The working principle of a double channel membrane pump

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The design principle of a double channel membrane pump is shown in figure 1. A channel with rigid walls is divided in its mid plane into two sub-channels. On the inflow side the two sub-channels are separated by a rigid plane. On the outflow side the sub-channels are divided by a membrane. A volume of fluid ΔV is displaced periodically. This can be done by flap a the end of the rigid plate or by piston acting on the side walls of the channel (see figure 1a).

In any case the displacement of the volume initiates waves traveling along the membrane. Note that these waves are the result of the interaction of the incompressible fluid and the membrane. As a net result a volume flux of the fluid and an increase in total pressure are generated. This device can serve as a pump or as a propulsion mechanism.Since it is a valve-less pumping mechanism it is intended to use it as pump for fluids with immersed solid particles (e.g. gravel,...).

In contrast to usual membrane pumps the double channel membrane pump works at high Reynolds numbers. Thus a first theoretical approach is be based on the theory of an instationary inviscid incompressible two dimensional flow around a slender profile. Here we want to point out two new aspects. Firstly the structure is placed in a channel of finite width and secondly the shape of the profile (membrane) is determined by an interaction with flow. Restricting to small amplitudes the flow can be described by a vortex distribution along the center line of the channel representing the plate, membrane and wake. The lateral pistons are described by a pair of sources (sinks) which eject and absorb the volume ΔV during each cycle.

A coupled system consisting of an integral equation for the vortex distribution and an ordinary second order differential equation for the shape of the membrane can be derived. Thus a thrust coefficient which is responsible for the possible pressure gain and an efficiency coefficient can be determined and thus optimal design parameters can be identified. For example we vary the location x_s of the sources (lateral pistons) while all other parameters are kept constant. In figure 1b) the thrust coefficient $F/\rho U \Delta V f$ where U is the mean flow speed and f the frequency is shown. It has three sharp maxima.

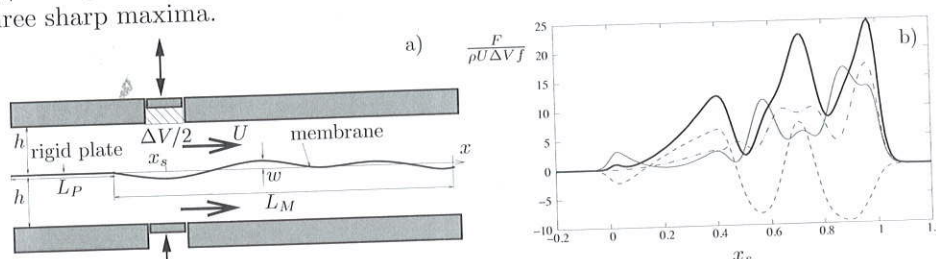

Figure 1: Design principle of a double channel membrane pump a) Thrust coefficient (thick line), contribution form membrane onto fluid (dashed - double dotted line), leading edge thrust (solid thin line), momentum transfer at pistons or sources (dotted line) as function of the location of the lateral pistons.

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