Reviewer’s comments on manuscript YJFLS-D-23-00524

General comments

The manuscript investigates, by numerical simulations, the formation of vortices through a two-dimensional orifice between rigid and flexible plates in a channel flow. This study focuses on the kinematics of the leading vortex pair, on the confinement effects and on the influence of the beam flexibility on the vortex pinch-off. Interesting conclusions are drawn. However, some of these deserve further analyses. This study could be of interest for both biologic and industrial applications despite a simplified configuration is considered.

According to my judgment, the quality of the manuscript is acceptable, but there is still room for improvement. I therefore recommend it for publication in Journal of Fluids and Structures, provided that the suggested changes are made, and a step-by-step rebuttal is addressed: a major revision is requested.

The general comments are listed below.

1. In my opinion, the discussion about the origin of the pinch-off mechanism is incomplete. I think that more emphasis should be put on the beam oscillation. It looks that the beams are perturbed from the rest configuration generating a transient dynamics with large amplitude oscillations. I think that the oscillations themselves are responsible for the pinch-off mechanism (see specific comment 15), therefore what you are observing is related to a transient effect, thus connected to the initialization of the problem. Would you observe a vortex pinch-off if the inflow rate was gently increased up to the target condition, rather than impulsively started? I suggest the authors to run a few more simulations for comparison.
2. Every time the term “slit” is used as past participle, such as in the expression “slit plates”, it results in a grammar mistake. I would write “slatted plates” instead.

Specific comments

1. P. 1, L. 54-58: The sentence “The resulting vortex pair growth is governed by the local flow as vorticity is fed into it through an attached trailing shear layer.” is quite unclear. Please rephrase.
2. P. 2, L. 15: The term “pinch-off” here is first introduced. I suggest to describe carefully what is physically meant for pinch-off.
3. P. 3, L. 55: Why is necessary to specify the width “b” in a purely two-dimensional configuration?
4. P. 4, L. 6: How did you select this specific value of the Reynolds number Re=330? Any reason behind that?
5. P. 4, L. 45: The definition of the Green-Lagrange (finite) strain tensor can be ubiquitous, depending on how you build the deformation gradient tensor. Please specify the form of $\nabla \boldsymbol{u}_s$;
6. P. 5 L. 42: I would specify that the LVP detach from the central jet, as here the concept of vortex detachment is first discussed.
7. P. 5, L. 55-57: I don’t understand if the assumptions of the simplified model require neglecting the flow entrained by the central jet or neglecting the flow of the jet itself apart from the LVP.
8. P. 6, Figure 4: The right panel shows the normalized radius of the LVP to match the simplified model by Afanasyev (2006) in the unconfined case, where the growth follows a $\sqrt{t}$ law. Conversely, the confined case presents a bounded growth. I have two concerns about this. First, it is worth mentioning how you computed the radius of the vortex pair obtained from simulations. This is not a trivial task, especially in wall-bounded flows. Second, the growth of the r/δ_{gr} ratio in the confined case is bounded by the normalized channel height $h/\delta_{gr} = 6.67$. Therefore, what’s the point of this comparison?
9. P. 7, Figure 5: I suggest a more accurate representation of rotation-dominated and shear-dominated regions. A discrete colormap with value blanking is useful for the illustrative purpose, but the contour edges are subjected to the arbitrary choice of the colormap bands. One option could be the use of the Ω-criterion [A1]. I found it very effective in delimiting the

regions dominated by rotation. This approach can also be used to delimit the LVP, provided that a zero-rotation threshold is established. The same considerations hold for figures 8, 9, 12.

10. P. 7, L. 32: The sentence "…, it no longer receives the vorticity and advects in the downstream." is misleading. The vorticity is a continuous field, and the shear layer does not push the LVP as elastic solids;
11. P. 7, L. 39: The following sentence suggests a curious result: "The confined case accumulates more positive circulation over time compared to the unconfined case." I understand that the confinement introduces a preferential rotation direction in the flow structure, although the boundary conditions maintain the symmetry with respect to the jet center. Could you comment on that? Did you observe these features in other cases? Do you think it is an instability-dependent effect?
12. P. 7, Figure 6b: Again, how did you compute the x_{lvp}? The procedure must be robust enough to be reliable in cases with complex vorticity pattern, such as some of the cases depicted by figure 10;
13. P. 8, Figure 7c: The trend observed for the curve $C_D/C_{D,rig}$ as a function of the Cauchy deserves to be further investigated. Well established experimental studies showed a monotonic decrease of the drag force as a function of the Cauchy number [A3-A4] for isolated structures undergoing a steady reconfiguration. It looks from figure 7b that your beams are undergoing a steady deflected posture after a transient dynamics. Therefore, I think that the $C_D/C_{D,rig}$ curve is sensitive to the extension of the time-window used to perform the averaging procedure. Furthermore, the duration of the transient dynamics is case-dependent. Please specify exactly how did you compute the $C_D/C_{D,rig}$ curve and provide a plot of the same curve obtained in the steady state condition. The sentence at P. 8, L. 47-48 needs to be modified as well.
14. P. 9, L. 49: The sentence "This increased drag is attributed to the fact that flexible oscillating structures offer more drag than rigid structures" is ubiquitous. Please rephrase with respect to the previous comment.
15. P. 12, L. 41: I think that the catapult metaphor is not suitable, since the vortex pair is not thrown by an elastic force. The LVP originates from the roll up of the shear layer created in the proximity of the beam edge. I think that the pinch-off is caused by the withdrawal of the plate trailing edge, which forces the creation of an opposite shear layer. This in turn breaks the momentum entrainment on the shear layer connected to the vortex, causing a "pinch off".
16. P. 13, Figure 13b: You could check if the frequency trend follows the first natural frequency of the clamped structure by superposing the curve $f_x h/u_0$ as a function of Ca. By considering the first natural frequency of a clamped beam [A2], with $k_1 = 3.52$:

$$f_x = \frac{k_1}{2\pi}\sqrt{\frac{EI}{bh^4}}$$

This could be expressed as a function of the Cauchy number:

$$f_x \frac{h}{u_0} = \frac{k_1}{2\pi}\sqrt{\frac{\rho_f h}{Ca}}$$

Neglecting added mass effects and transient effects one can tell that the vortex pinch-off definitely depends on the structural oscillations. For Ca<0.01, the amplitude of structural oscillations is too small to trigger the pinch-off mechanism.

Additional References

[A1] Liu, C., Wang, Y., Yang, Y., & Duan, Z. (2016). New omega vortex identification method. Science China Physics, Mechanics & Astronomy, 59, 1-9.

[A2] Conway, H. D. (1980). Formulas for Natural Frequency and Mode Shape, by Robert D. Blevins.

[A3] Gosselin, F., De Langre, E., & Machado-Almeida, B. A. (2010). Drag reduction of flexible plates by reconfiguration. Journal of Fluid Mechanics, 650, 319-341.

[A4] Luhar, M., & Nepf, H. M. (2011). Flow-induced reconfiguration of buoyant and flexible aquatic vegetation. Limnology and Oceanography, 56(6), 2003-2017.