THE STUDIES OF FLOW MECHANISM AND SUPPRESSION OF WING ROCK MOTION FOR WING/BODY MODELS WITH BOTH LOW- AND HIGH-SWEPT WINGS

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Summary The studies of flow mechanism and suppression of free wing rock motion for wing/body models with both low and high swept wing have been carried out in low speed wind tunnel. Wing rock motions are dominated by forebody asymmetric vortices only for model1 and by two pairs of asymmetric vortices from forebody and wing for model2 respectively. Based on correlation of tip perturbation and forebody asymmetric vortices both rock motions can be controlled by tip perturbation rotating and turning it from 90^o to 0^o respectively.

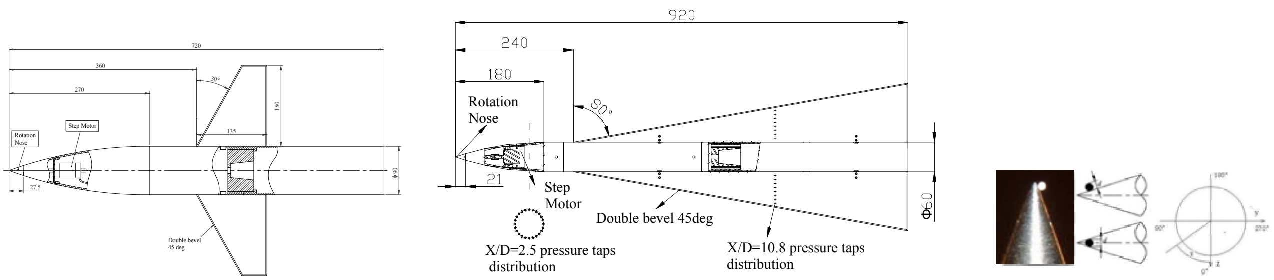
INTRODUCTION

Wing rock phenomenon of the aircraft would usually occur at high angles of attack [1, 2]. Wing rock could be induced by the leading edge asymmetric vortices from slender delta wing alone and has been studied intensively [1, 2]. Brandon and Nguyen [3], however, found that a wing/body model with a low swept wing (λ= 26 deg) could also exhibit free wing rock. Wang and Deng et.al [4] have studied it recently and found that such wing/body rock is mainly induced by forebody asymmetric vortices. And the tip perturbation dominates the forebody asymmetric vortices flow and it makes wing rock pattern is non-deterministic. So that is reason for setting artificial micro-perturbation on tip of model to get determinacy of asymmetric vortices flow and wing rock pattern [4]. From previous results, the present paper will study whether the tip perturbation could control the wing/body rock motion regardless of wing swept angle low or high based on the flow mechanism generating wing rock motion?

EXPERIMENTAL PROCEDURE AND TEST RESULTS

Experimental models and test conditions

Two testing models of wing/body configuration with low-30^o and high-80^o swept wing as shown in Fig.1 have been tested in D4 low speed wind tunnel at BUAA in China. And a micro- artificial perturbation ball was attached at model tip as shown in Fig.1c) for determinacy of forebody asymmetric vortices. The wing rock tests were performed at angle of attack range from 0^o to 70^o and the Reynolds numbers based on body diameters are 1.53E05 and 1.06E05 respectively, at which the forebody asymmetric vortices are all under the subcritical Reynolds number regime.



a) Model1 with low swept wing b) Model 2 with low swept wing c) tip perturbation

Fig.1 Testing models and tip perturbation

Test results and discussions

(1)Model1 wing rock motion behaviours, flow mechanism and its control technique The results in the past studies[4] have been shown that the wing rock of model1 is induced by forebody asymmetric vortices only and determinacy of rock motion can be made with adding an artificial micro-perturbation on model tip. During free rock motion of model1,

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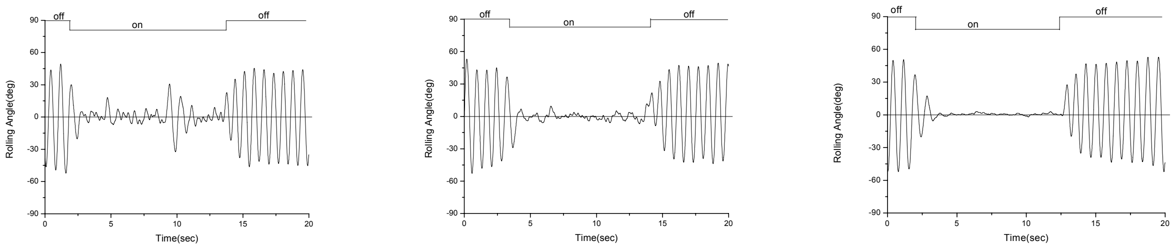
rock motion of the model and forebody asymmetric vortices with accompanied driving roll moment are in self-adaptive state. That means the model has “enough adaptive” time to make rock motion with certain amplitude under driving roll moment induced by forebody asymmetric vortices. If the self-adaptive oscillation of tip perturbation of model1 is

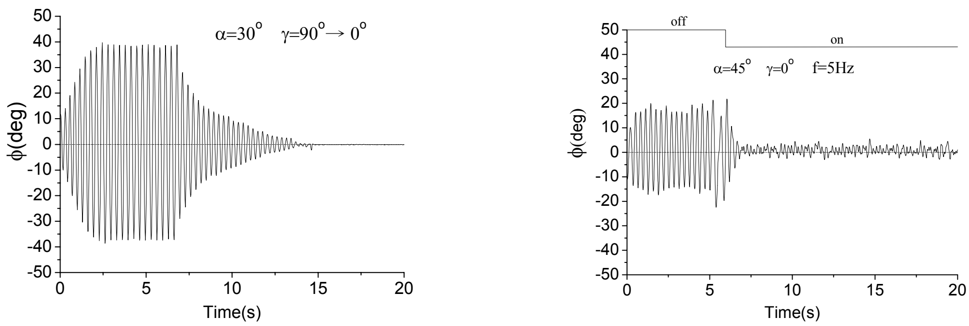


(a) tip perturbation frequency 3Hz (b) tip perturbation frequency 4Hz (c) tip perturbation frequency 6Hz

Fig.2 Control effect of roll motion by forced rotating tip perturbation and its frequency effect

destroyed with forced rotating tip perturbation by stepping motor inside model as shown in Fig.1a) and if its rotating frequency is higher than free roll frequency 1.375Hz, the free roll motion is suppressed as shown in Fig.2. And the higher rotating frequency of tip perturbation is, the smaller amplitude of wing rock of model is as shown in Fig.2. It means that the time of driving roll moment induced by asymmetric vortices becomes shorter therefore the roll amplitude will be reduced as shown in Fig.2.

(2)Model2 wing rock motion behaviours, flow mechanism and its control technique Present results indicate that the patterns of free rock motion appear two regimes in whole testing region of angle of attack α: 1) In the region of $\alpha \approx 25^o$–40^o, free rock motion is dominated by two pairs of asymmetric vortices one from forebody and another from high swept wing. If two pairs of asymmetric vortices are in phase coincidence, it makes wing rock stronger while they are in phase reversal the wing rock becomes weaker. Testing data show that if the circumferential angle γ of artificial micro-tip perturbation is 90^o, they are in phase coincidence and if $\gamma=0^o$, they are in phase reversal. Therefore in order to



(a) tip perturbation control in region of middle α (b) tip perturbation control in region of high α

Fig.3 Tip perturbation control effect on wing rock motion of model 2

suppress the free wing rock motion the tip perturbation is simply turned from $\gamma=90^o$ to $\gamma=0^o$ and its effect is obvious as shown in Fig.3a). 2) In the region of $\alpha \approx 45^o$–55^o the free rock motion is dominated by forebody asymmetric vortices only. Therefore the control technique in this region is similar to one of model1, and forced rotating tip perturbation by stepping motor inside model can easily suppress wing rock motion as shown in Fig.3b).

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