Pitch Control for a Semi-track Air-cushion Vehicle Based on Optimal Power Consumption*

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In order to improve the crossing-terrain ability of the vehicle on soft terrain, a new type of combined vehicle, semi-track air-cushion vehicle, was developed. With the help of frequency converter the load distribution between the track and vehicle body can be realized properly. As long as the air-cushion force exerted by fan is big enough, load distribution ratio, which is a ratio of air-cushion force divided by total vehicle weight, can be acquired from zero to one. That means the relationship between vehicle and ground can be changed from full touch to full float.

But if we treat the air-cushion force as one force we can find from the early studies that the semi-track air-cushion vehicle has pitch effect with the change of the ground condition and driving status. So it is necessary to split one air-cushion force into two. We divided one air-cushion into two to produce extra anti-lift and anti-dive torque. And each air-cushion has unchangeable air passage and changeable air passage, as shown in Fig.1. The air through changeable passage is controlled by two DC motors separately.

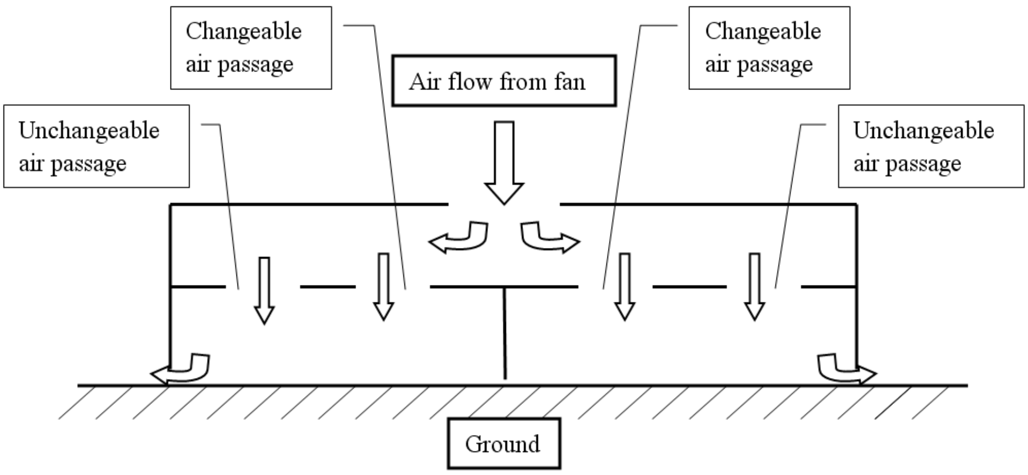

Fig.1 Air flow demonstration in semi-track air-cushion vehicle

It is clear that the vehicle body can be controlled stably. And early studies also

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show that total power consumption of semi-track air-cushion vehicle is a problem and can be significantly affected by load distribution ratio. So we have to get a balance between the pitch control and total power consumption.

In this paper, a pitch controller, based on the optimal power consumption, is developed for our future physical prototype as shown in Fig.2.

(1) Optimal power consumption is calculated according to the driver command and the ground condition. Then we will get a desired load distribution ratio (δ_d).

(2) Distribute the total air-cushion force to front and rear sub-air-cushion force using sequential quadratic programming (SQP) algorithm.

(3) Control the semi-track slip ratio to get ground support force and desired vehicle acceleration.

By minimizing a quadratic cost function J (Eq. 1), which contains weighted combination for different performance requirements, the air-cushion forces are optimally distributed.

$$J = E^T W_E E + \Delta u^T W_{\Delta u} \Delta u + u^T W_u u \quad (1)$$

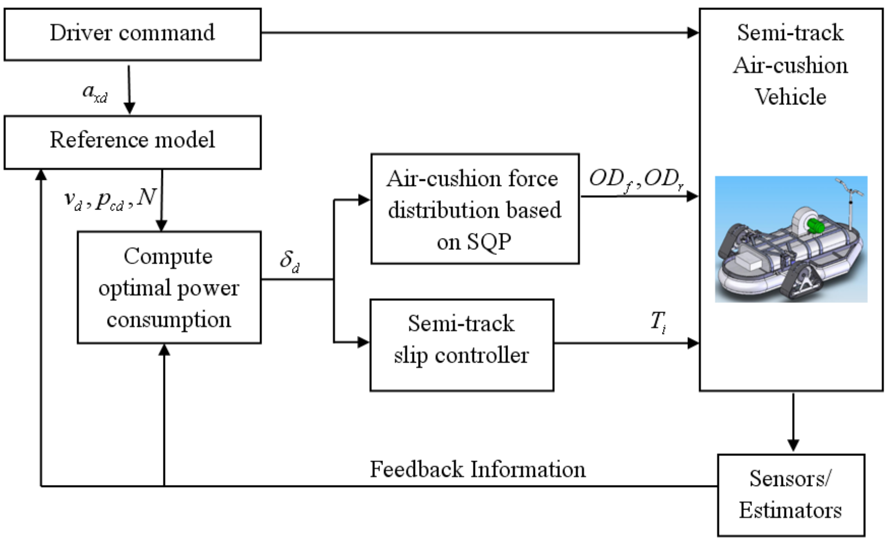

Fig.2 Pitch control framework for semi-track air-cushion vehicle

The proposed controller is evaluated through the co-simulation between Matlab/Simulink and the multi-body dynamics simulation software ADAMS/View. Results show that, with the trade-off control method and the controlled changeable air passage, the vehicle body can be stabilized and at the same time total power consumption is limited to an acceptable range. Therefore, the performance of the semi-track air-cushion vehicle is improved.