Multiphase Microfluidics
Dr. Raghvendra Gupta
Department of Chemical Engineering
Indian Institute of Technology, Guwahati

Lecture – 24
Concluding Remarks

So with this we are now, at the end of this 20 hours course titled as Multi-phase Microfluidics.

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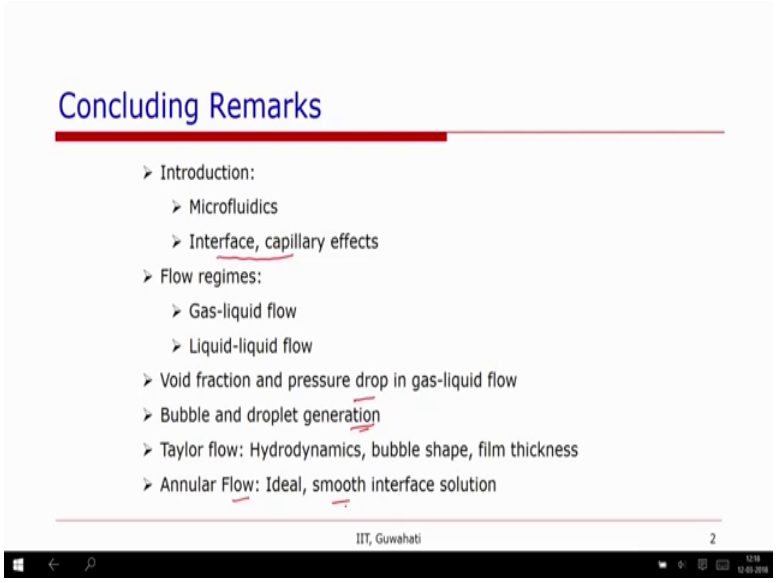

I have listed here the topics that we have discussed. We started with the Introduction to Microfluidics. What are the physical effects or what is different or what can be different in micro channels as well as the basics of Microfluidics and Multi-phase flows.

So, in Microfluidics because the interfaces are generally large and capillary effects are important. So, more than one need to understand the interfaces capillary effects in to understand the Microfluidic at the Multi-phase flow behavior in micro channels. The second part of this the interfaces in capillary effects; we have divided into 2 different sections which were discussed at 2 different time times during the course or at 2 different stages during the course.

The first stage, where we talked about the Surface tension and Gas-liquid or Liquid-liquid interactions; we discussed at the start of the course. Once, we have developed a bit

of understanding in the next stage we discussed the Three-phase contact angles where we also looked at the droplets sitting over a sphere and the a contact angles and things like that. So, once we have understood the basics of Multi-phase flows or the fundamentals, the definitions, the equations n-Laplace law, Cassie Baxter law and the terms that we use in this area.

Then, we looked at the flow regimes that can happen in Gas-liquid flow and Liquid-liquid flows and it turned out that one of the most often and most important flow regime in terms of the applications is the Taylor flow regime. So, we have devoted a large chunk of this course to the hydrodynamics heat and mass transfer in the Taylor flow regime. We also looked at that then because one need to precisely control the size of the bubbles and droplets that are being generated.

So, we have looked at the we have in a brief lecture, we have looked at the bubble and droplet generation that are and the mechanism of it and equations, the mechanism of bubble generation at a treasons and in a flow focusing device has been discussed in this. One while dealing with the Gas-liquid flows void fraction is a very important information and designing any Microfluidics device, Microfluidic device one need to have an idea of the pressure drop because that will determine the energy that is required for the pumping in the fluid.

So, we have in a in a lecture, we have also discussed the void fraction and pressure drop in Gas-liquid flows in micro channels. We have briefly touched upon the annular flow and looked at the analytical solution for an ideal annular flow and a how we can calculate the interfacial radius or the thickness of the liquid film and the pressure drop in ideal conditions in annular flow. However, the conditions are not always ideal or almost never ideal, when especially when we are dealing with Gas-liquid flows and that will be instabilities at the interface.

So, one need to look at further the Hydrodynamics of a slug annular and annular flow and decision an area which has not been explored fully in a Gas-liquid flow in micro channels. Then, we have also looked at flow boiling in micro channels. So, the evaporation and the nucleate boiling and the questions that are there, the to address the that which boiling it is it the nucleate boiling or the evaporator boiling which is dominant

is a still not addressed and one need to further investigate to establish the dominant mechanism of flow boiling in micro channels.

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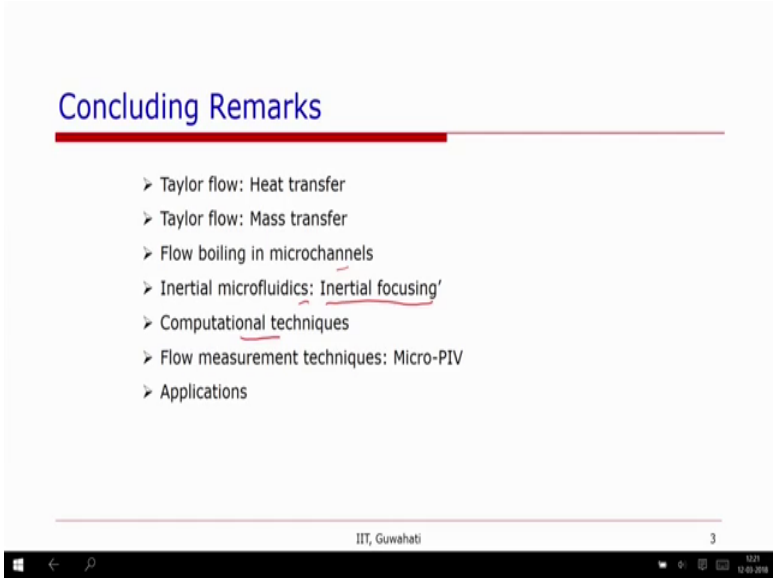

Taking a divergence from the entire theme of this course we have also looked at the inertial micro fluidics where the main discussion was about inertial focusing. The focusing of the particles in a channel and we looked at the rigid particle focusing, but one can also look at the focusing of a the flexible particles, a cells, bubbles and droplets in the channels and they it has as we have seen that it has a number of applications in Microfluidics. Then, during the middle of the course, we have introduced the computational techniques for modeling Multi-phase flows and it because the interface size is large in Multi-phase Microfluidics.

So, one often prefers to capture the interface. So, the interface capturing techniques such as volume of fluid method or level set method or phase field method or lattice Boltzmann method are more popular in a Microfluidic applications rather than say Oiler-Oiler method where the interface cannot be captured and one need to rely on the closing or the closure equations for the momentum exchange between the 2 fluids or the gas and a solid or gas and liquid phases..

Then, we have a briefly discussed the different flow measurement techniques and in one lecture we also looked at the basics and fundamentals of micro particle image

velocimetry which can be used to understand the velocity field and with laser induced fluorescence; fluorescence the temperature and concentration field in a micro channels.

And in the last 2 lectures, we have looked at the number of applications and the potential of the micro fluidics to impact the different sectors and our day to day life. So, I hope that you have learned some of the basics. And this course has a motivated you to learn more about Microfluidics..

We welcome the suggestions to further improve the course. I would also request you to post any questions or doubts that you might have or any suggestions that might have in that you might have about the course to post on the course website.

Thank you and good luck.