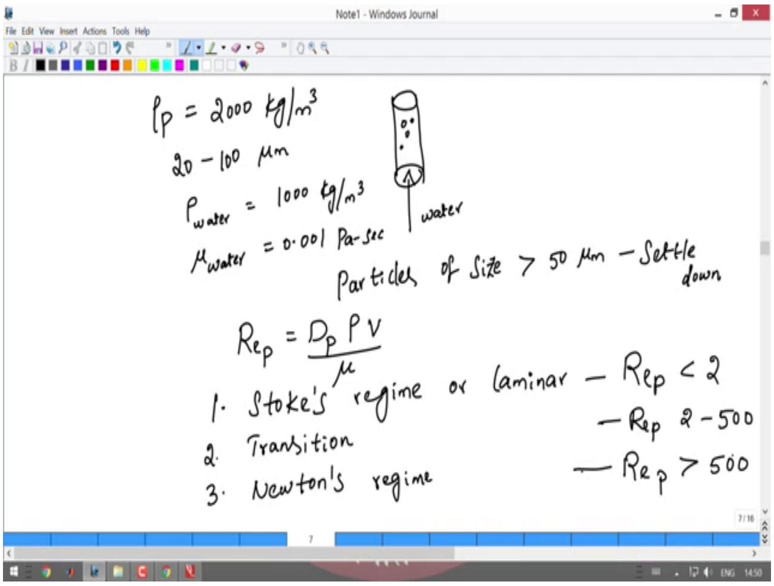
Fluid and Particle Mechanics
Prof. Sumesh P. Thampi
Department of Chemical Engineering
Indian Institute of Technology, Madras

Lecture - 43
Tutorial - 06

Hello, everyone. Today, we are going to solve a problem on settling of particles.

(Refer Slide Time: 00:25)

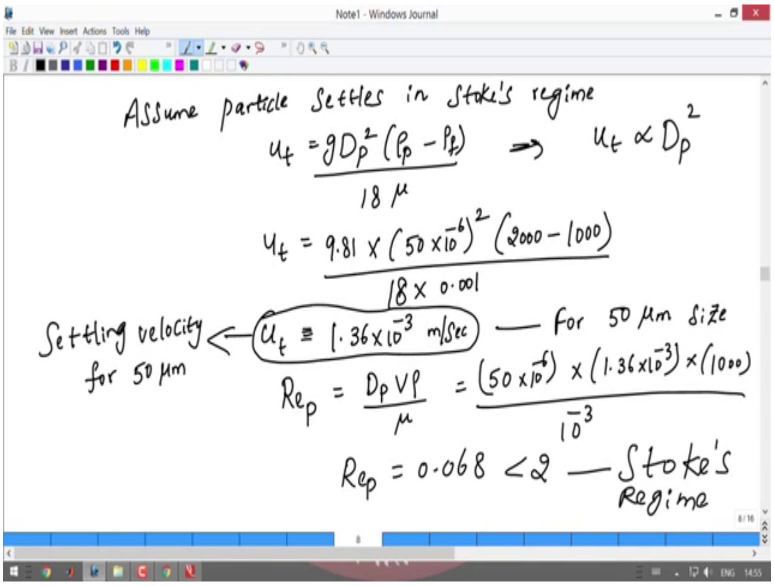


So, the problem is we have spherical particles of density. Particle density given as 2000 kg per meter cube and these are in the size range of 20 to 100 micrometers and we have a stream of water flowing upwards in a vertical pipe of diameter. So, this is the schematic. We have water flowing upwards and we have particles and the density of water is 1000 kg per meter cube with viscosity 0.001 Pascal second.

Now, we are asked to find the maximum water velocity which is required to ensure that no particles of diameter of size greater than 50 micrometers are carried upwards with the water which means that particles of size greater than 50 micrometers have to settle down. So, the first approach to solve this problem is to find the Reynolds number of the particle. So, the Reynolds number of the particle is given as diameter of the particle density velocity by viscosity so, but the unknown here is the velocity of the particle.

So, based on the Reynolds number of the particle we can divide the setting of the particles into three regions. The first region is the Stokes region or laminar setting and the second region is the transition and the third region is the Newton's; Newton's regime. So, in this region the Reynolds number of the particle is less than 2, here the Reynolds number lies between 2 to 500, in Newton's region the Reynolds number of the particle is greater than 500.

(Refer Slide Time: 03:43)



So, we assume that particle settles in Stokes regime. So, in Stokes regime the terminal velocity of the particle is given as. So, now, we have to find the settling velocity of the 50 micrometer particle. g is the acceleration due to gravity which is 9.81 meter per second square and the diameter of the particle is 50 micron, rho p is the density of the particle which is 2000 kg per meter cube and the rho f is the density of the fluid which is 1000 kg per meter cube divided by 18 times viscosity of the fluid which is 0.001 Pascal second.

So, the terminal velocity for the 50 micrometer particle comes out to be 1.36 into 10 power minus 3 meter per second this is for a particle of 50 micrometer size. So, since we assume that the particle settles in a Newton regime, the Reynolds number of the particle should be less than 2. So, we will check if the Reynolds number of the particle is less than 2 to make sure that our assumption is correct.

So, now, we will calculate the Reynolds number of the particle for a 50 micrometer diameter of the particle. So, 50 into 10 power minus 6 multiplied with V is the settling velocity which is 1.36 into 10 power minus 3 and density is 2000 viscosity is 10 power minus 3 sorry, this is the density of the fluid. So, it is 1000 kg per meter cube and we get

Reynolds number as 0.068 which is less than 2. So, our assumption of Stokes regime is correct.

So, now, in the question we are asked to calculate the maximum water velocity with which we should pump the water, so that particles of size 50 and less than 50 should settle down should sorry, it particles of size 50 and less than 50 should be carried up with the water. So, if we pump the water with this velocity which is the settling velocity settling velocity for 50 micrometer particle. So, if we pump the water with this velocity all the particles of size less than 50 will be carried upwards with the water and particles of size greater than 50 micrometers will be settled down because this is the terminal velocity of the 50 micrometer particle.

And, if you see the terminal velocity is directly proportional to the square of the particle diameter. So, the particles of greater the particles of diameter greater than 50 micrometers will have a settling velocity of higher than settling velocity greater than settling velocity of 50 micrometer particles. So, that when we pump the fluid with this velocity all the particles of less than 50 micrometers will be carried upwards with the water and those particles which are heavier in size which are greater than 50 micrometer in diameter will be settled down.

Thank you.