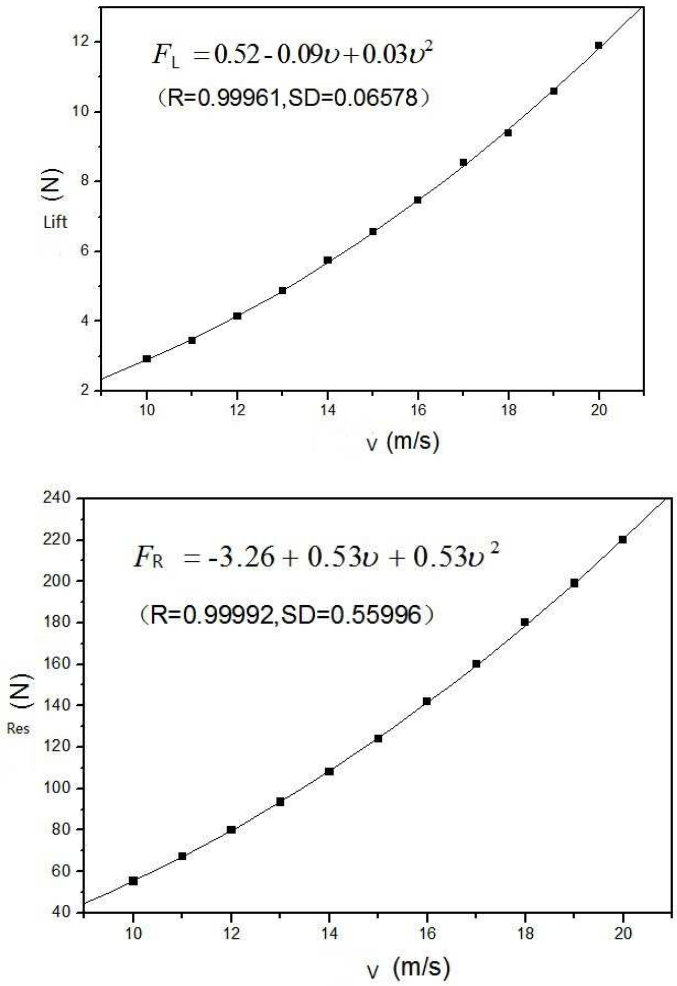


Fig.7 Curve and equation between resistance and sliding velocity
(Note: figures 6 and 7 in the R correlation coefficient, SD as the standard deviation of the fit)

Seen from Fig. 6 and 7, both lift and drag sliding velocity increases as the athletes and non-linearly increases , the curve is concave , and therefore with the sliding speed increases athlete , increased lift and drag , the faster the lift resistance is concerned than an order of magnitude smaller . athletes slide to the area , if the sliding speed of 20m / s, from Figure 6 and 7 shows , drag and lift of approximately 220N and 12N, at which point its own gravity (with the securing fitting) of the tangential and normal components of approximately 548N and 283.07N. Visible, lift compared to the component itself in terms of gravity was much smaller, so that the lift can be ignored. The friction between the skis and the slide is mainly due to the component of gravity and centrifugal force caused. Resistance is the tangential component of gravity rather , a strong air resistance and gravity tangential component of the double effects , athletes tangential acceleration up -12.2m / s, so athletes slide sliding speed at the end of the curve will decreased rapidly.

CONCLUSION

According to the theory of the reverse modeling, based on the created entity model of freestyle skiing aerials in the curve slideway period, we have created the space model of flow field within 3D virtual design software and simulated the there were effectives in study on the aerodynamic characteristics of freestyle skiing aerials slipping phase with CFD. The results show that: Athletes should try to keep away from the eddy zone formed by the slope on leaving platform and the angle area of the vertical wall and made against the stability of athletes' movements on leaving platform. At the end of the curve slideway, the influence of friction between skateboard and slideway by lift could be neglected. The air resistance is similar to own gravitational tangential component, so it will have a large tangential acceleration and sliding speed will decay rapidly. If athletes want an enough leaving platform speed, besides raising the starting height properly, still need to try to reduce own weight and front face area.

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