Fluid Flow Operations
Dr. Subrata K. Majumder
Chemical Engineering Department
Indian Institute of Technology Guwahati

Lecture – 01

Introduction

Keywords: Basic fluid flow; Drop coalescence; Application of fluid flow; Hydrostatic fluid; Hydrodynamic fluid; Streamline fluid

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Hello everybody, welcome to massive open online course sponsored by Ministry of Human Resource Development Government of India. The course is on Fluid Flow Operations, today's lecture will be on Introduction on the fluid flow operations. So, as we know that in our everyday lives there are several products which are produced by different chemical and biochemical even other process engineering systems to produce those products and like if we see that we are using soap in our daily life that soap is produced in chemical industries by a certain process.

In fact, you know that some other products like, if we consider that if we use some transport slight vehicles they are also you will see some extent these vehicles are processed which will be linked to these fluid flow operations. In suppose transport processes if we want to cross the river for get the easier transport from one bank to another bank or from one location to another location.

So, there we need one bridge so whenever bridge is made of course, there you have to know some extent the what with the flow characteristics in the river and based on which thus as that bridge will be made and also you will see some other different products in our daily lives, we are using the paste of course this paste is one type of fluid.

Now that paste how it is made, you have to know the flow characteristics of the fluid different properties of the fluid, so that you will be knowing this paste is what type of fluid and what extent of this fluid how can this fluid to be packed in a pack and it will be consumed through our daily life. Also, you will see some other in chemical industries of course I told that earlier the transport processes without oil we cannot survive, now you cannot use that crude oil from the nature directly to your transport vehicles.

So, that you can easily go from one location to another location, now you have to process that fluid that oil to get it is to some extent refined, so that you are using that refined oil as a different products for your vehicles. While other type of different oil you are using for different uses that you have to know that the characteristics of the oil; oil is one type of fluid.

You know that we are using LPG that LPG is coming from where that is also from crude oil after processing with different steps in distillation unit. In distillation column there of course you are handling the liquid you are operating this fluid at a particular process, so that you can separate that different components of your products like LPG like some other heavy oils, lighter oils, kerosene, gasoline even some other products.

So, in that case the fluid flow operations are very important and some extent these fluid flow operations if you know how it is to be handled, how what will be the flow rate what will be the amount of fluid we supplied to get each different products and byproducts and also you will see some other operations like producing this electricity. How this electricity is coming? There also some extent this fluid flow operations are directly or indirectly related what is that.

You will see that this production of electricity is by certain process, there you have to use the gas or you have to produce the gas from the coal you have to process the coal in a certain way what is that way that is called Fluidization operation. Now that if you use this coal to produce the gas, that is gas that gas will be used to produce this power also you will see that from the coal there are other several different types of gas is produced by fluidization operation.

You will see the production of synthesis gas nowadays green technology, they are producing different synthesis gas to produce different products of gas even that gas will be is being used for energy sector and for transportation and other operations in the power plant. You will see by coal burning there is a production of steam that by steam turbine you are producing this electricity.

So, there is a process for the fluid flow operations and then fluid flow operations you can say that it will be related in directly or indirectly in such a way that you are handling this fluid and you are operating this fluid to get these daily life products and also energy.

Another way that you can say we will see there are so many products which is dependent on the flow characteristics like if flow is flowing through the pipe.

Now you will see, if fluid is flowing the flow will be in different way sometimes the flow will be in laminar sometimes flow will be in turbulent, laminar means very slow motion of the fluid turbulent means very high motion of the fluid. And also you will see if you are using the complex fluid, if you are using mixture of fluids you will see whenever mixture of fluids will be flowing through the pipe it will give you different patterns and this patterns will affect the transport processes of the operations and in that case the yields of the product depends on this flow pattern of this fluid.

Now in this course you will be learning different aspects of fluid flow, different patterns of the fluid flow even what will be the statics of the fluid, what will be the pressure that exerted by the fluid whenever fluid is flowing through the pipe you will see there will be a certain extent of pressure and by us you will see that pressure will be as a frictional pressure. Now you have to know what extent of that friction is being occurred by the fluid flow so you have to know. So, before going to the depth of those things we will first go to the history of this fluid flow operations first here see.

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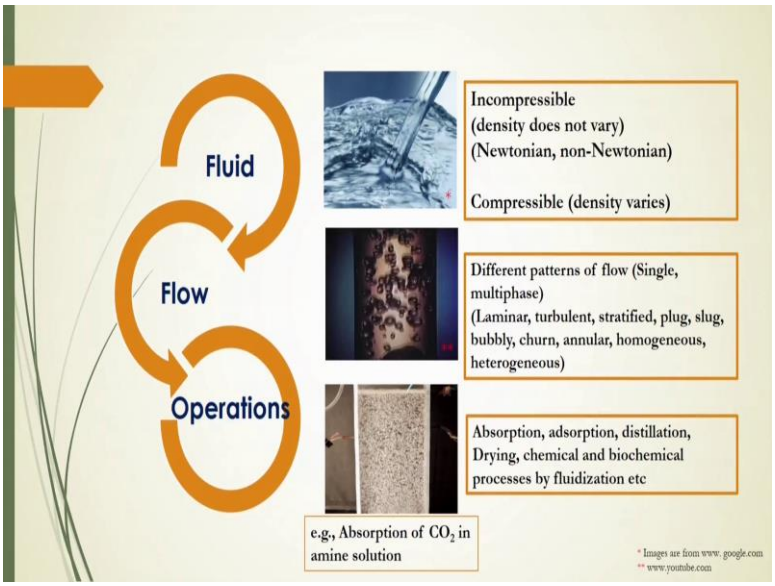

If we say that fluid flow operations first of all you have to know what is that fluid. You know that fluid? The fluid start has some certain density we will describe each in details at the later on subsequent lecture and here you just see the fluid may be incompressible

in that case density does not vary with what is that time and also it may be Newtonian and non Newtonian. You will see the fluid may be compressible in that case density may change with respect to time and with respect to other parameters. So, in this particular fluid whether it is incompressible or compressible more details will be later on.

Now, if we flow this fluid you will get different patterns of flow, whether it is single flow whether it is multi phase. In case of single fluid, if we flow it what will happen, you will see there will be a laminar there may be a turbulent, in that case the each molecule of the fluid in case of turbulent it will happens early or you can say heterogeneously it will be flowing through the pipe the in is at this point of the pipe the velocity of the fluid will not be same, so you will get different type of pattern there so laminar turbulent.

Now, in case of mixer flow suppose there is a gas and liquid flow, you will see there will be a flow of like this stratified flow in that case one flow one liquid will be flowing over the other fluid, there may be a plug flow one liquid will be flowing as a what is that called it is as the chunk of one liquid components or liquid bulk over other or inside the other liquid.

Similarly, slug flow similarly you will see bubbly flow here in this video you will see there is a bubbly flow and slug flow some see some flow is there, you see there is a mixture of gas and liquid. You will see in this figure in this figure there is a flow of gas and liquid, see gas is flowing from the bottom to the top and there is a certain pattern of this flow of fluid here gas is flowing from the bottom to the top as a bullet shape of bubbles.

Sometimes some bubbles will be dispersing as a smaller size and here see the bottom video you will see the bubbles will be dispersed as a dispersed phase of molecules or you can say gas is flowing in a liquid medium as a dispersed phase of bubbles and in this case you will see the uniform bubbly flow occurs.

So, this is the operations so this one is flow this is also flow, but how this flow will be operated for particular process to get particular products. Like one example, here if I see that this video this is one reactor in this reactor from the bottom some carbon dioxide gas is supplied in a liquid medium, the liquid is being used as an amine solution this carbon dioxide gas is being absorbed in the amine solution or you can use some other solution

also. If you use sodium hydroxide solution then carbon dioxide gas will be absorbed in a sodium hydroxide solution.

So, we are using these flow this bubbly flow for this operation of absorption. Similarly, if you use some solid particles in the liquid you can have the operation for the adsorption of the gas to the solid surface. Even if you are using the column of distillation you see the liquid crude oil will be processed by it is boiling point or by heating to get it is several products and suppose for drying of any feeding, suppose weight fade is to be dried or coffee bean to be dried to be roasted in a column.

So, in that case hot dry air to be supplied through the bed of the coffee bean or bed of the weight paddy, you will see there whenever the hot air will be supplied through the bed of the weight paddy or that calls coffee bean. You will see this coffee bean will be roasted at a certain temperature and also paddy will be dried, so we can use this fluid operation for the dry even some other chemical biochemical processes also by fluidization is possible to produce the synthesis gas by coal burning, you are using the fluidization operation in the column so that is also an important process that that is called flow operations. So, overall we are getting this fluid flow operations for certain applications for industrial applications to get our daily products, ok.

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Now, we will discuss about that where this fluid flow, you know everyday life is being used. Let us consider this acoustics you know that the truck or car or bus they are using

horn, this horn by blowing of air. So, horn is the mechanism just by blowing of air, so here fluid that is air is flowing so fluid basically liquid air and some other form like plasma.

So, in this case we are considering that liquid and air and also you see in our daily life, see this picture or video see in our coffee, if I add some milk as a jet what will happen the milk jet and the coffee it will be mixed. So, here in this case the mixing of coffee by turbulent jet of liquid and also you will see some rotational flows in our daily life. In your toilet after flashing what will what you will see there is a circulation of the liquid, so there is one operation here it is a liquid fluid flow liquid flow.

Another point is that non-Newtonian fluid flow faced whenever we are taking out of the paste from the pack, you will see there will be flow of paste this paste is one type of non-Newtonian fluid we will describe in details about this non Newtonian liquid later on. So, this toothpaste is one type of non Newtonian liquid and having this toothpaste from it is pack a simple this way.

Now aerated jet flow you will see washing mouth or hand, so this is you are see this is this is aerated jet air and liquid both are coming from the tap as jet. So, we are using that for hand wash, mouthwash, drying off here you will see in our daily life what we are using for drying our hair for drying our hair, hot air to be supplied through the jet here it is called hair dryer. So, from the hair dryer hot air is being jetted to this hair here so that it will be dried.

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Other like a splashy in the skis by in this by liquid we are splashing the liquid in our mouth, ok. Flow of liquid drops you will see sometimes we are using the liquid drops in our bathroom from our showers force convective flow, you see there you will see there will be a fan in this case air is flowing by force from it is fan that is called convective flow.

Flow buoyancy driven pumps another example, it is a liquid flow by atomization whenever we are painting our wall the paints is coming from the spray as a atom very fine droplet of paint liquid, so that case liquid flow by atomization. Similarly, we can say that free surface flow in that channel you will see the river you will see there will be a flow of water, the water will get to the free space free surface to flow.

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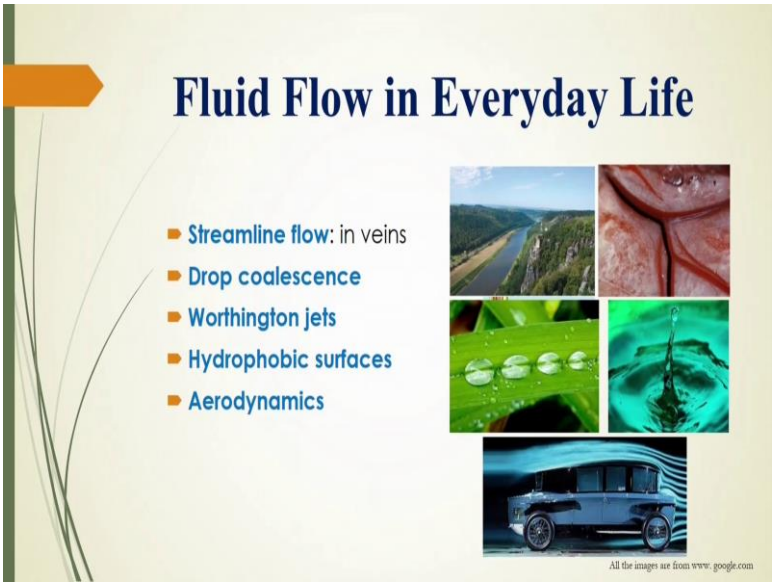

Another example, you will see in our vein there will be liquid flow, now liquid is flowing very slow rate so it is called the streamline flow. You will see there will be drop coalescence and this you will see there will drop successive drop, if we if the drops are coming to each other in the picture you will see both the drops are coming to each other and joint you will see there will be a big drops formation.

So, this phenomena is called coalescence of drop or drop coalescence and this is sometimes to control the surface for a particular operations the coalescence process is important. Have you seen the Worthington jets this how the jet is formed, if you drop some object on the surface of the liquid you will see pool of the liquid will be coming as a jet from the surface, so this type of jet is called Worthington jets.

Hydrophobic surfaces you will see this is the hydrophobic surfaces in date, in that case you will see the water droplet in where you will see on the leave the surface how it is being bent towards the surface that is water is repelling from the surface.

Aerodynamics, you will see whenever aero plane is flying what is that there will be leave of fumes and also there will be downward movement upward movement of the plane, also whenever there will be a car playing surrounding the car or aero plane you will see there be flow of airs. Now there will be a friction of airs whenever it will be flowing over the surface, so there were certain frictions you have to maintain certain exchange of flow to get reduce this friction also.

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You will see have you seen that there will be a particulate in flow and the storm you will see the storm dust is flowing over the surface of the land, so that is particle laden flow. Lift how much lift of airplane does bio-inspired flow; you never you will see if animal is taking the water from the that is any bucket or any pond or any river by their tongue you will see they are lifting the watch it licking the liquid, so this type of things bio inspired fluid flow.

Multi phase flow; there are several applications of this multi phase flow gas liquid flow, gas liquid solid flow for the operations to get the synthesis gas to get the synthesized products to get to get the powered by burning the coal there is a multi phase flow. Evaporative flow; you will see that way air heater and cooler flow through porous media, media in our daily life what happened we are using filter we are using filter for drinking water. In that case, water is flowing through the porous media like candle; candle is nothing but nothing but a porous media.

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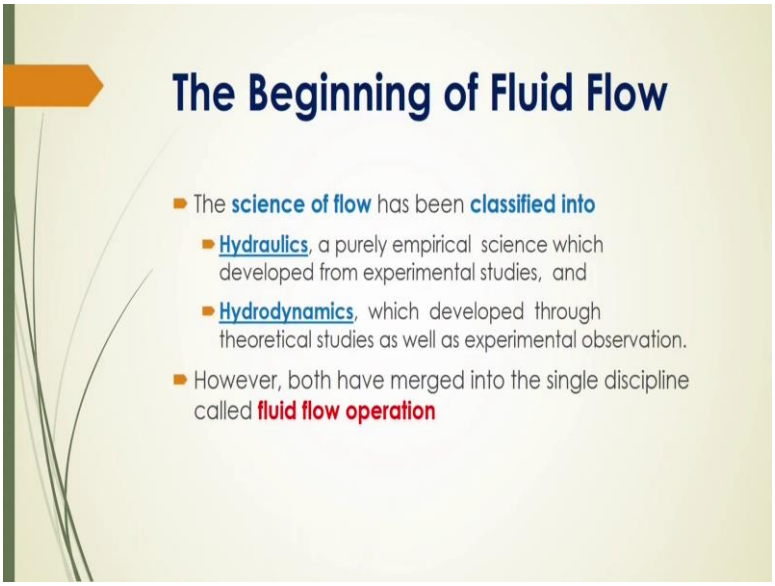

Now, question is that all the fluid flow of course it is related to the products of our daily lives, how it is processed to get these products and everywhere in chemical biochemical or the design of any mechanical devices, these fluid flow operations is related to the design and also to get the optimum characteristics of the unit or device for the particular uses in the process industry In this case then there will be certain science of this fluid flow what you are going to use for the particular processes to get our daily products.

So, what is the science of flow, so what is that particularly this science of flow is actually started from very beginning. So, we will start we will say that what does that actually start of that fluid flow will discuss here. So, in this case science of flow we can classify it into Hydraulics and Hydrodynamics. So, in this case what is that hydro die hydraulics? Hydraulics is purely empirical science and who is developed from the experimental studies based on the experimental observations how this flow mechanism of the flow can be denoted by mathematical formula or how can express this happening so science of the flow by mathematics.

So, this in the hydraulics is the science of the flow that will be basically the empirical science which is developed from the experimental studies. Hydrodynamics also it is developed through theoretical studies based on the experimental observations, so in this case the science actually developed based on the energy and momentum balances and also some other material or thermodynamic law.

So, based on that sign or theory this hydrodynamics of this flow is being actually developed and however both have this hydraulics and hydrodynamics have some extent the similarity. So, now a days these hydraulics and hydrodynamics both have masked into the single discipline which is called fluid flow operation.

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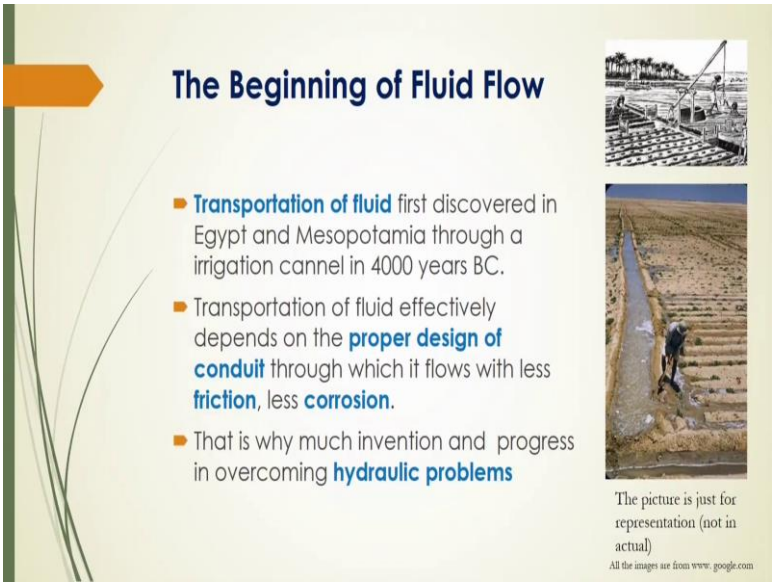

And, if we see very beginning or see that transportation of the fluid how it was happened in the early 4000 years BC and it was first discovered in Egypt and Mesopotamia through an irrigation channel in 4000 years BC and transportation of the fluid effectively depends on the proper design of conduit, through who is it flows with less friction and less corrosion.

At the at that age, it was seen that whenever fluid is flowing through the channel there was there were sudden friction of the fluid with the wall of the channel and based on which the engineers or the expert the hydraulic engineer hydraulic expert, they have designed this channel for their irrigation purpose by considering what will be the friction, what will be the corrosion of the fluid, whenever it will be flowing through the conduit.

That is why from that period onward the huge invention and progressed in overcoming the hydraulic problems was considered. In this case you will see this is the channel that through the channel the fluid is flowing and how liquid is flowing there.

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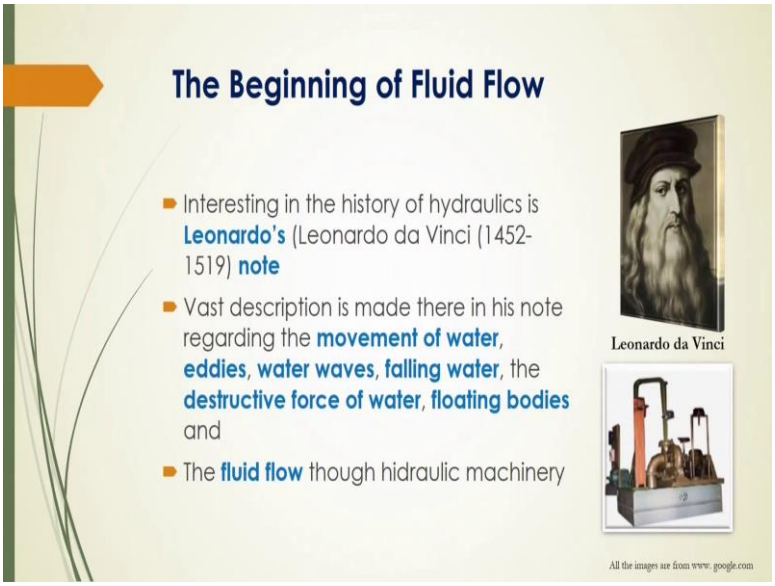

And if we go to the age of 1452 to 1450 1519 interesting that the history of hydraulics is given by that Leonardo's. Now, Leonardo's note he has described some fluid flow phenomena how water is moving and eddies of water how it will be moving and also how the water makes waves and whenever water is falling down and also how the destructive force of the water is prevailed and also the floating body is how it will be behaving whenever it will be flowing over the surface of the liquid. So, he has I think 1452 to 1519 he has described all this fluid flow phenomena in hydraulic machineries.

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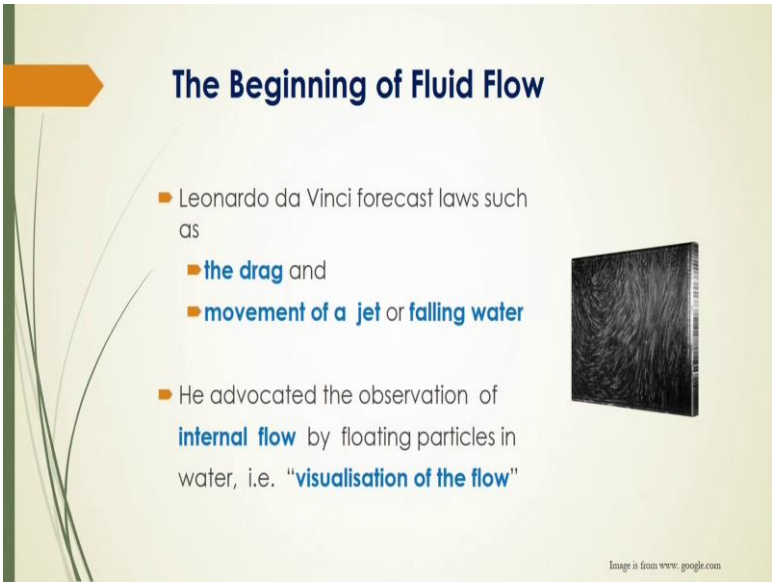

And also Leonardo da Vinci he was one of the pioneer I think investigated and he forecast some laws such as the drag whenever fluid is flowing through the pipe or channel, how this fluid is moving and whenever it will be flowing how drag is formed over the surface of the solid. Even whenever a jet of liquid is moving and when liquid is falling how it will behave what will be the flow pattern of this fluid he has given in details at that period. He also advocated to the observation of internal flow by floating particles in water by visualization of the flow.

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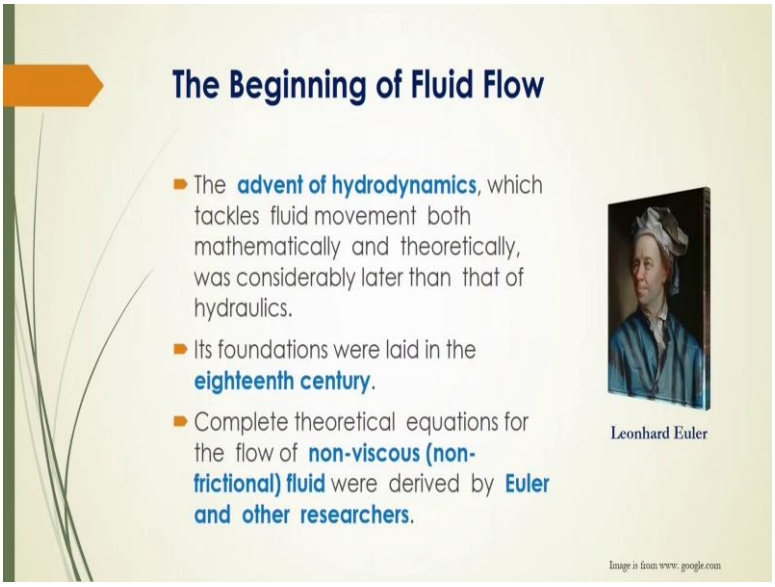

And very interesting that the advent of the hydrodynamics this tackles the fluid movement both mathematically and theoretically and it was first considerably described by I think Leonardo Euler in 18th century and he has given some theoretical equations for the flow of non viscous, non fictional fluid where derived by him and other researchers.

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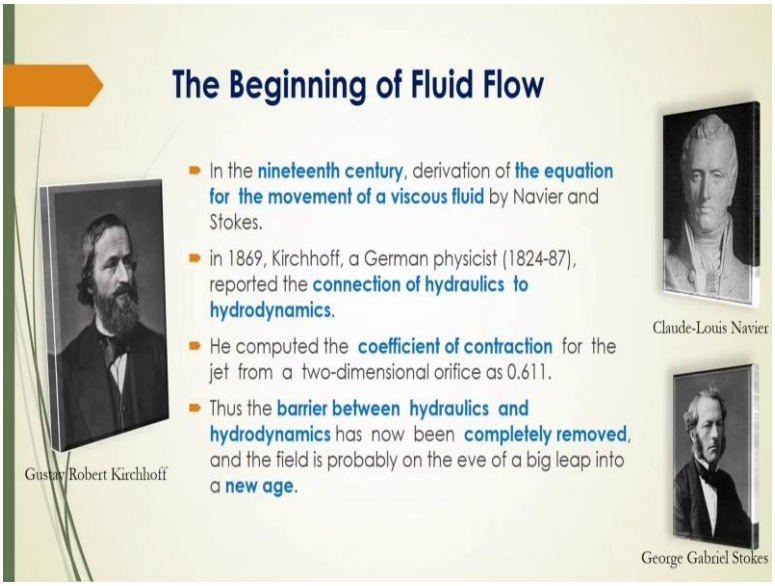

In the 19th century, the equation for the movement of viscous fluid derived by Navier and Stokes, later on in 1869 Kirchhoff a German physicist 1824 to 87 and he reported to the some relationship of the hydraulics to the hydrodynamics and he computed the coefficient of correction for the z from a two dimensional orifice as 0.611.

So, from then onward they observed that there will be certain barrier between these hydraulics and the hydrodynamics. Now that barriers whenever they have described in terms of different laws of a different phenomena of the fluid flow, they have observed that actually there was no barrier between that hydraulics and hydrodynamics. These two terms this two sciences are almost similar and they are related to each other with a certain with a certain platform. So, in that case in the in that case that the barrier between that hydraulics and the hydrodynamics completely removed and the field of probably on the eve of a big leap into a new age has come from then onward.

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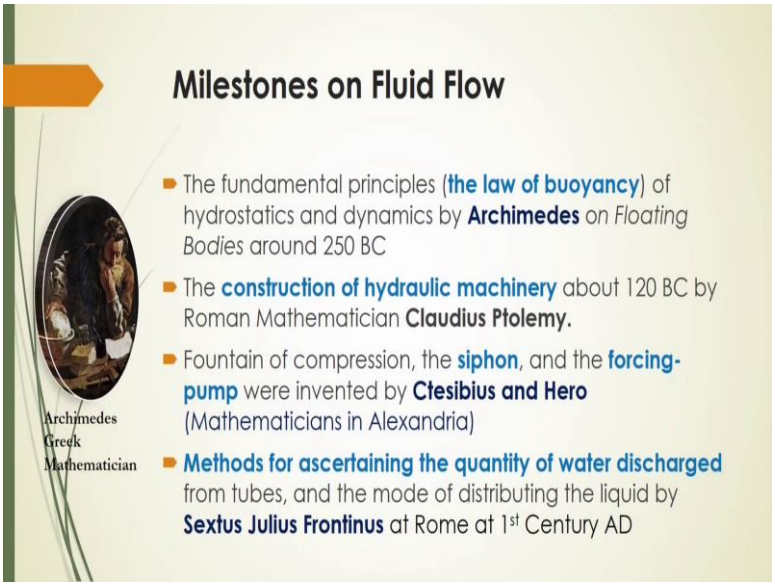

The fundamental principles of the hydrodynamics and dynamics this fundamental principles has started from a certain milestone of the fluid flow. So, we will describe here the several milestones from which the fluid flow operations and the phenomena of the fluid for the different aspects. But the design of different hydraulic machinery for the different fluid flow operations in the different chemical, biochemical and mechanical processes even civil engineering processes also. So, in that case some milestones of the science has come out, the milestones the started from the Archimedes from 250 BC.

The Archimedes is has given the fundamental principles of the buoyancy of a floating bodies around 250 BC and after that about 120 BC another Roman mathematician he has constructed a hydraulic machinery based on the principles of this fluid flow and he explained that the machinery is designed or can be designed based on the frictional contribution of the fluid for a certain operation and also later on at the same century Ctesibius and Hero they have observed that there will be a fountain of compression the siphon and the forcing pump they have invented those things.

Though they are mathematicians they are not engineers, but based on the principles of the fluid flow they have invented this forcing pump and also some methods for ascertain in the quantity of water discharge given by Sextus at Rome at 1st century AD and he has formulated some techniques how to measure the quantity of quantity of water which is discharged from the tube and distributing each in a certain operation.

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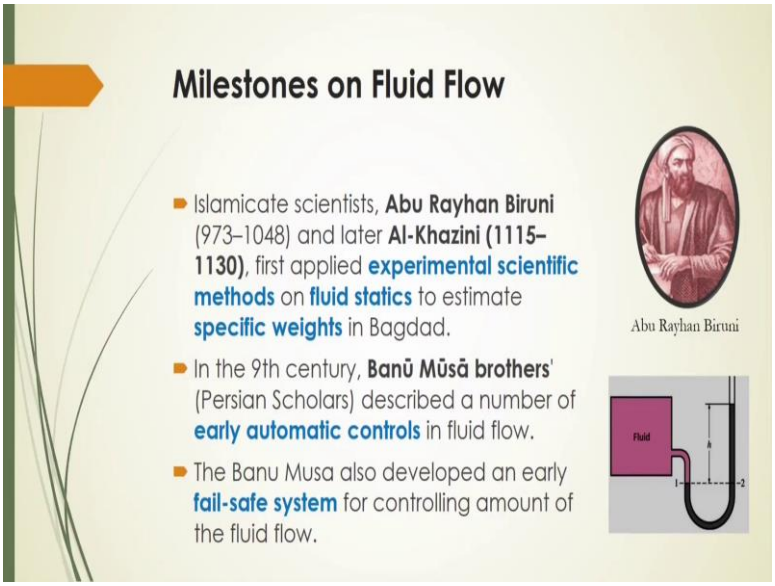
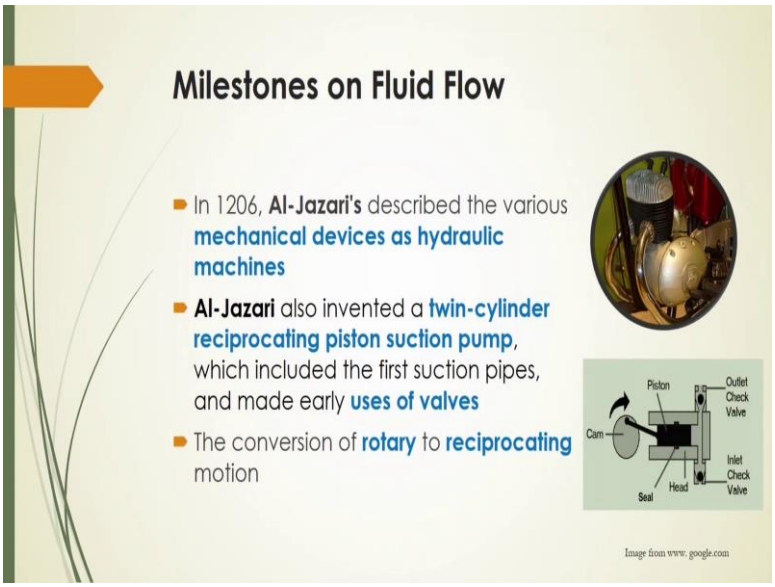


After that 1115 to 1130 Islamic scientist Abu Rayhan Biruni 1130 they have first applied experimental scientific methods on fluid statics to estimate specific weights in their location is in Bagdad and in the 19th century 9th century Banu Musa brothers they are actually Persian scholars, they have described a number of early automatic controls in the fluid flow. The Banu Musa also delivered an early fail-safe systems for controlling amount of the fluid flow. After that in 1206 Al-Jazari's description of the various mechanical devices as hydraulic machines turn to the discovery to the design of various hydraulic machines based on the methods they are used.

Al-Jazari's also invented a twin cylinder reciprocating piston suction pump based on this Al-Jazari's is initial principle and this include the first suction pipes and made early uses of valves, after that they have converted of this rotary pump to the reciprocating pump by their principle of motion.



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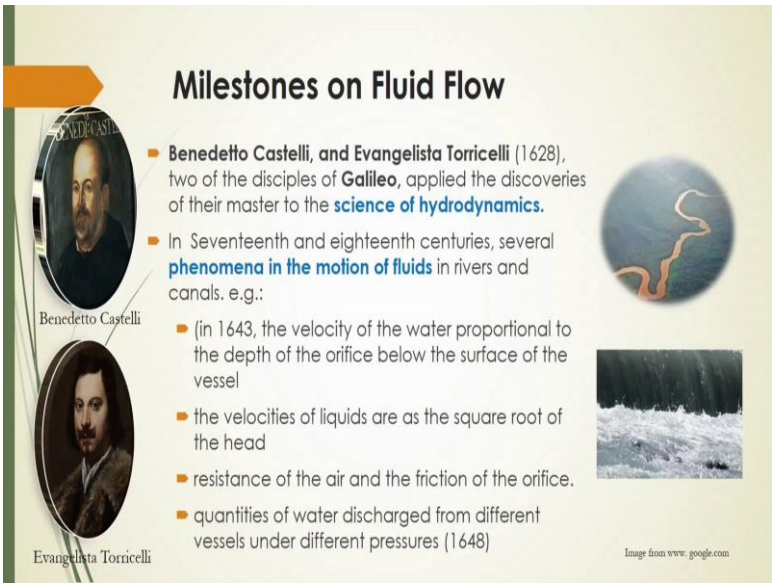

Later on 1628 Benedetto Castelli and Evangelista Torricelli the two disciples of Galileo they have applied the discoveries of their master to the science of hydrodynamics and in 17th and 18th centuries also several other phenomena in the motion of fluids in the rivers and cannels they have observed and based of they are based on their observation in 1643, they proposed that the velocity of the water will be proportional to the depth of the orifice due to the surface of the vessel and the velocities of the liquids which are flowing will be the square root of the head of the fluid flow.

And whenever the flow of fluid, there will be certain resistance if it is air there will be resistance of air and whenever air is flowing through the orifice there will be certain

friction and this frictional quantities of the air or some liquid whenever it will be sourced from the different vessels there undergo some pressures.

So, at different pressures at different resistance at different frictional resistance there will be a certain pressures. So, those pressures will be coming out from the discharge and it will depend on the quantities of the water how much it will be discharged. So, this resistance will give you the amount of discharge of water or fluid coming out from the vessel, so that is proposed in 1648.

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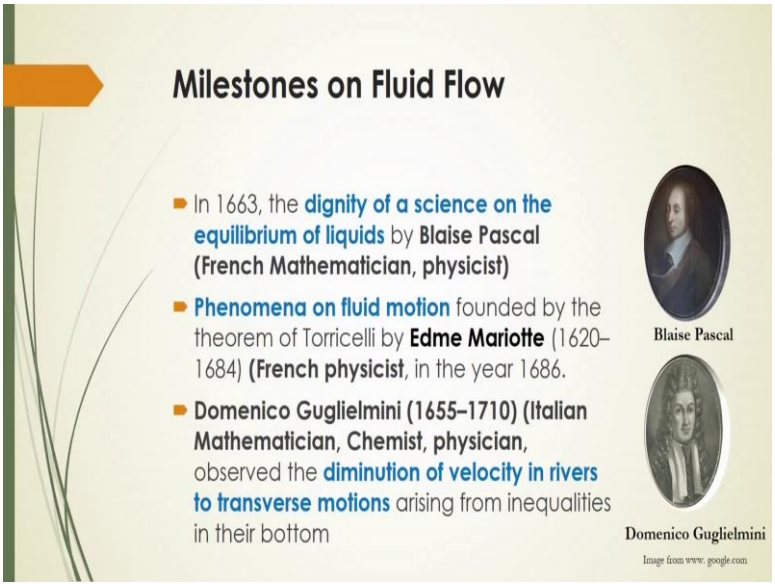

After that, in 1663 the dignity of the science on the equilibrium of liquids by Pascal which was one pioneer French mathematician and also physicist who has given the one significant milestone for the discovery of the science and based on his discovery of the dignity of the science and all the phenomena of the science of the fluid flow Edme Mariotte in the year 1686, he is a French physicist following that Pascal.

He has given some theory on phenomena of the fluid motion and he has also followed the theorem of the phenomena of the fluid motion based on the Torricellis principles. After that between 1655 to 1710 the Guglielmini Italian mathematician and also chemist you can say he is also physician, he has observed that diminution of the velocity in the rivers to transverse the motion arising from the inequalities which is observed in their bottom part of the river.

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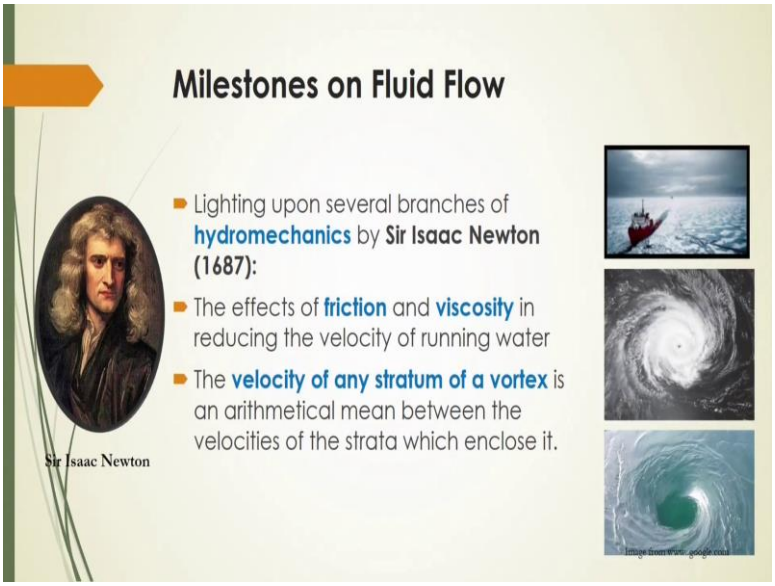

After that in 1687, the several branches of hydrodynamics was come out and it was described by sir Isaac Newton and he has observed the different effects of friction and the viscosity in reducing the velocity of the running water and also he has observed some vortex phenomena of the fluid whenever it will be flowing in a certain conduit and he observed that the velocity of any stratum of a vortex will be an arithmetical mean between the velocities of the strata who is enclosed each like this here is that the strata and what will be the velocity of this strata, this velocity will give you the vortex and the velocity of this vortex that depends on the velocity of the strata.

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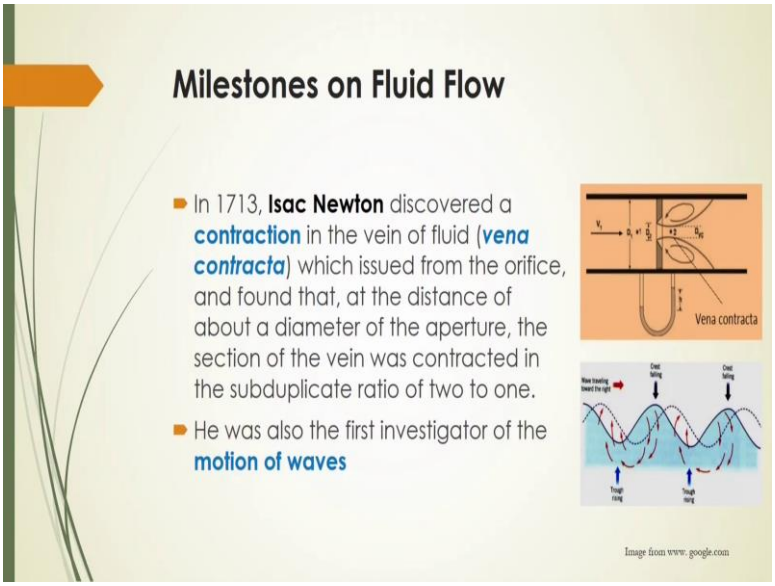

After that in 1713, Isaac Newton discovered a contraction in the vein of a fluid that is called vena contracta and this contraction in the vein whenever fluid is flowing to the tube or issued from these, he found that at the distance of about the diameter of the aperture of this vena contracta the section of the vein was contracted in the sub duplicate ratio of two to one. He was also the first investigator of the motion of the waves. So, Newton's he has first observed this vena contracta phenomena and how the circulation of the fluid happens surrounding this vein of the fluid in the contraction vena contracta the region.

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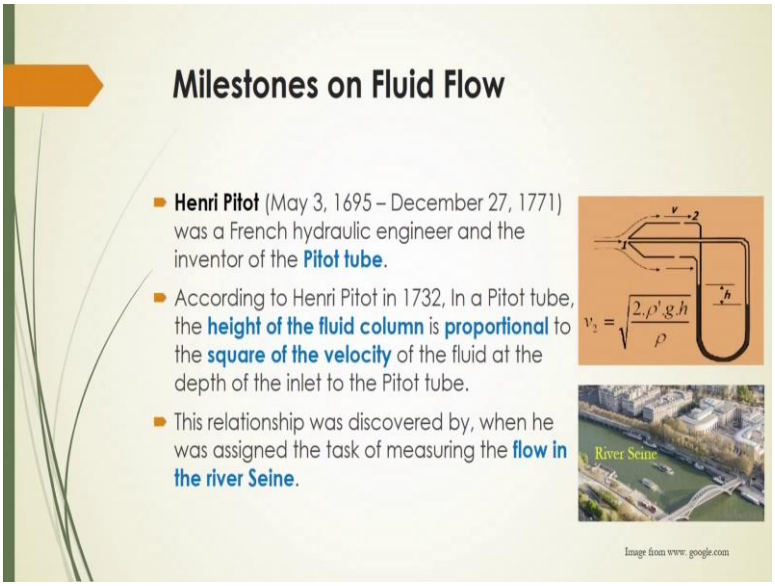

and after that there is a you can say significant discovery for the Pitot tube Henri Pitot around 1771 he has discovered the French hydraulic machine it is called Pitot tube, he was also French hydraulic engineer and by which he has measured the what will be the flow rate of the fluid and according to that Pitot principles 1732. The height of the fluid column will be proportional to the square of the velocity of the fluid at the depth of the inlet to the Pitot tube.

So, based on these principles still now the velocity of the fluid through the pipe how it is measured. See, here it is the formula is given that depends on the head of the fluid and velocity and this velocity is measured by this what is that Pitot tube. The principle of the Pitot tube will be described later on in a subsequent lecture will be there, the relationship

was discovered when he was assigned to the task task of measuring the flow in the river seine.

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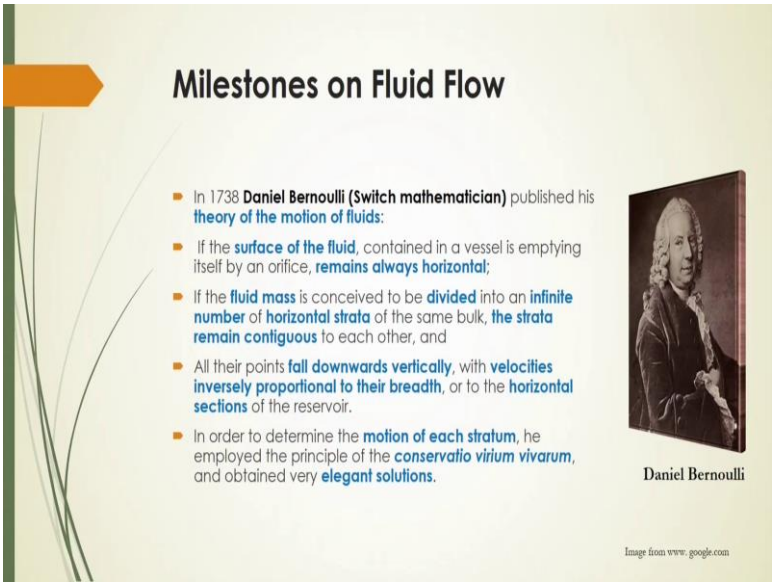

After that, in 1738 Daniel Bernoulli which was a Switch mathematician revealed his theory of the motion of fluids, he observed that if the surface of the fluid contained in vessel in employing itself by an orifice remains always horizontal and also if the fluid mass is concept to the divided or concept to be divided into an infinite number of horizontal strata of the same bulk, the strata remains contiguous to each other.

He also pointed out that, whenever liquid is falling downwards vertically with a certain velocities, the velocities inversely proportional to the breadth or to the horizontal sections of the reservoirs from which the liquid is falling down. And also based on the motion of each stratum, he also been employed to obtain the solution of the conservation of the energy, whenever fluid is flowing through the pipe and he also determined the solution and also got the elegant solution for the movement and conservation of the energy how it will be consumed in the flow of fluid.

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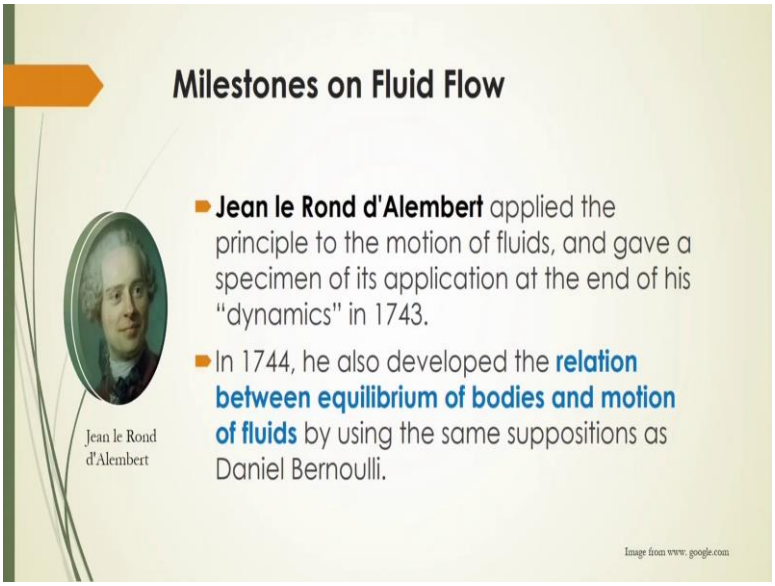

After that few years later in 1743 Jean le Rond d' Alembert he has also suggested the principles of motion of fluids and based on his principle of motion of fluids he has given a specimen of it is application or suggested a specimen of it is application at the end of his and publish article dynamics in 1743. In 1744 and the subsequent year he also revealed one relationship between equilibrium of bodies and the motion of fluids and he has developed a nice relationship this equilibrium with the motion of the fluids by the same assumption which was made by D Bernoulli earlier.

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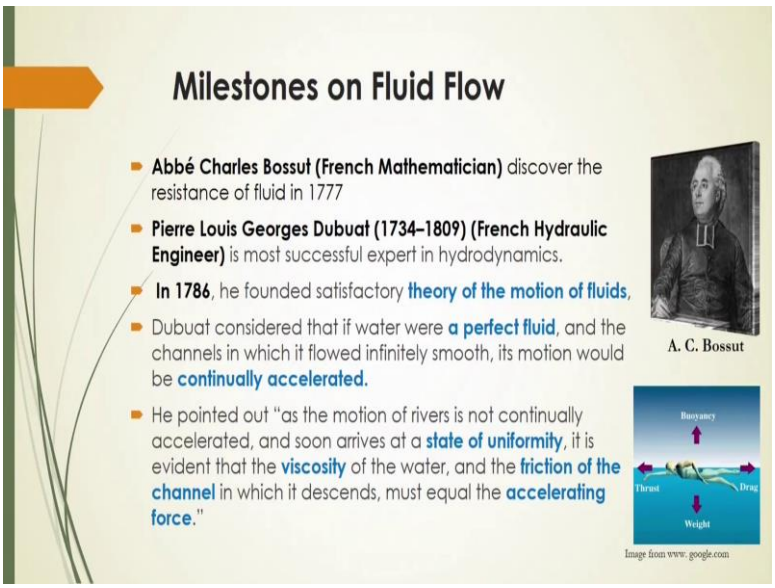

After that more than 30 years in 1777 AC Bossuet discovered the resistance of the fluid in 1777 and in 1786 also Dubuat most successful experts in hydrodynamics founded satisfactory theory of the motion of fluids and he pointed out as the motion of the rivers is not country is not continually accelerated and soon arrives at a state of uniformity. It is evident that the viscosity of the water and the friction of the channel in which it descends must equal the accelerating force.

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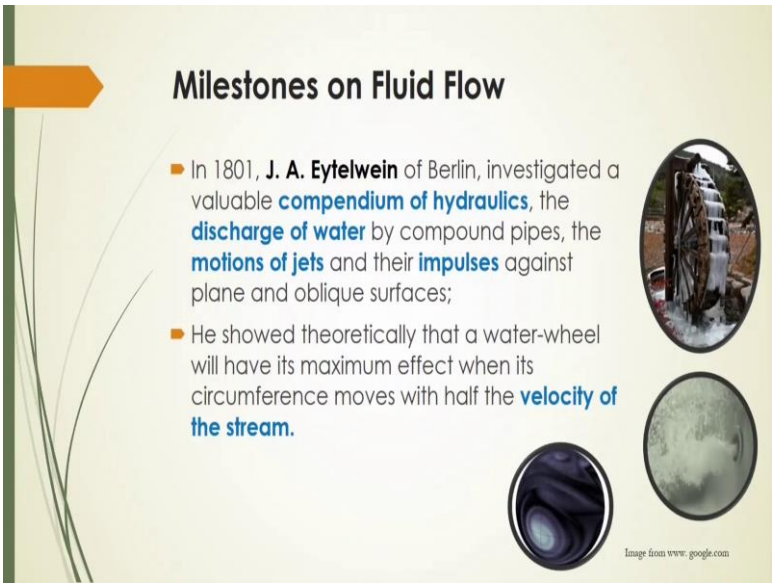

After that 1801 J.A. Eytelwein a Berlin investigated a valuable compendium of hydraulics, the discharge of water by compound of pipes the motion subjects and their impulses agonist the plain and oblique surfaces. He showed theoretically that waterwheel will have it is maximum effect when it is circumference moves with half of the velocity of the stream.

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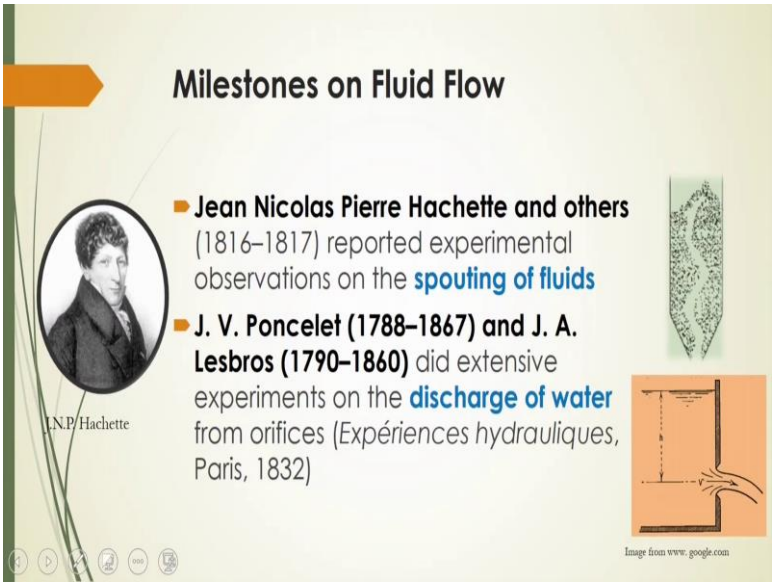

Jean Nicolas Pierre Hachette and others investigator reported experimental observations in between 1816 to 1817 on the spouting of the fluids. After that Poncelet and J.A. Lesbros did extensive experiments on the discharge of the water and which was the one important milestone to discover the orifices and how it was working to measure the discharge of the fluids.

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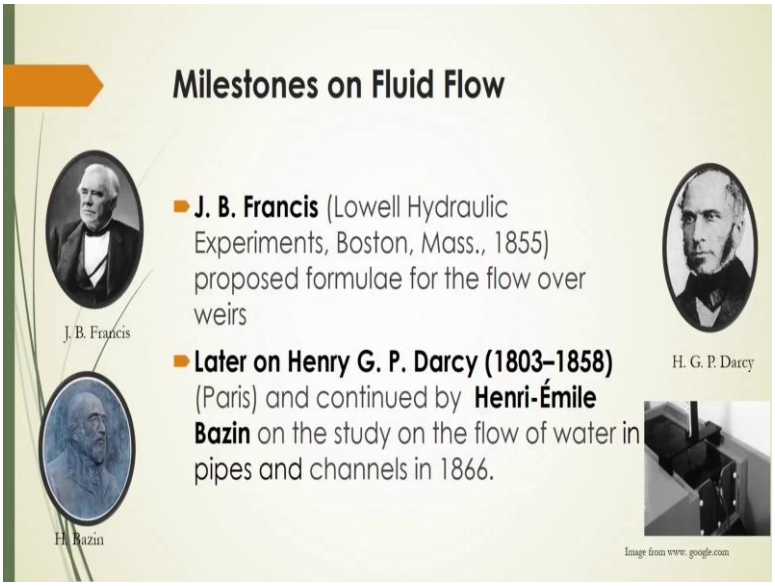

And the J.B. Francis after that 1855, they have published their proposed formula for the flow over years this is also one important milestone for the civil engineering discoveries. Later on Henry Darcy

they continued with Henri-Emile Bazin for the study of flow of water in pipes and channels in 1866.

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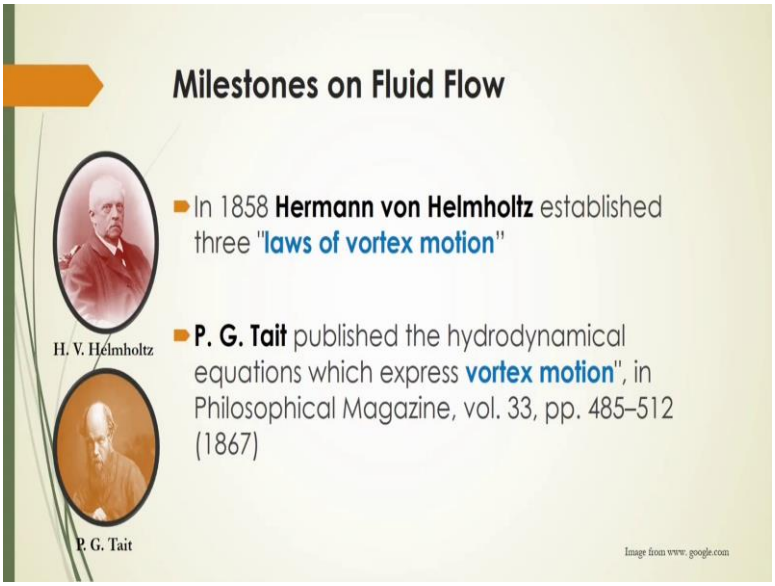

Later on in 1867 P.G. Tait published the hydro dynamically questions which expresses vortex motion based on the laws of vortex motion that is given by Herrmann Von Helmholtz in nineteen in 1858.

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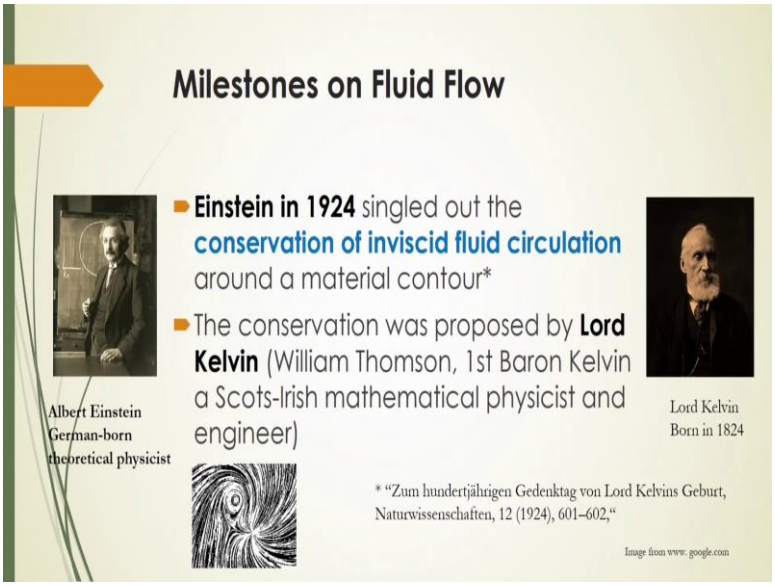

Einstein after that 1924 after several years later and he has given one even wonderful theory for the conservation of inviscid fluid circulation around a material contour. They

have discovered how the energy is transporting in the inviscid fluid whenever it will be circulated around the material, the conservation was proposed by Lord Kelvin and he was the 1st Baron Kelvin a Scots Irish mathematical physicist and engineer as well.

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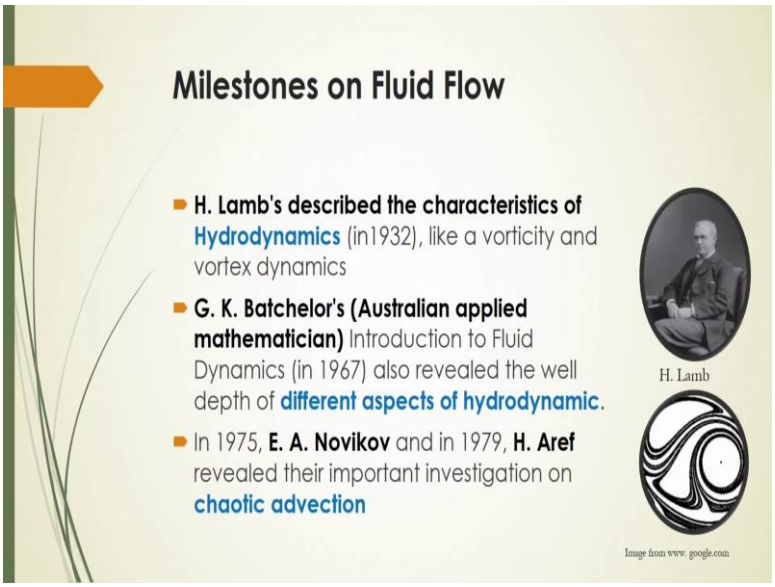

After that in 1932, you can say this the H. Lambs sorry it is H. Lambs discovered the characteristics of the hydrodynamics based on the vorticity and vortex dynamics and then G.K. Batchelors introduced to the fluid dynamics in 1967 and published to the well depth of different aspects of hydrodynamic. After that in 1975 Novikov and in 1979 Aref revealed their important investigation on the chaotic advection.

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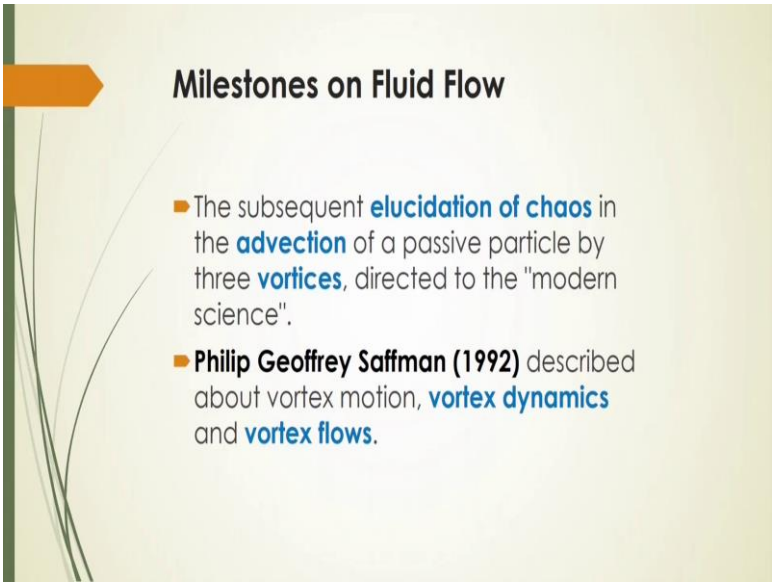

And then the subsequent elucidation of cells in the advection of chaos particle by 3 vortices based on the previous that is principles of the vortices and which will be directed to the modern science for the fluid flow operations. After that 1992, Philip Geoffrey Saffman he described about the vortex motion in details and also brought it is dynamics and the vortex flows in more details for the application in the several processes.

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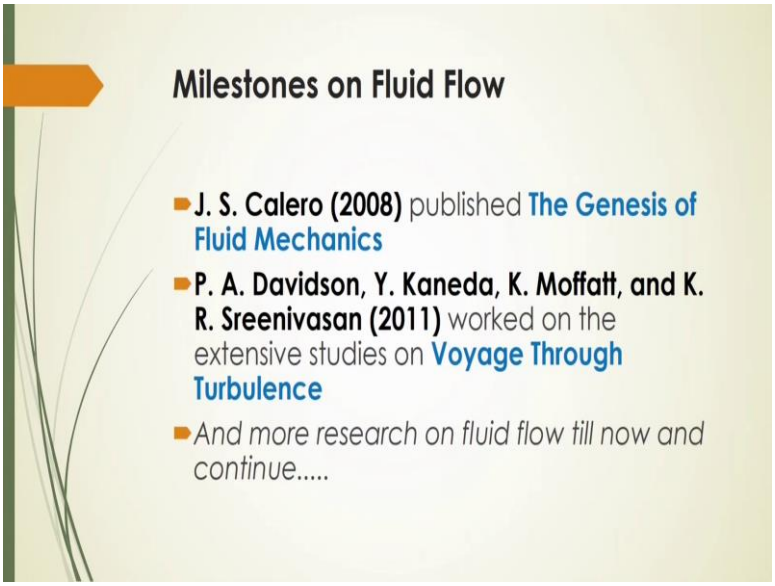

In 2008, later on this one is also important milestone and J.S Calero has published to the genesis of the fluid mechanics and after that in the subsequent year the lot of research is

going on and different authors different investigators they published a lot of words from the fluids phenomena and one important aspects in 2011 the Davidson et al they have worked on the extensive studies on the voyage through turbulence and how this turbulence will be affecting the different processes and how it can be minimized and how it can be maximized for the beneficiation of the process yield and from then onward there will more research on the fluid flow till now and it is being continued.

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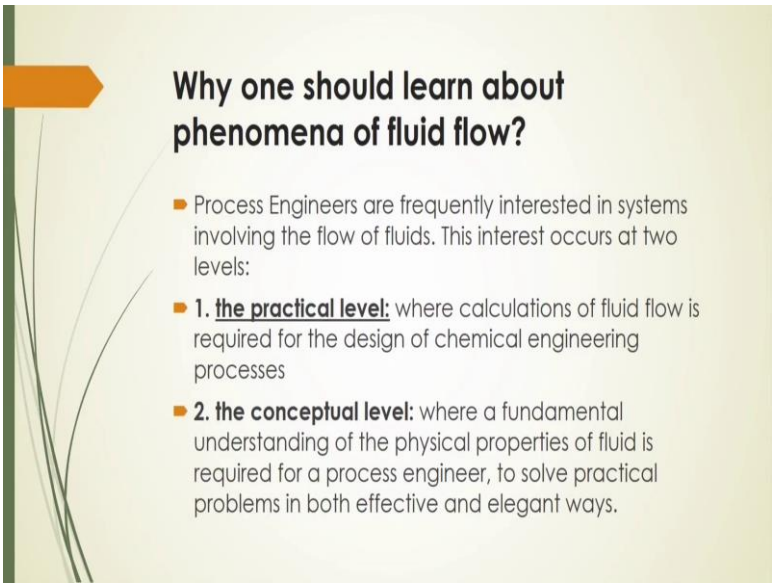

Then question is that this is the history after that knowing this history there are several worth several investigations is going on the fluid mechanics and fluid flow operations. Now, why the people should learn the fluid flow operations or why one should learn everybody cannot learn, so why are who is actually learning this of course, this is important for the process engineers.

So, process engineers are very interested in the systems that would be in well involving the flow of fluids and that is why interest is going on to the fluid flow operations because, this fluid flow operations is directly related to the process yields. So in that case the for the design of various equipments various process equipments and the development of the process even intensification of the process it is very necessary to know the fluid flow operations by the process engineers.

So, process engineers of course interest occurs at the 2 levels here to know the fluid flow operations; one is the practical level which is actually consists of calculations of the fluid

flow which is required for the design of chemical engineering processes and the second one is the conceptual label by who is the engineers or process engineers you can say they should learn the fundamental of the fluid flow, the physical properties of the fluid which is required for him to solve the practical problems in both effective and elegant ways.

Also you will see that this fluid flow calculations that will include several things, like how pipe network will be designed that depends on the fluid flow because the sizing of the pumps that depends on the discharge rate of the flow and the pipeline through which it will be transported. So, through the pipe lines whenever fluid will be transporting there will be some frictions, so you have to know the friction mechanism and also the fundamental of the frictions.

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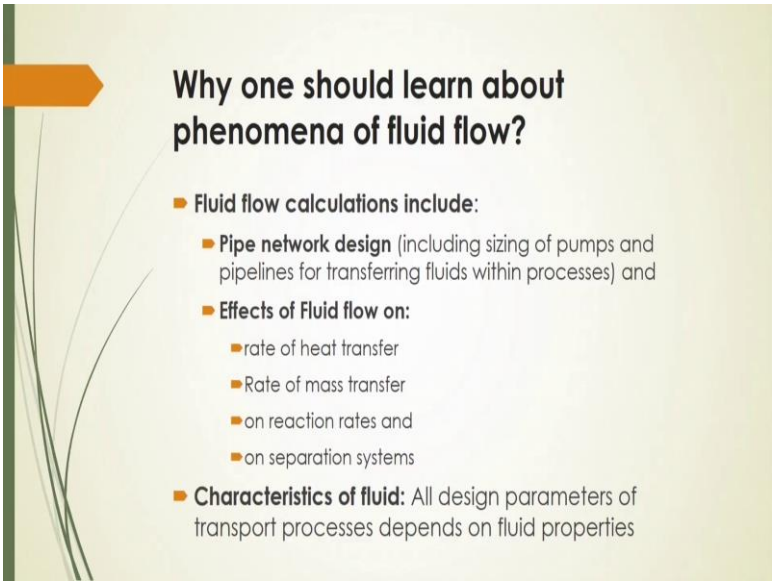

Also, the effect of fluids on the you will see there will be different operations for the heat, for the mass, for the reaction, and also for the separation processes in our daily lives. You will see the heat transfer equipment for the mass transfer equipment like suppose crystallization this is one mass transfer equipment, there will be a distillation column mass transfer equipment absorber mass transfer equipment packet operations were the adsorption of the contaminants of the liquid to the surface of the solid particles this is one type of equipments.

So, whenever designed these equipments you have to know the fluid flow phenomena there, so this fluid flow fluid flow phenomena will give you the yields of the rate of the

heat transfer yields of the rate of the mass transfer, yields of the reaction rate, yields of the separation systems, and also for this the process yield based on the this fluid flow operations you have to know the characteristics of the fluid.

Because, if you know the fluid characteristics then what will be the fluid is flowing, what type of fluid is flowing, what will be the physical properties of the fluid, how friction is happening, what will be the rate of the fluid or flow rate of the fluid inside the reactor, what extent of friction during the fluid, what will be the circulation velocity of the fluid inside the fluid that depends on the fluid properties? So, all design parameters of the transport processes depends on the fluid properties.

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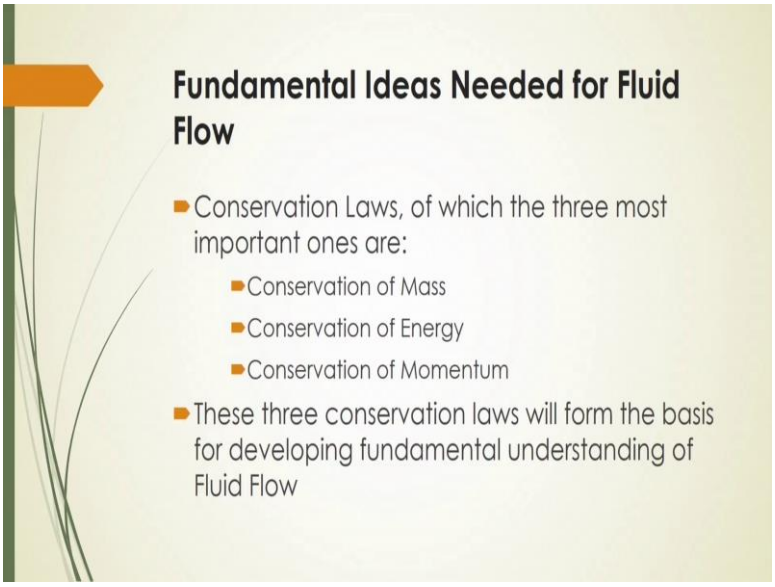

And also you have to know or engineers should know the fundamental ideas needed for the fluid flow. You should know the conservation laws which is very important and which has 3 most important parts; one is conservation of mass, conservation of energy, conservation of momentum. By these 3 laws one can solve the process parameters for the heat and mass transfer for the particular separation processes for mass transfer operations.

And also fluid phenomena inside the equipment how it is happening, what will the flow pattern, how energy is distributing, how the concentration of the fluid elements will be distributing throughout the column or reactor? That will be solved by this conservation of mass, conservation of energy, conservation of momentum.

These three conservation laws will form the basis for the developing fundamental understanding of the fluid flow.

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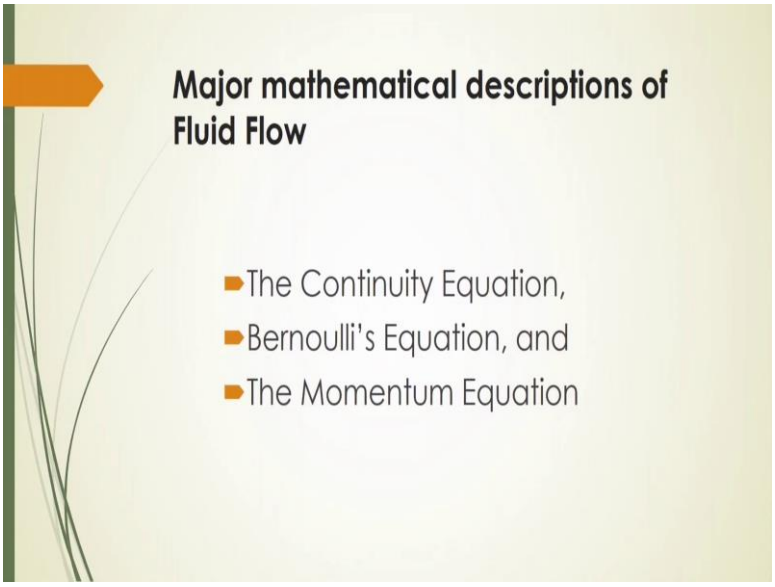

And to express this mathematical form of the process yield or design parameters or the phenomena of the fluid inside the conduit or inside the reactor, inside the equipment, the mathematical expressions are classified into 3 are described by 3 equations here that is called the continuity equations, the Bernoulli's equations and the momentum equations.

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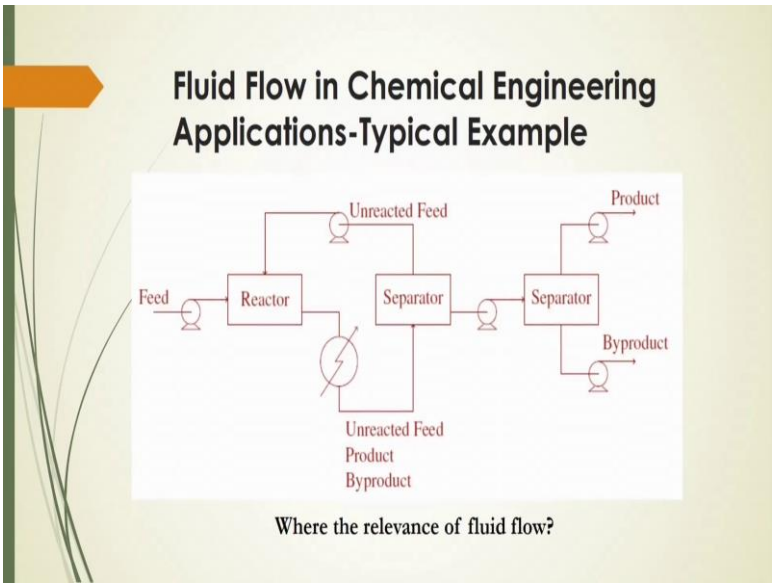

Let us see one example here how fluid flow operations will be related to the equipment for the particular chemical engineering processes here.

See one processes here. In this case one reactor is being used for this processes to yield the different products and byproducts and feed here the feed is transported by a pump through pipe, to the reactor and from the reactor through the pipe the unreacted feed is coming and it will be sent to through the pipe by pump to a separator and also unreacted feed products and byproducts it will be sent to separator. And in this separator after a certain chemical processes the products will be separated into various types of products these products and also byproducts.

So, for this to sending to send from one equipment one unit to another unit, the pump is required pipe is required and also for the process the different units are required. So, in this case you will see the relevance of the fluid flow to the design of the process unit or pipes.

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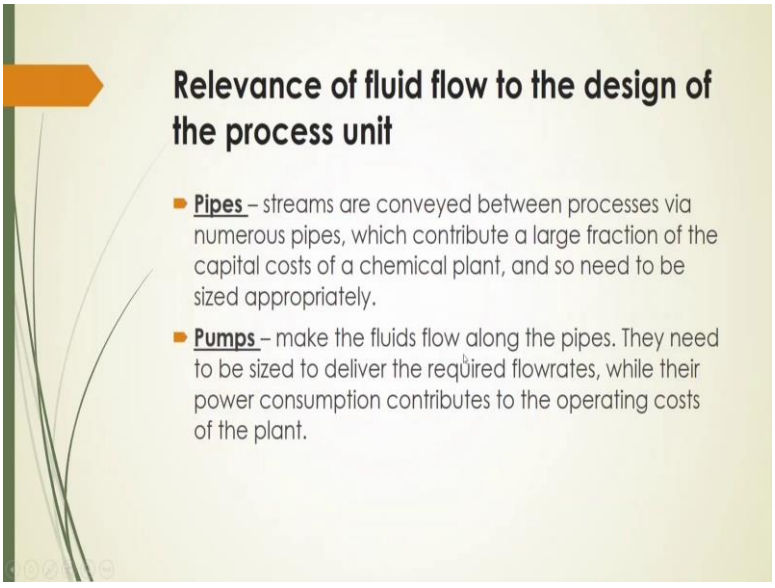

So, in this case streams are conveyed between processes via numerous pipes, whose contributes a large fraction of the capital costs of a chemical plant and so, need to be sized appropriately. And if you are using pumps it will make the fluid flow along the pipes. They need to be sized to deliver the required flow rates, while their power consumption contributes to the operating costs of the plant.

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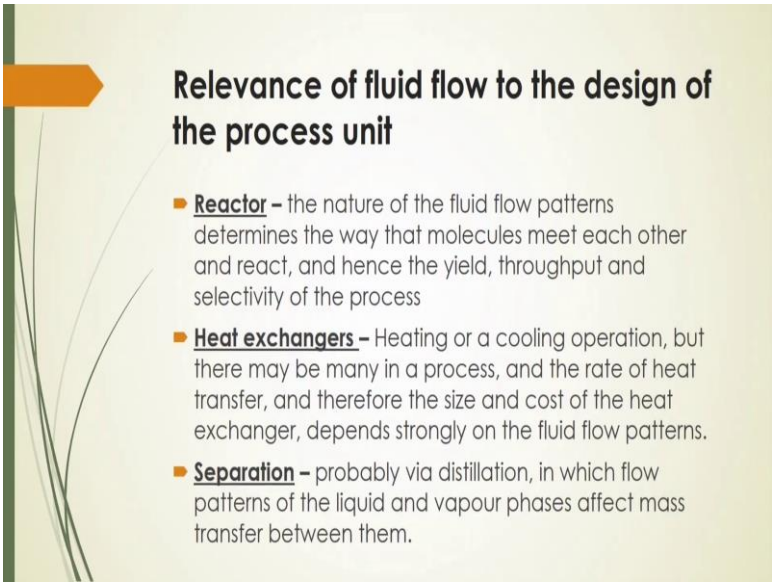

Reactor also the nature of the fluid flow patterns determines the way that molecules meet each other and react and hence the yield throughout and selectivity of the processor.

Heat exchangers in this case heating or cooling operation, but there may be many in the process and the rate of heat transfer and therefore, the size and cost of the heat exchanger depends strongly on the fluid flow patterns. In the separation processes in the separator of course, the probably by distillation for the for getting the different byproducts in who is flow patterns of the liquid and a vapor phases which will affect the mass transfer between them.

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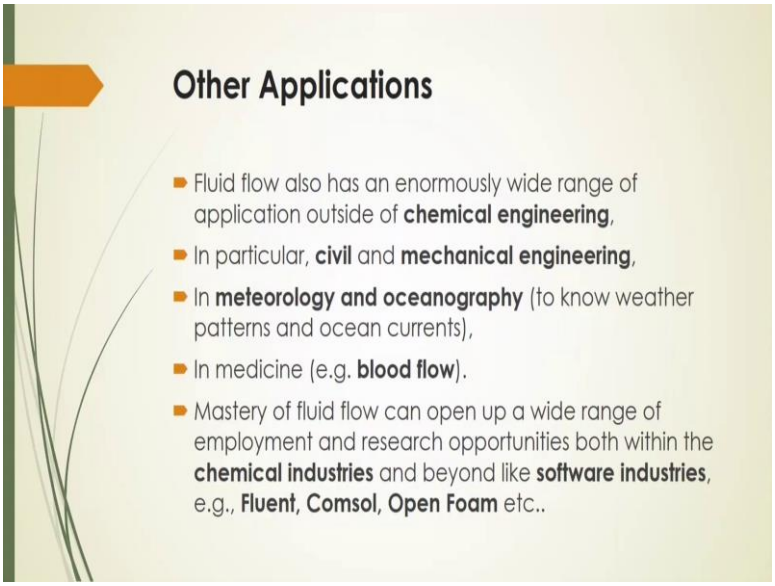

Other applications like fluid flow also has an anonymously wide range of application outside of chemical engineering, in particular civil and mechanical engineering, in meteorology and oceanography to know the weather patterns and the ocean currents. In medicines like how blood is flowing through the way mastery of fluid flow can open up a wide range of employment and research opportunities both within the chemical industries and beyond like software industries example like fluid flow, Fluent, Comsol, Open Foam etc are using different softwares and they are making softwares and these softwares are made based on the principles of the fluid flow.

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So, I suggest to read more about the fluid flow operations and you can follow the Wikipedia and also some other references here. So, thank you for your patience and we will be discussing and then subsequent lecture, the main part of the courses that is the fluid what is fluid, what is the fluid statics, how fluid will be actually represented by different equations, fluid phenomena and other parts.

So, this lecture only the fluid flow operations, what is the history of that fluid flow operations, how these people operate are related to the different processes; whether it will be chemical or biochemical or civil engineering processes. Some extent it will be related to the other engineering processes. So, fluid flow important for that and this is directly related or you can say some processes it will be indirectly related for the yield of the product by that particular processes.

So, thank you.