A Computational Study of the Reynolds Piped Flow Experiment

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INTRODUCTION

The study of interaction of fluid with matter assumes great significance for most engineering applications. Instabilities of various types like vibrations, dust cause deviations from the pictures shown in the textbook. We have used simulations in COMSOL to demonstrate the Reynolds pipe flow experiment. We present simulations in COMSOL to show the likely complications that can happen in an UG laboratory apparatus, and the resulting deviations from the ideal case

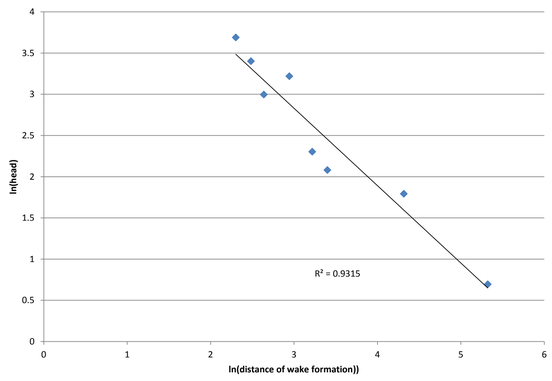
LAMINAR FLOW

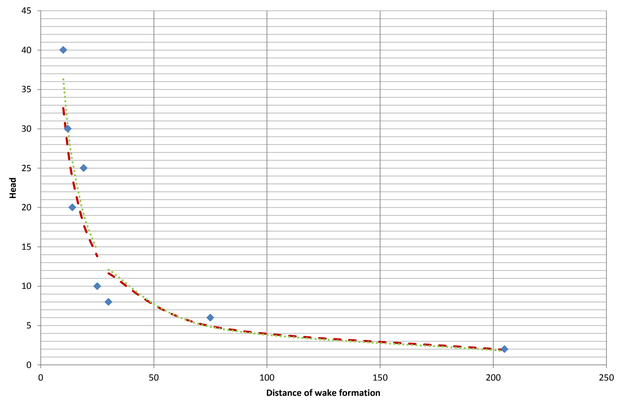
In fluid dynamics, laminar flow is characterized by high momentum diffusion and low momentum convection. There are no cross currents transverse to the direction of flow, nor eddies or swirls in the fluid.

The dimensionless Reynolds number is an important parameter that classifies flow conditions between laminar and turbulent flow. We have varied pressure conditions and added a random noise was to the simulated flow in Reynolds pipe.

• Effect of head on wake formation

Different pressure-heads were given at inlet of the pipe to study the onset of wake formation. The distance for the onset of turbulence for different heads were plotted and trend lines were fitted. It was found the results obeyed power law with correlation coefficient of $R^2 = 0.9451$. This result is shown in below excel graph (a)





Graph (a)

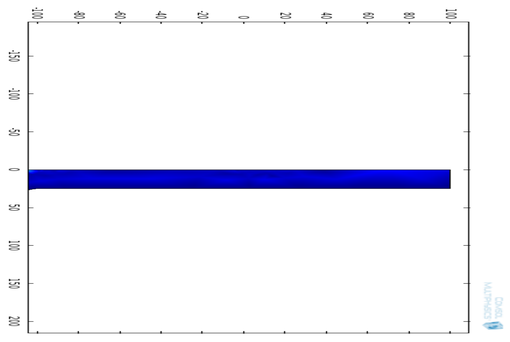


Fig (a):Head of 200 Pa

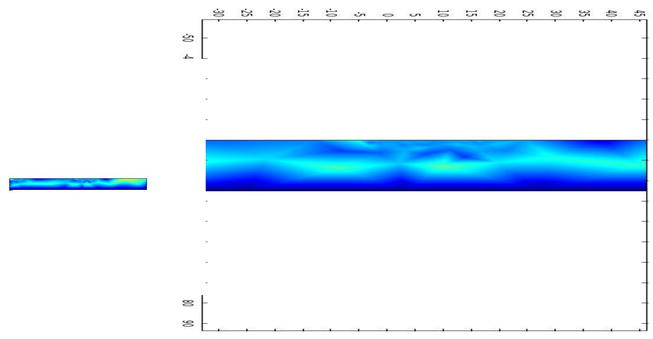


Fig (b):Head of 600 Pa (zoomed image)

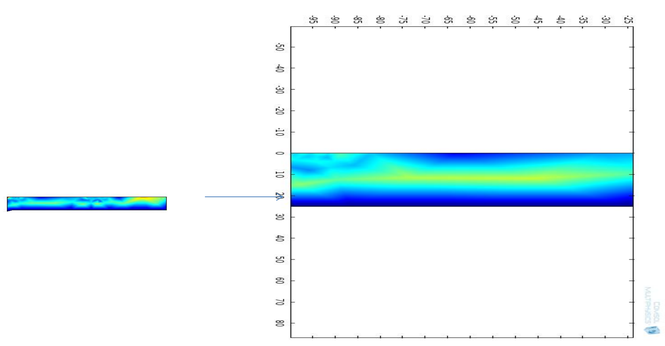


Fig (c):Head of 1000 Pa (zoomed image)

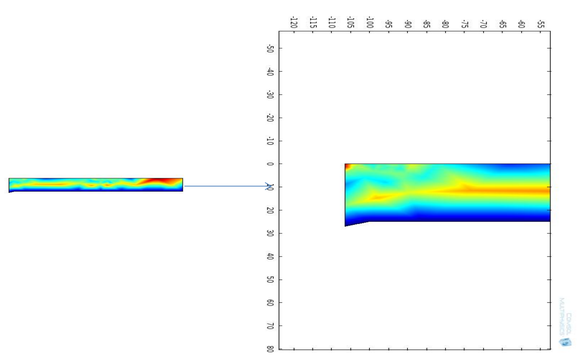


Fig (d): Head of 2000 Pa (zoomed image)

• Effect of noise on Flow

Studies were done to simulate situations arising from a small tap or situations of seismic disturbance. Noise was introduced at different times as shown in Fig(e) and (f). The flow observed for the induced noise in Fig(e) is shown in Fig.(g) .

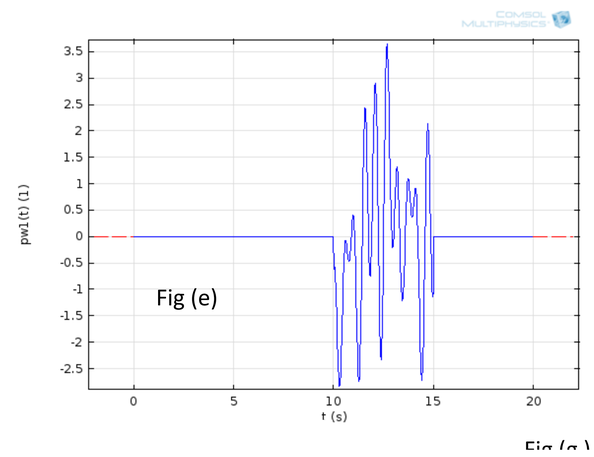


Fig (e)

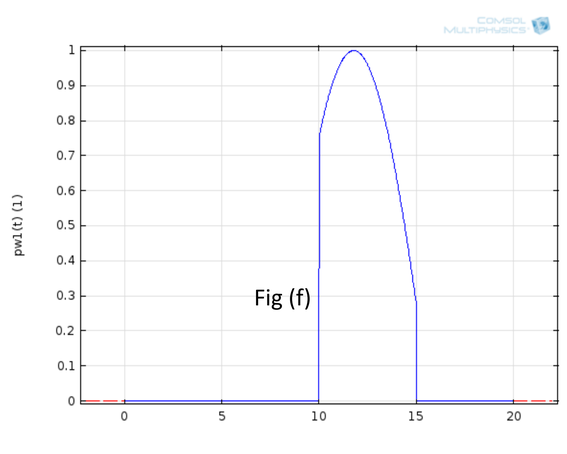
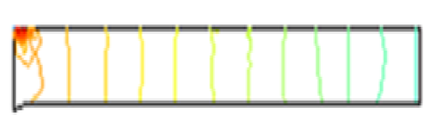


Fig (f)

Fig (g)

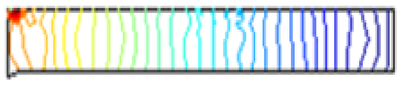
Time 9.3 s

Time 9.95 s



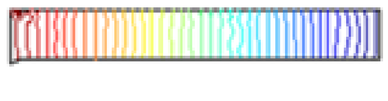
Time 10.05 s

Time 10.09 s



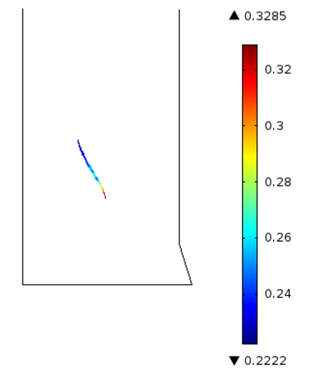
Time 13.1 s

Time 15.05 s



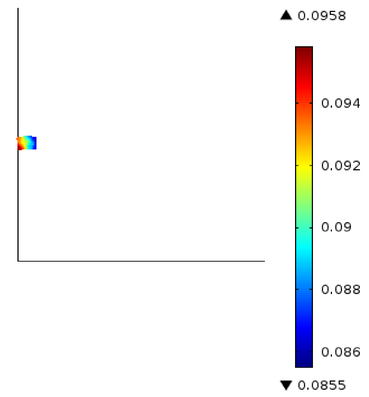
Time 15.7 s

Noise creates a huge pressure variation and disturbance around t=10 sec in the flow. This is shown by the curvature of streamlines. The disturbance dampens and we see no pressure variation at around t=11 sec. A new equilibrium develops inside the pipe and leads to a new pressure profile . When we stop the vibration another pressure disturbance originates in the flow which dampens quickly and equilibrium is restored.



With Noise

Fig (h)



Without noise

CONCLUSION

COMSOL can be used as a tool to demonstrate the formation of wakes. In this presentation we have shown the decrease in the length off wake formation when pressure is increased. The dependence of pressure on wake formation can be described by a log plot. We have also explored if this relationship can be simplified to

head=Constant/Distance of wake formation

We have also performed calculations with temporal disturbances to show the effect of noise in the laboratory. Analysis has been done of the streamlines and also by using the particle tracing module. The fpt plot shows disturbance creates motion in the radial direction and certain particles travel slower than others which is not obvious from streamlines.

Excerpt from the Proceedings of the 2013 COMSOL Conference in Bangalore