BioMEMS and Microfluidics
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Lecture - 42
Review Lecture of 29, 30, 31, 32 and 33

Hello and welcome to this review lecture on BioMEMS and micro fluidics for lectures 29 through 33. Now, in this section, we are talking about first the how the navier stokes equations can be simplified greatly with respect to incompressible flows, and assuming that there is a constant viscosity taken in this equations. And then finally, arriving at a very abridged formulation of the Navier Stokes in terms of indices where we talk about the, you know, the variation along the rows and the columns of all the 3 dimensions, you know, the equations in all the 3 dimensions of the navier stokes as derived earlier.

And then, we assume both a distance scale and velocity scale, and then assuming these 2 scales and putting them back into the indexed equations in the Navier Stokes we are able to actually get situation where we can have a very small nominal value Reynolds number coming out of the equation in a manner so that it becomes time independent. So, the final formulation that we arrive at here is that the pressure gradient which is there that is del p star by del x j star where these p star and the x t star are basically the scaled down pressure or the scaled pressure or the special scale and the distance scale, this becomes equal to the del 2 u i star by del x j star square.

So, therefore, the shear stress part of the equation is proportional only to the pressure gradient, thus removing the time domain totally out of the equation, and that is what typically happens when we talk about low Reynolds number flow in micro mixing etcetera, where there is really no time dependency if you are having a mixer where there are let say 2 fluids flowing together. And, if you just go back in time you would be able to extract the 2 fluids as, because there is hardly any mixing because of any turbulence related issues at such a low Reynolds number domain.

So, in a way practically, whatever we have derived with scaling down is also seen at various levels where we talk about micro flows and micro fluidics. This lecture also includes a section dedicated 2 micro mixers where we talk about the various generations of micro mixers like the first generation t type micro mixers, the second generation out of plane, in plane, type micro mixers and then finally, the third generation where there is a rotation, the rotational behaviour of the flow which creates diffusion pathways of one fluid into another by virtue of that.

And, what we really learn is that most of the mixing at this particular scale because there is hardly any time dependence, and at a low Reynolds number there is hardly any eddies or vertices created or turbulence created. So, the most of the mixing is actually diffusional in nature. And, with that we actually compare the diffusions time scales with the resident time scales and see how we can vary the fluid paths in a manner so that the time scale increases as far as the resident time scale is concerned.

And, it can somehow be able to match the diffusions time scales which are in any event huge because of the very low diffusion coefficient of the fluids in micro scale mixing. So, thereby we make the various design constraints for passive and active mixers, talk about different lamination, sequential and parallel mixers. And then, we also look at some of the mathematical models of how to handle the mixing, how to predict the mixing time, the mixing path length, so on, so forth.

We also look into details of how, you know, some of the micro scale control mechanisms can be executed in a engineering manner by looking at micro valves, micro pumps, and that both active and passive, we talked about peristaltic micropumps, for example, how to design the particular micro pumps. And, then also talked about pneumatic and thermopneumatic micropumps and micro valves. In a nut shell we have summarized that what are the applications of such scale down fluidics which we learn from the navier stokes analogy earlier into the realistic, you know, physical scale, you know, where we are talking about experimental validation of some of those theories.

So, in a way, in a nut shell, what the lessons that we learned is that micro flows are very low Reynold number flows. They are typically time independent flows. And then, most of the mixing at the micro-scale takes place to diffusion driven mechanics. And then, also the surface forces become very predominant where it is felt increasingly that if you actually initiate that anomic of flow through more surface initiation it is a much better energy efficient means than going by the volume or pressure driven mechanisms as earlier, as normally takes place in the micro scale.

So, in a way the behaviour, the flow behaviour at the micro-scale is quite counter into a different with respect to what in otherwise trained engineer in the fluid mechanics would envision in the micro-scale.

Thank you so much.