How the Rip Entry Allows Divers to Reduce their Visible Splash

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Summary

Competitive divers who produce little to no visible splash receive higher scores. To accomplish this divers use the rip entry maneuver – performing a somersault after impact. We use experiments with a single jointed geometrically simplified diver model to show that by changing shape and trajectory after impact divers are reducing the depth of pinch off and thus their visible splash. These results explain how the rip entry works and can be used to help divers increase their consistency.

Introduction

When an object impacts water with a large enough velocity it creates a splash. The final visible splash results from the entrained air cavity collapsing, the splash height correlates with the pinch off depth and impact velocity [2-4].

Divers must limit this splash to receive higher scores so they perform the rip entry after impact. By performing the rip entry divers are rotating their body in a somersault after impact and altering the shape and size of the entrained air cavity [1]. In this presentation we consider how the shape change affects the splash formation.

Methods

We develop a geometrically simplified single jointed diver model that performs a passive roll after impact with the free surface. The time to complete this deformation is controlled by the asymmetric wedge size, hinge stiffness, and impact velocity. We drive the diver model into a pool of water using a dropping cage at impact velocities between 2.1 and 4.5 m/s. We capture the impact with a high speed camera (5150 fps) and analyze the images for impact velocity, deformation, pinch off depth, and splash.

Results and Discussion

The arms of the hinged diver models rotate forward after impact with the water (Figure 1a). The time required to complete this deformation is dependent on the model geometry, hinge stiffness, and impact velocity.

Figure 1a and b show the impact for a hinged and fixed diver model with identical Froude numbers (2.43) and asymmetric wedges. At 0.057s after impact we see that the hinged model has almost completed its deformation and the entrained air cavity has re-attached to the model's legs. While the air cavity for the fixed diver model is still attached to the edge of the asymmetric wedge. There is also a difference in the shape of the entrained air cavity. The cavity for the hinged model has more of an hourglass shape while the fixed model has more of a wedge shape.

We performed experiments with fixed and hinged diver pairs for four asymmetric wedge angles. This allows us to understand the influence of deformation time. The results for all tested models are reported in Figure 1c, where we have plotted the pinch off depth and Froude number. These results demonstrate that the pinch off depth increases with increasing impact velocity for both model types.

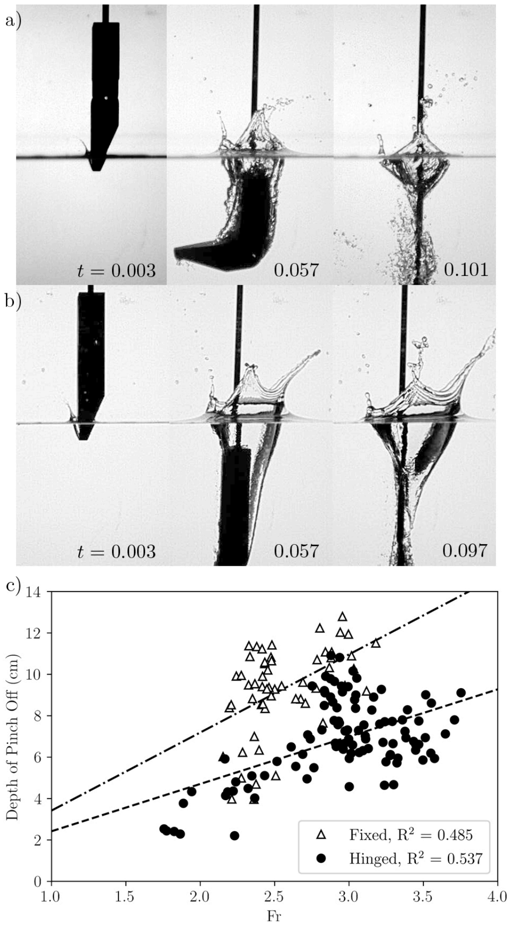

Figure 1: Example impact of (a) a hinged and (b) a fixed geometrically simplified diver model. (c) Plot of pinch off depth and Froude number ($Fr = u/\sqrt{gL}$) for all tested diver models.

It also shows that the pinch off depth is shallower for hinged models at all tested impact velocities. The time series in Figure 1a and b show the moment of pinch off for both models, and demonstrates how the upper cavity is smaller for the hinged model than the fixed model.

Conclusions

Divers reduce their pinch off depth by performing the rip entry maneuver. Our results demonstrate how the shape change allows for the air cavity to re-attach to the legs of the diver thus changing the characteristic length scale for splash formation. We show that the pinch off depth reduces by half for our hinged divers compared to the fixed models across impact velocities. We compare our results to those found for other non deforming entry bodies in the literature to show how divers change the characteristic length scale for splash formation.

References

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