

Effects of Pointed Splitter Position on Attached Jet Switching

By

Tsutomu WADA and Akira SHIMIZU

Department of Industrial Science

(Received May 15, 1971)

Synopsis

In this report, the effects of splitter position on the attached jet were experimentally investigated for the purpose of discussing the applicability of a usual mathematical model without splitter. As results, the followings were confirmed,

(1) For the splitter distance shorter than the critical distance, the pressure in the bubble lowers and the jet radius of curvature shortens.

(2) At the ratio $L_s/D=4\sim 5$, the switching control flow rate becomes maximum. And bordering this value, the effects of splitter position on the switching are quite conversely. For the splitter distance longer than the above value, the switching control flow rate decreases, as increasing the distance.

(3) For the splitter distance of 1.5~2 times critical distance, the switching is almost never affected by the splitter.

§ 1. Introduction

In studying the switching of attached jet theoretically, the basic mathematical model¹⁾ will usually be a model without splitter. However, it must be investigated how far the solutions from this model have applicability to the practical devices.

Of the devices with small offset, the authors already reported. In that report²⁾, the followings were confirmed. There is a critical splitter distance (L_c), beyond which the splitter does not affect practically the attached jet. And even applying control flow, splitter with the distance of 1.5 times L_c does not affect the attached jet. Thus, the switching may not be affected by the splitter.

On the other hand, with splitter distances smaller than the critical one, the effects of splitter on the switching have not been mentioned.

In this report, therefore, including the investigations of the attached jet with the relatively large offset, the experimental re-

sults are supplementally reported and discussed on the effects of splitter of the switching of an attached jet.

§ 2. Experiment

In Fig. 1, the fabricated model is shown, so

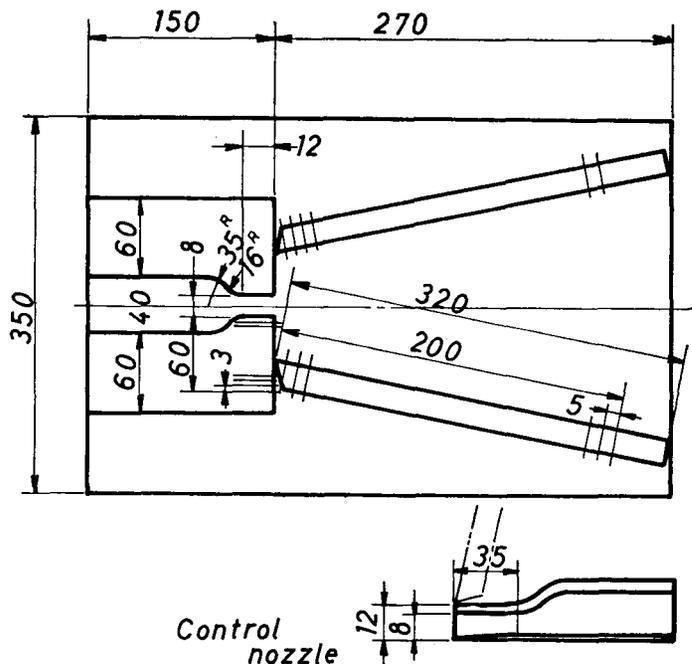


Fig. 1 Large scale model

the splitter position and the offset are change-able. On the offset and the side walls, the holes with 1 mm diameter are tapped to measure the pressure distributions on the walls.

The working fluid is air. The main jet is supplied by means of a blower with the glass-wool filter at the inlet section (Max. flow rate 2.4 m³/min, Max. discharge pressure 400 mmH₂O). The main jet Reynolds number is 1.5 × 10⁴, where a characteristic length is the nozzle width. Now, the control flow is introduced into the control nozzle via a flow meter from a constant pressure tank.

Adding to the pressure distributions, the attached jet velocity profiles are measured by means of a hot-wire anemometer (Hot wire DISA-55F31).

§ 3. Experimental results and discussions

In Figs. 2~5 are shown the loci of the maximum velocity points on the profiles and the pressure distributions, with the splitter distances $L_s/b_s = \infty, 17.5,$ and 10.5 respectively and the offset $D/b_s = 6$. For large offsets as well as small offsets, the pressure in the bubble lowers and the radius of jet curvature shortens, when the splitter distance is shorter than a critical distance. And applying the control flow, the growth of the radius, that is, the growth of low pressure bubble seems to be clearly affected by the splitter position (Fig. 6). Interacting the splitter with the attached jet, the bubble growth is suppressed by the splitter.

Thus, if the above phenomena may be taken simple and easy, the jet will attach firmly and then the control flow to detach (switch) the jet may become more with the shorter

splitter distance.

In Fig. 7 are shown the relations between the splitter distances and the switching flow

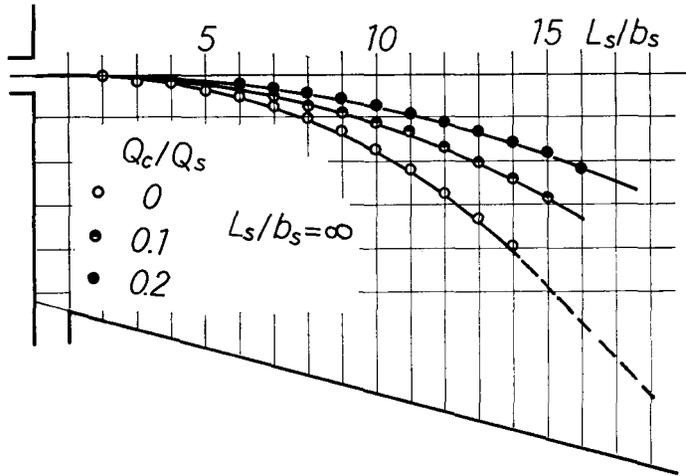


Fig. 2 Attached jet centerline

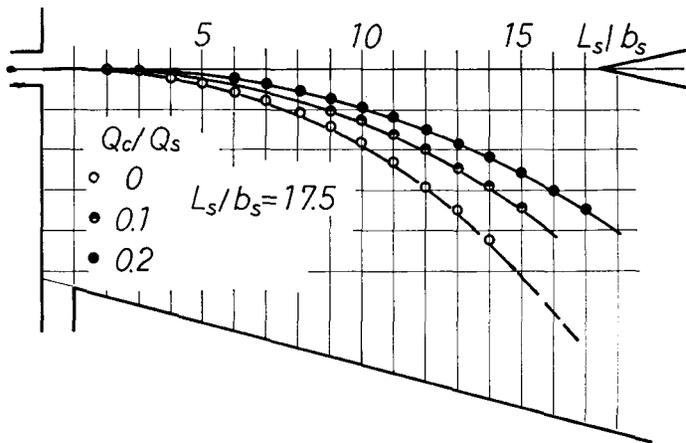


Fig. 3 Attached jet centerline

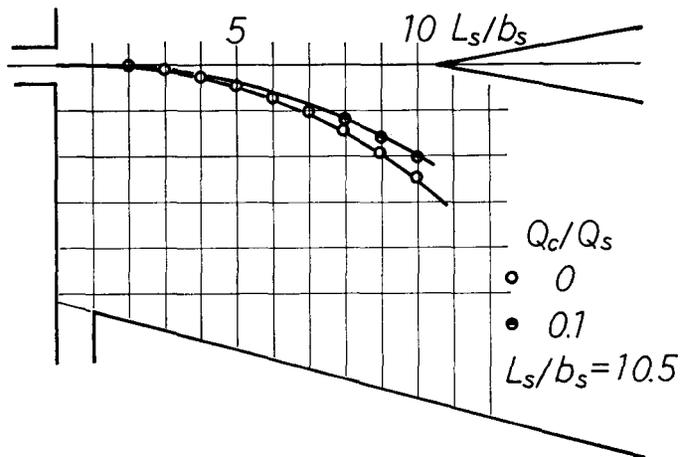


Fig. 4 Attached jet centerline

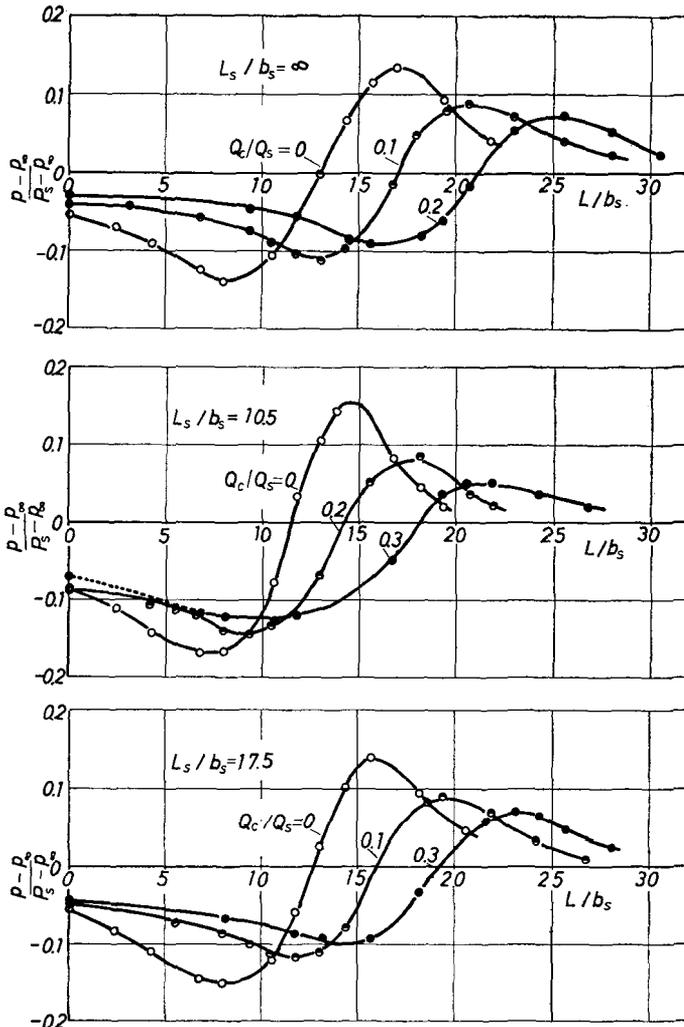


Fig. 5 Pressure distributions on walls for some splitter distances

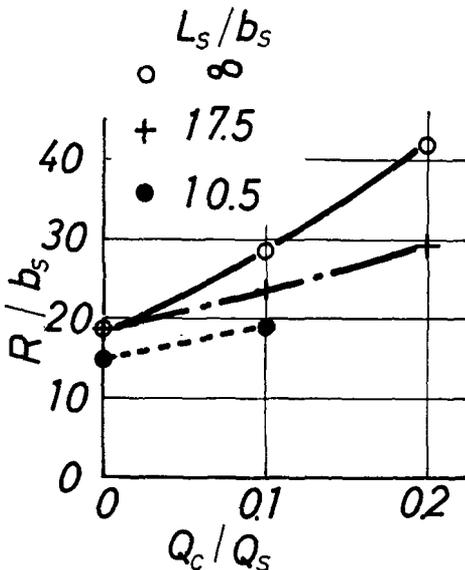


Fig. 6 Jet radius of curvature vs. control flow rate

rates. Discussing of the results from a certain geometry, the attached jet switches easily with the shorter splitter distance. This fact is different from the above simple idea. This may imply the followings: the outer edge of the jet will interact easily with the splitter tip by less control flow, and then the stability of jet may be decreased. On the other hand, the switching of the attached jet may be suppressed by the splitter with relatively long splitter distance.

In Fig. 8 and 9 are shown the difference of switching behaviors between short and long splitter distances.

On the short splitter distance, the jet is not yet deflected to the opposite side, and this may be confirmed by the pressure at control nozzle exit lower than that of the opposite side wall. Nevertheless, the pressure of opposite side lowers remarkably. This can be characterized by the opposite sided vortex, which is developed by the relation between the entrainment of jet and the overflow into the opposite duct.

On the long splitter distance, the jet is deflected to the opposite side, so the pressure at control nozzle exit is higher than that of the opposite side and the pressure on this side lowers abruptly in the cause of the restricted entrainment.

In both cases, the instability of attached jet may be related to the lowered pressure at the opposite side wall. But, these mechanisms of the pressure decreases are quite different.

Now, the quantities, that may represent the degree of interacting between the attached jet and the splitter, must be mentioned. One of these quantities may be the ratio of splitter distance L_s to jet radius of curvature R . That is, the jet with larger R against a certain distance L_s may be easily interacted by the splitter. And the radius R is proportional to the offset D in geometries developed here³⁾. So, the above quantity may be equal to L_s/D .

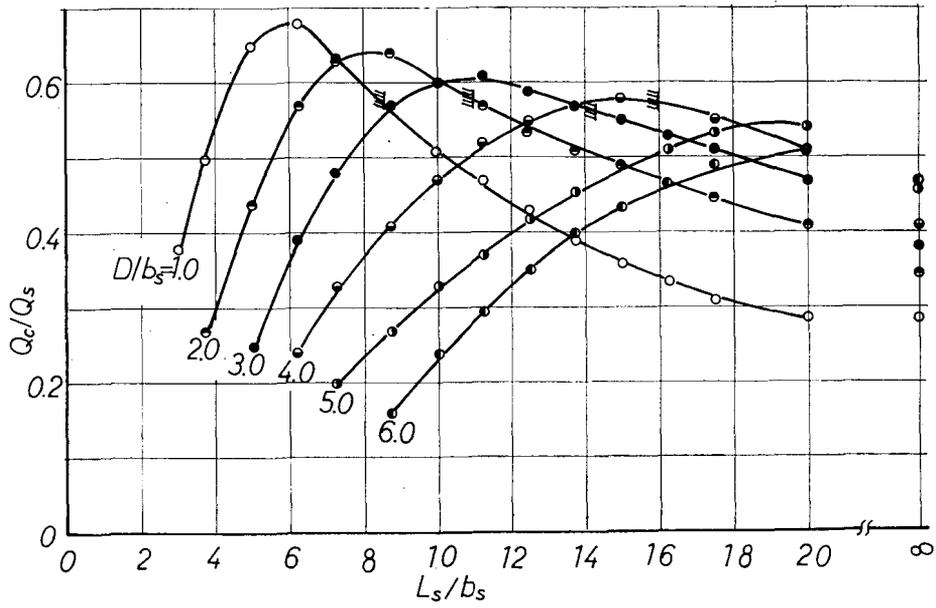


Fig.7 Switching control flow rate vs. splitter distance

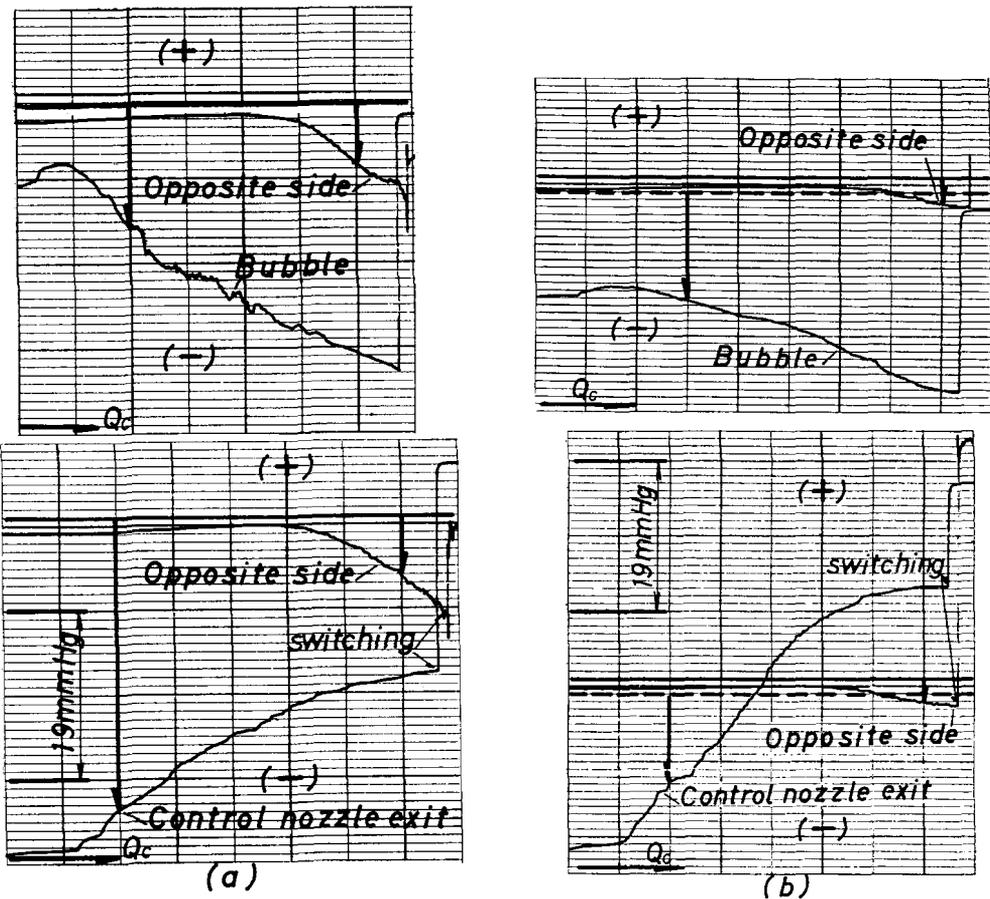


Fig.8 Pressure on walls with control flow (a) $L_s/b_s=10.5$, (b) $L_s/b_s=17.5$

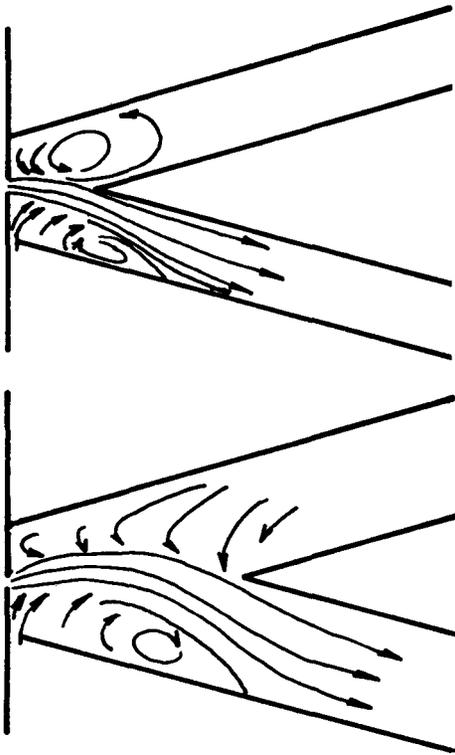


Fig.9 Flow pattern for control flow rate just before switching

From **Fig. 7**, the followings will be confirmed. Shortening the splitter distance, the splitter suppresses the jet switching for $L_s/D > 4 \sim 5$, but pushes forward it for $L_s/D < 4 \sim 5$.

For the splitter distance longer than and equal to 1.5~2 times critical distance, the splitter may give no effects on the switching, as the authors's report²⁾. In the devices with these geometries, the above-mentioned basic model has practically sufficient applicability.

On the other hand, it may be the argument

matters that the mathematical models with splitter are built up. For the purpose of building up this models, the attached jet with splitter must be more precisely investigated.

§ 4. Conclusion

Were experimentally investigated the effects of the splitter position on the attached jet switching. The followings were confirmed,

(1) For the splitter distances shorter than the critical distances, the pressure in the bubble lowers and the jet radius of curvature shortens.

(2) At the ratio $L_s/D = 4 \sim 5$, the switching control flow rate becomes maximum. And bordering on this value, the effects of splitter position on the switching are quite conversely. For the splitter distance longer than the above value, the switching control flow rate decreases, as increasing the distance.

(3) For the splitter distance of 1.5~2 times critical distance, the switching is hardly affected by the splitter.

Acknowledgement

The authors wish to thank Mr. S. Ogo for great assistance offered during the course of the work.

References

- 1) H. L. MOSES, and D. I. McREE: ASME Paper 69-FLCS-31 (1969).
- 2) T. WADA, and A. SHIMIZU: Trans. SICE, Vol. 6 (1970) No. 3, 214.
- 3) T. WADA and A. SHIMIZU: Proc. 5th National Sym. on Fluidics (1970), 43.