Basic Principles and Calculations in Chemical Engineering

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Lecture – 1
Definition, History, Role of Chemical Engineer

Welcome to massive open online course on basic principles, and calculations in chemical engineering. So in this course we have 12 modules and around 36 lectures, and we will cover all the basic principles, and calculations in chemical engineering or successively. And today we will discuss in module 1 as an introduction where some definition history and role of chemical engineers should be discussed in this lecture.

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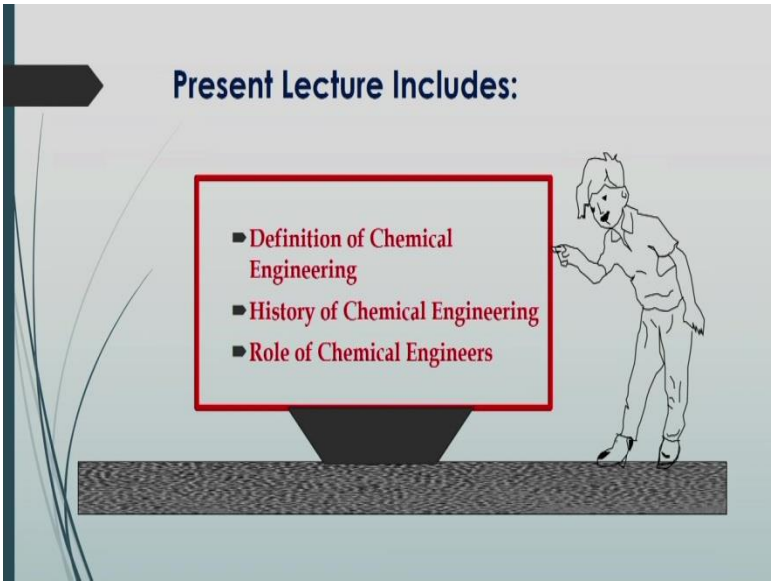

So it will include the definition of chemical engineering, history of chemical engineering and role of chemical engineers in the society.

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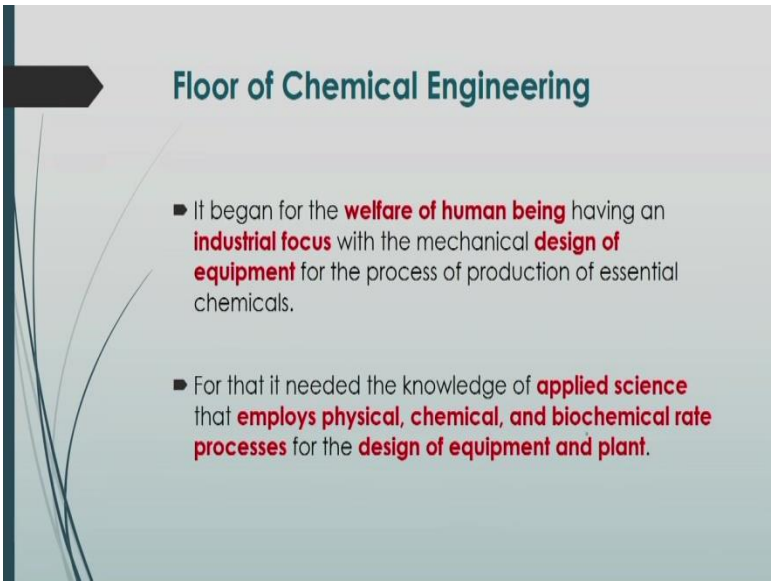

Now as you know that various suspects of chemical engineering which actually leads to for the welfare of human being based on industrial focus with some mechanical design of equipment for the process of production of essential chemicals. Which are very important for our daily life so for that the knowledge of applied sciences that employs physical chemical and biochemical rate processes for the design of equipment and plant?

So, if we say about the core of chemical engineering. We have to think about based on which that engineering aspect for the welfare of the human being is required. So initially we have focused on that what should be the basic history of that chemical engineering from where this chemical engineering profession started? And what are those main aspects of chemical processes? And also how that chemical engineering processes developed for the production of essential chemicals in society, which is required for our daily life.

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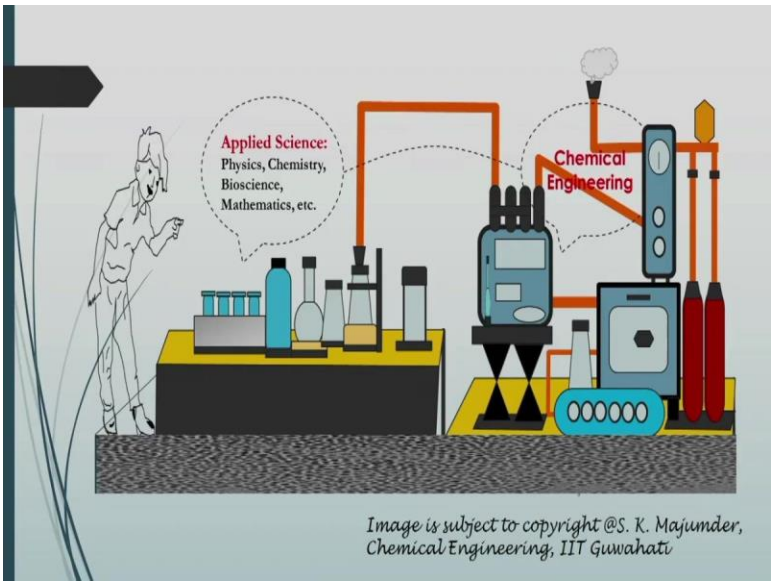

So in that case before going to that, we have to say that this engineering, whether it is chemical engineering or mechanical engineering, civil engineering. All those engineering streams basically depends on that some sciences theory of sciences and then that sciences to be applied for the production of essential chemicals there. So, you have to apply those sciences how to develop the process based on that sciences. Like to produce suppose that some sodium hydroxide solution, calcium hydroxide, even chlorine gene some organic chemicals LPG even like petrochemical industries there are several oils those are produced.

That is of course coming based on some processes. So, all those process whenever being done that processes of course will be based on some fundamentals of the knowledge on sciences. Those sciences may be Physics may be chemistry may be bioscience, even mathematics also. So those sciences will be required to develop equipment. And also that plant accessories to that procure plant to produce that particular a chemical based on a certain process. So, anywhere if any process is developed that will be depending on the applied sciences.

So, that applied science is converted to the chemical engineering based on that knowledge of physics, chemistry, bio-science, and mathematics, etc. So here one schematic diagram of that process is shown of that is basically the laboratory scale some process is developed based on that sciences like physics, chemistry, bioscience and mathematics. And from those sciences if you applying in laboratory scale. And what should be the product? Then that process will be scale up

in industrial scale, and that scaling of that processes and converting this process is represented by the chemical engineering. That will be called as the aspect of chemical engineering and related to that applied sciences.

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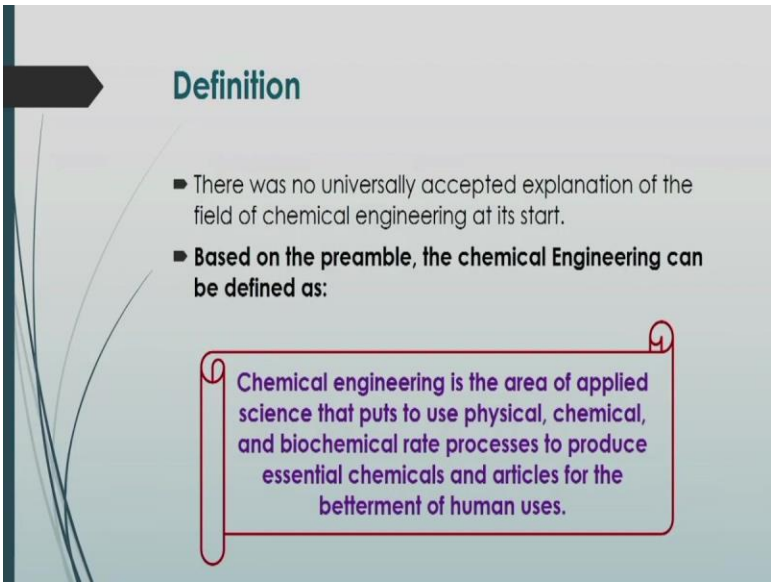

Now before going to the discussion on this chemical engineering process and also different aspects of chemical engineering. And its basic calculations and also principles of that chemical engineering process. You have to know what is the definition of that chemical engineering. Actually there was no universally accepted explanation of the field of chemical engineering at its start. And their some process is developed at early stages basically in 19th century there.

Whenever process was developed, that processes were actually based on that some engineering aspect based on some science knowledge and also for that some preamble of consortium to make this chemical engineering profession and based on that preamble the chemical engineering actually was defined as that chemical engineering is the area of applied science that puts to use that physical or chemical biochemical rate processes to produce essential chemicals and articles for the betterment of human uses.

So, this was the first definition of this Chemical Engineering. Which were made based on the preamble of the chemical engineering aspects of the 19th century.

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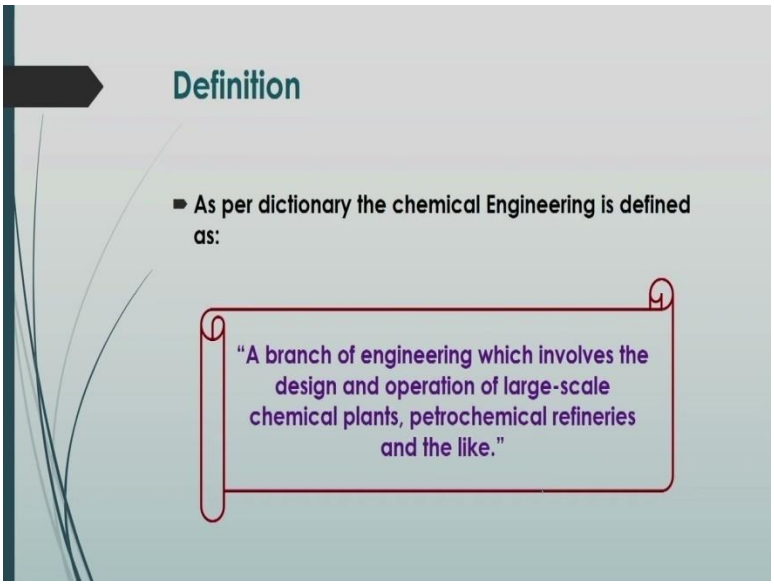

And as per Dictionary, the chemical engineering is defined as; it is a branch of engineering which involves the design and operation of large scale chemical plants petrochemicals, refineries, and the like others. So, this is the definition of chemical engineering as per dictionary of chemical engineering.

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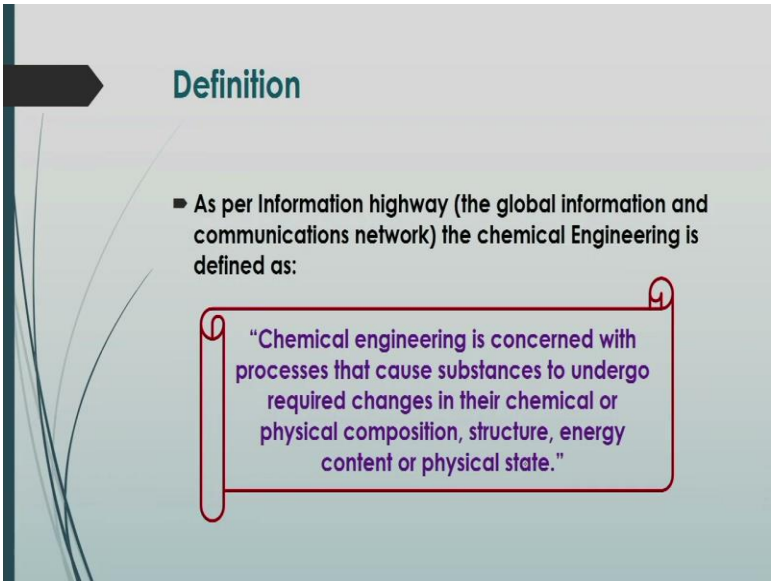

Even other definitions of the chemical engineering given by different organization like in that as per information highway that Global Information and Communication networks. So based on their aspects their view the chemical engineering is defined as it is actually concerned with the process that cause substances to undergo required changes in their chemical or physical

composition, structure, energy content or physical state there. So this is the definition given by information Highway.

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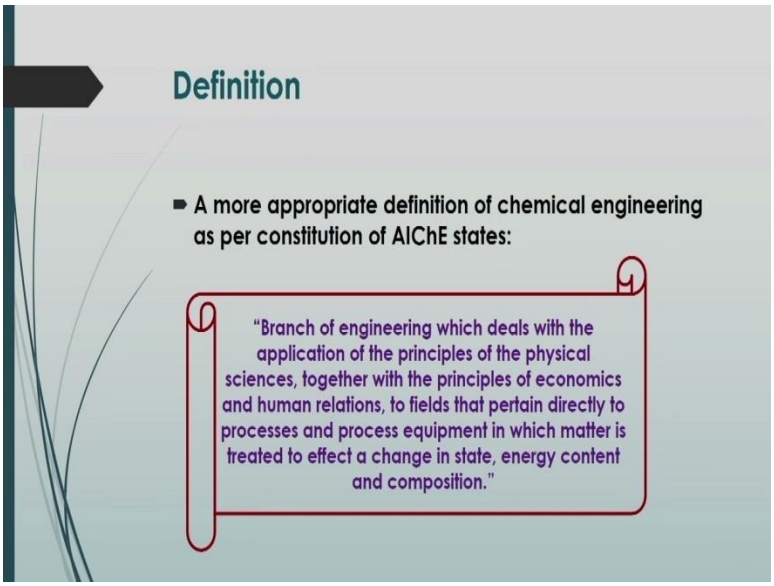

And later on more appropriate definition of chemical engineering as per constitution of American institute of chemical engineers. And the organization states this definition of the chemical engineering as the branch of engineering which deals with the application of principles of the physical sciences together with the principles of economics, and human relations to field that pertains directly to process and process equipment in which matter is treated to affect a change in state energy content and also composition.

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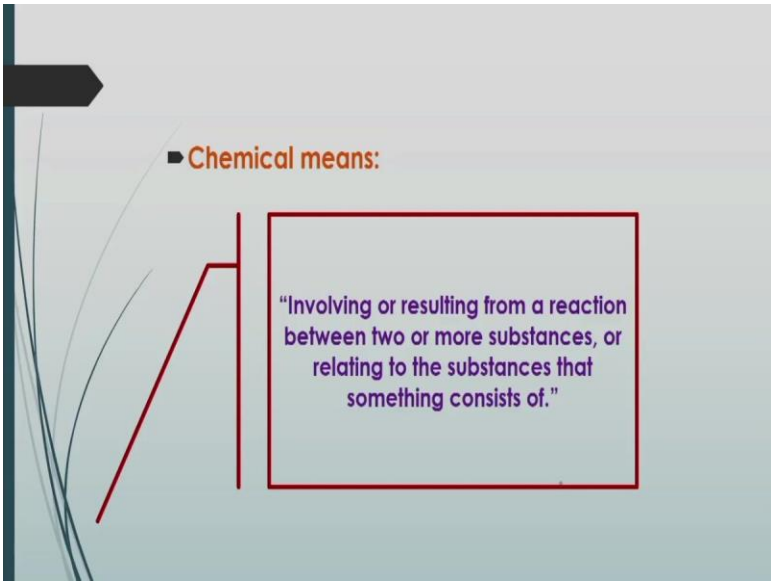

And so these are the different definitions of the chemical engineering given by different organization and based on which can say that basically this chemical engineering which is developed based on the knowledge of applied sciences. So all sciences will be contributing to the development of the chemical engineering. So that is why this chemical engineering now days is the interdisciplinary professions.

In which all the streams of sciences are contributing a lot for their basic sciences to the application state to the chemical engineering processes. And what is that chemicals actually? You have to also understand the meaning of that chemical. This is basically represented by a substance which involves results from a reaction between two or more substances. You can say that to relate to the substances that something consists of, so in this way you have to define that chemical. What is that chemical means?

Aspect of chemical engineering from where you can say that based on the chemical how it can be processed so that processing is actually represented by that engineering aspects and that engineering will be based on that the science that is of all streams.

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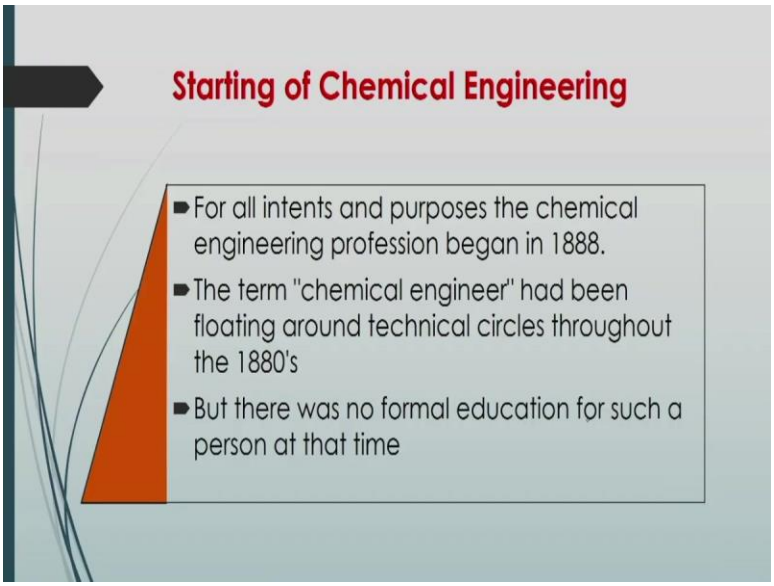

Now if we look back to the starting of the chemical engineering. So in 18th century at the last part of 18th century especially in 1888. You will see that for all intents and purposes. The chemical engineering profession actually it began in 1888 and the term in that case chemical

engineer had been floating around technical circles throughout the year 1880's. But there was no formal education for such chemical engineering profession to given to a particular a person recognition at that time. So this is actually beginning of this chemical engineering.

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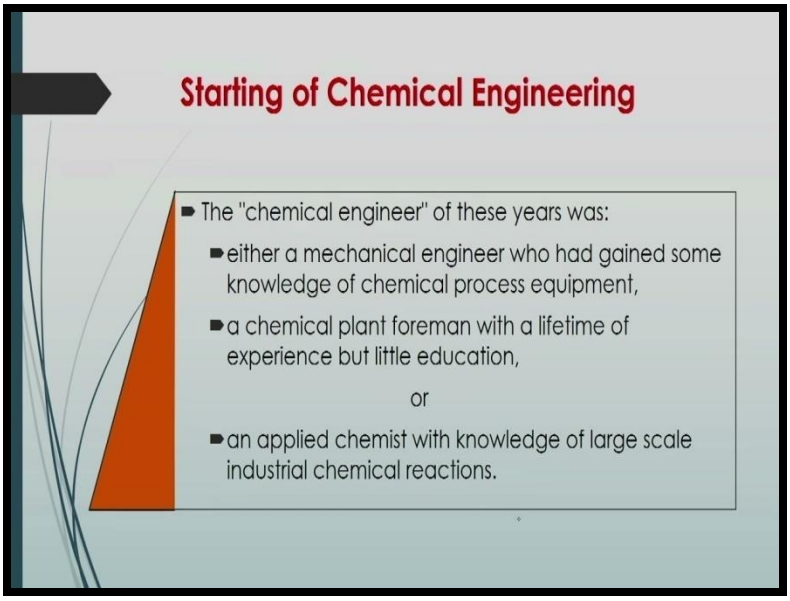

However the chemical engineer at this stage that was both a mechanical engineer who had gains some knowledge of chemical process equipment and also the chemical plant sometimes required some the observer or you can foreman. So at that time a chemical plant foreman with lifetime of experience but little education regarded as a chemical engineer. And at that time it was say that an applied chemist who can be regarded as a chemical engineer.

If he has some knowledge of large scale industrial chemical reactions. So, basically the chemical engineering was not defined properly at that time. If anybody works on the chemical plants which some special knowledge of some chemical reaction or some knowledge of chemical process equipment. They were regarded as chemical engineer.

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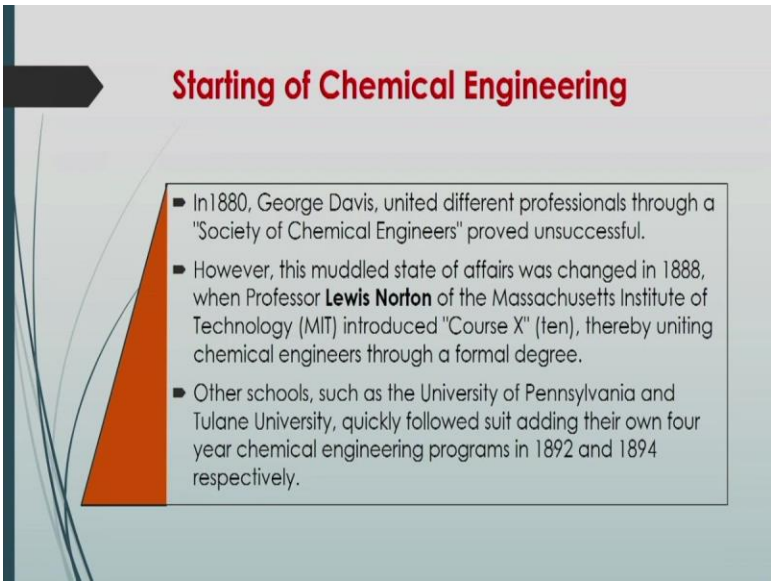

In 1880, George Davis so at that period he just made a group of those foremen and some persons those who know that chemical process equipment design as well as the reactions. They are making together as a Society of chemical engineers but anyway these makings of chemical engineering society were not successful at that period. However this model state of that appears to make the society of chemical engineering was changed in 1888.

When this professor Lewis Norton of the MIT USA that introduced course 10. There by uniting chemical engineers through a formal degree. And at that time some other organization also was thinking how to make that one profession of chemical engineering by giving some post work, some peoples also some new peoples are giving the training of that chemical process equipment design as well as that reactions. So they have started their formal degree on this chemical engineering.

So in that case university of Pennsylvania and Tulane University quickly followed sweet adding their own 4-years chemical engineering programs in 1892 and 1894 respectively. Just after that 1888 when this professor Lewis Norton made a course 10 for the chemical engineering degree by giving those course training there and after that there are several persons they got their chemical engineering degree from different organization and they become renowned chemical engineer based on their work experience as well as their development of some other equipment which will be directly or indirectly related to the chemical engineering process.

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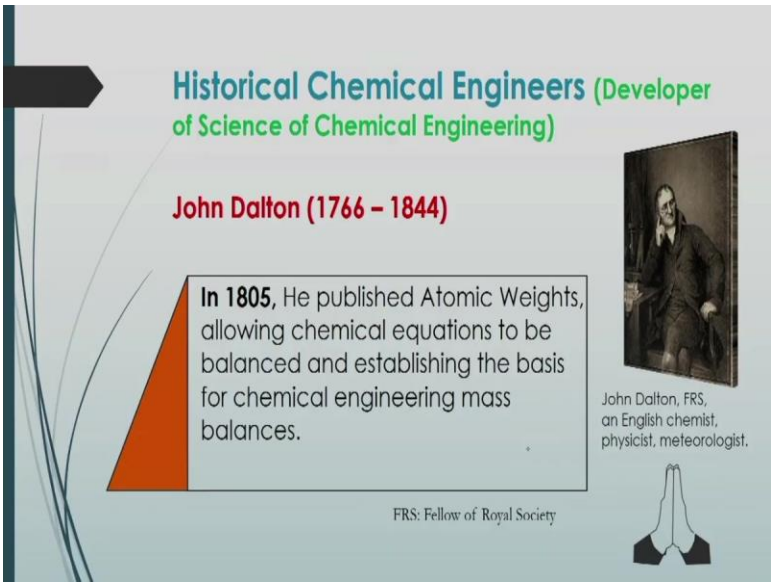

So in that case we have to salute them historical chemical engineer who has developed chemical engineering based on science of different streams and they have regarded it as a science or chemical engineering. So those historical chemical engineers have contributed a lot initially to develop this chemical engineering professions In this case John Dalton. He is one of the finer chemical engineers at that time.

And he published atomic weights in their research articles when he was working with this development of science of chemical engineering. And he worked on those atomic weights. How these atomic weights will allow the chemical equations which is to be balanced and also how it can be established the basis of chemical engineering mass balances. That was done in 1805. And he was at that time the fellow of royal society and he was English, physicist and was called as meteorologist in 1805.

So he was the first person who has developed the chemical equations, how to balance sheet and also how to do the mass balance for the chemical engineering processes. After that 1824 of French physicist Sadi Carnot and he also worked on, it is called combustion reactions and what is the thermodynamic aspects of combustion reactions energy in energy out. And what should be the different characteristics of the thermodynamic properties on that, combustion reactions.

He in 1824 he has written book to study the thermodynamics of combustions, reactions. And he described to the Carnot cycle in his book, how to relate to the theory of heat engines are also described in his books. And he published that books what was the name was that the reflections on the motive power of fire. So that was the first book to study the thermodynamics of combustion reactions.

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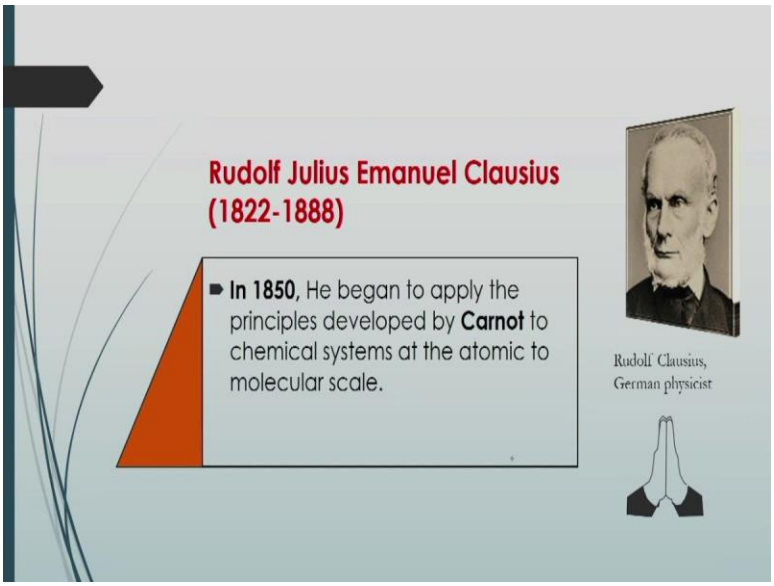

After that 1850 R. J. E. Clausius, he begins to apply the principles that are developed by Carnot to chemical systems atomic to molecular scale. So this was one of the important the milestone of at that 19th century. Where this chemical engineering processes based on the development of the chemical systems based on that converting from the atomic to the molecular scale.

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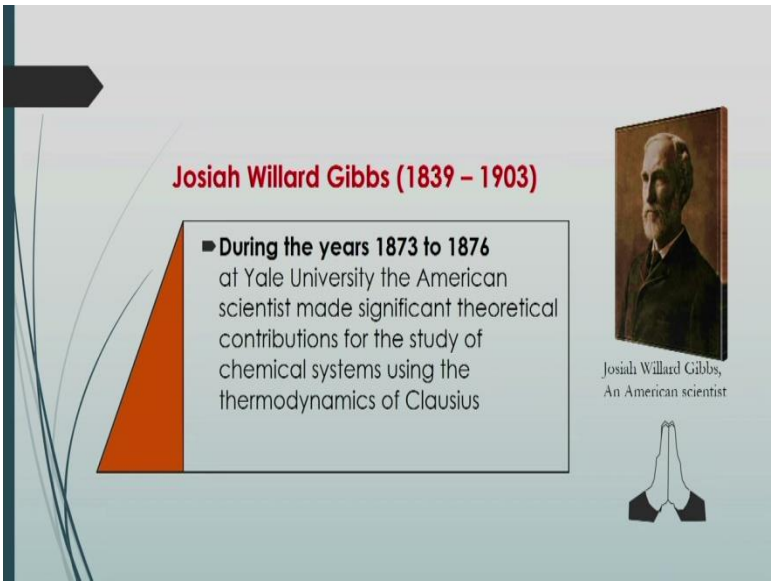

After that around 10-years that is 1873-1876 during that period at Yale University. The American scientist is called Josiah Willard Gibbs. He made significant theoretical contributions for the study of chemical systems which are used to calculate the thermodynamics characteristics. And also it is called the thermodynamics of Clausius. So this is one of the important period where this chemical engineering contribution to that thermo dynamic analysis was significant even remarkable.

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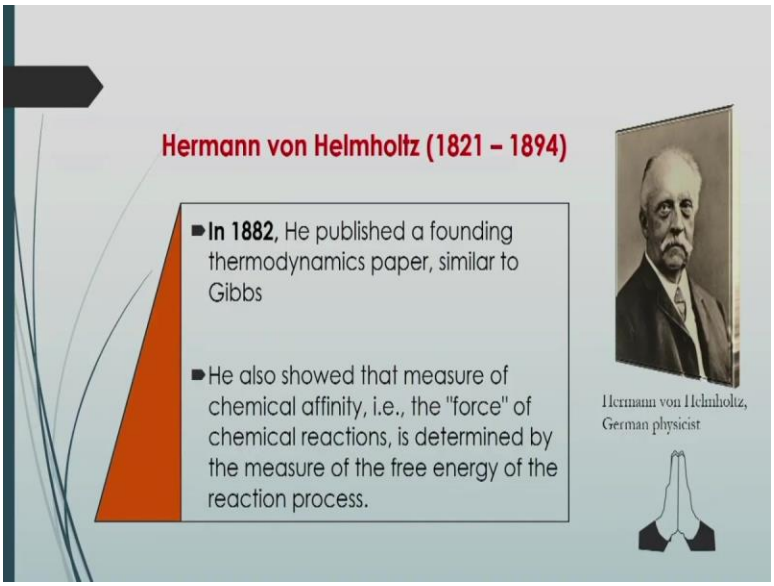

After that 1882, Helmholtz he published a founding thermodynamics papers similar to Gibbs. And he also showed that the measure of chemical affinity that is ‘force’ of chemical reactions, how that chemical reaction is happened and based on what is the driving force for that chemical

reaction. And he gave that theory to determine and also by measuring the free energy of the reaction processes. So he actually gave that theory of force of chemical reactions which is determined by the measure of the free energy of the reaction process.

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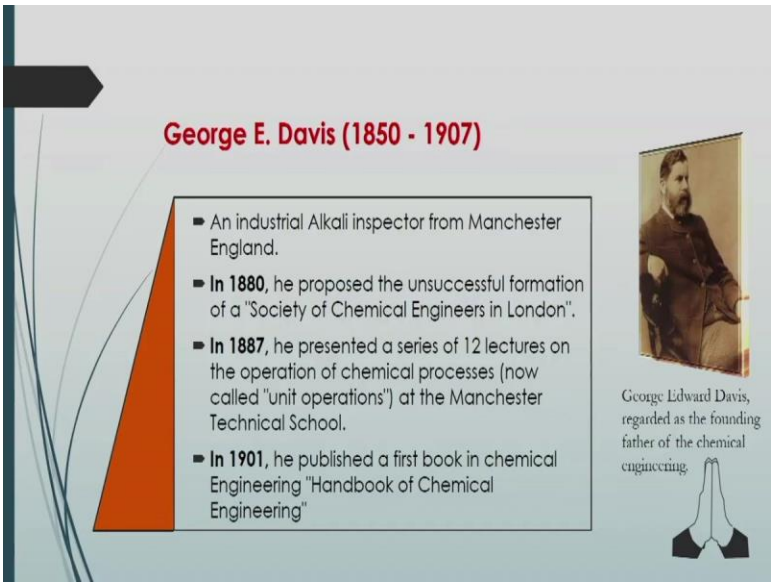

After that 1880, is called George Davis, he proposed to the unsuccessful formation of the society of chemical engineers in London. That I have already discussed that it was not successful just to make the society of mechanical engineers based on persons those who are working on chemical industry and who has some knowledge on that chemical processes. Later on because of this unsuccessful formation of this society of chemical engineers in London in 1887, he presented a series of 12 lectures on the operation of chemical processes.

Now it is called a unit operation that is of the main important subjects in chemical engineering. And he presented this series of 12 lectures on these operation chemical processes as a unit operation at the MIT technical school. And in 1901 he also published a first book in chemical engineering that is called “Handbook of Chemical Engineering”. There he described a lot of theory even development history of the chemical engineering and what are the different aspects for the professions of the chemical engineering.

He described in his first book of chemical engineering and how this science can be applied and it can be processed for the betterment of the human life just by developing different essential

chemical, he has given some theory on that. So it was one of the important books in chemical engineering history.

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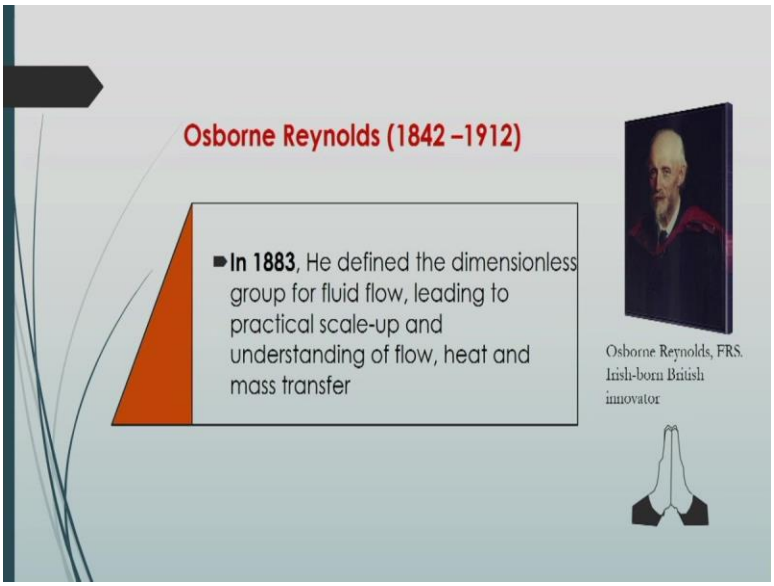

And after that in 1883. Osborne Reynolds, he is also one of the renowned person in chemical engineering who has contributed a lot in fluid flow operation based that in which all chemical processes are assessed. And he defined the dimensionless group for fluid flow. And that dimensionless group for the fluid flow leading to the practical scale up. And also understanding of the flow behavior, heat transfer behavior, and even mass transfer characteristics in the chemical engineering processes.

Those who are now a day's still it are hard core subject in chemical engineering education as well as in industry for their design of equipment and other process development.

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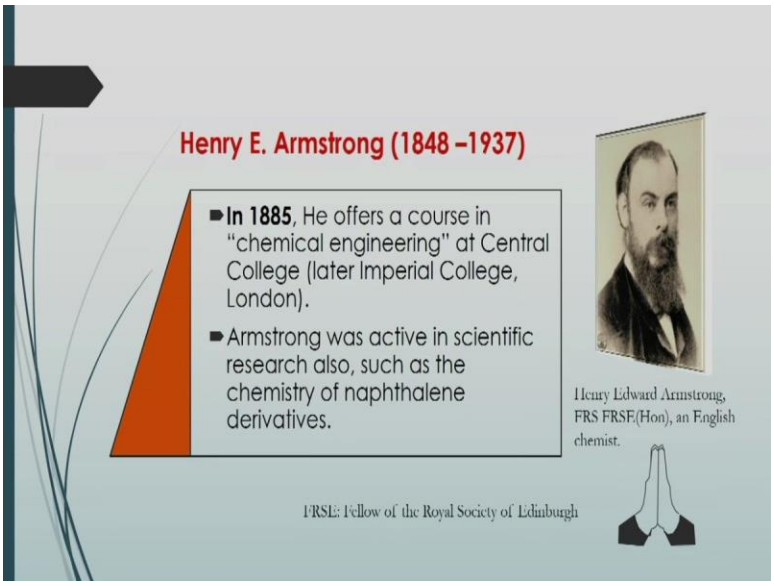

And in 1885. Henry Edward Armstrong, he offers a course in "chemical engineering" at Central College, now name is changed it is called Imperial college London and he was active in scientific research and he was actually working on the subject of chemistry of naphthalene derivatives how to do naphthalene can be produced. From that crude oil as well as some innovative how we can be produced from the naphthalene, so she has given that theory on that chemistry of naphthalene derivations from the crude oils there, he was also fellow of royal society of Edinburg.

He is basically English chemist so from that chemical knowledge of that the conversion of chemistry of that naphthalene derivatives from then onwards there are several synthesis of the chemicals that was done based on the idea that is opened by 'Henry E.Armstrong 1885.

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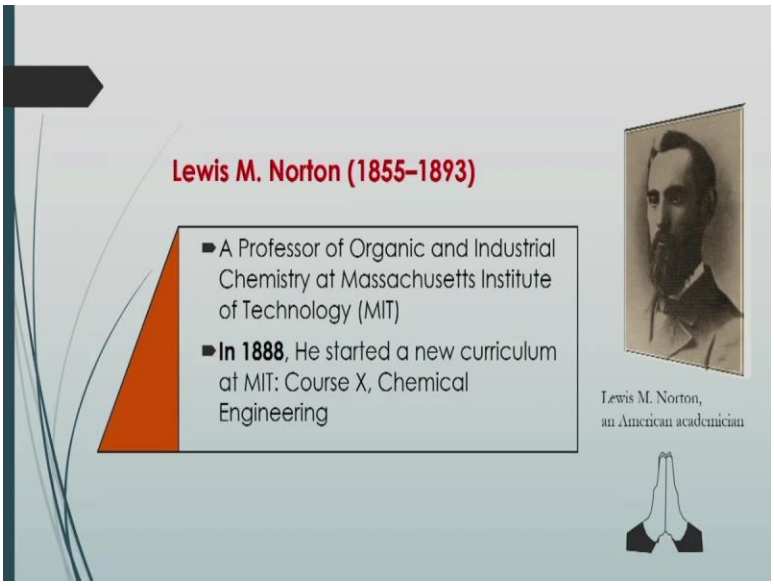

And, later on 1888, that is professor of organic and industrial chemistry at MIT he started a new curriculum at MIT as a course 10. As a chemical engineering from that basic degree of chemical engineering started based on this course 10.

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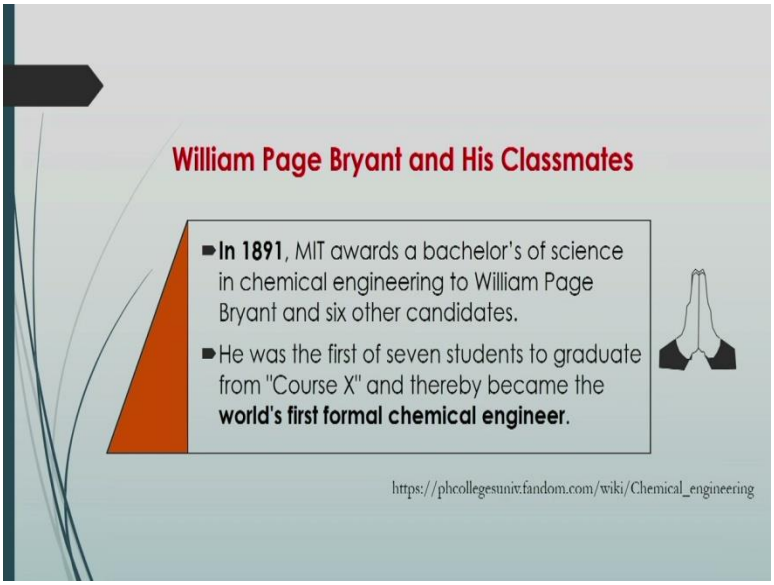

And then based on this course structure he made first chemically engineer you can say that world's first formal chemical engineer was 'William Page Bryant' and his classmates. So in 1891, MIT awards the bachelors of science in chemical engineering to William Page Bryant and six other classmates of that William Page Bryant and they were recognized world's first chemical engineers group from MIT in that case William Page Bryant was the first of 7 students

to graduate from course 10. And thereby become the world's first formal chemical engineer and he is known as like that.

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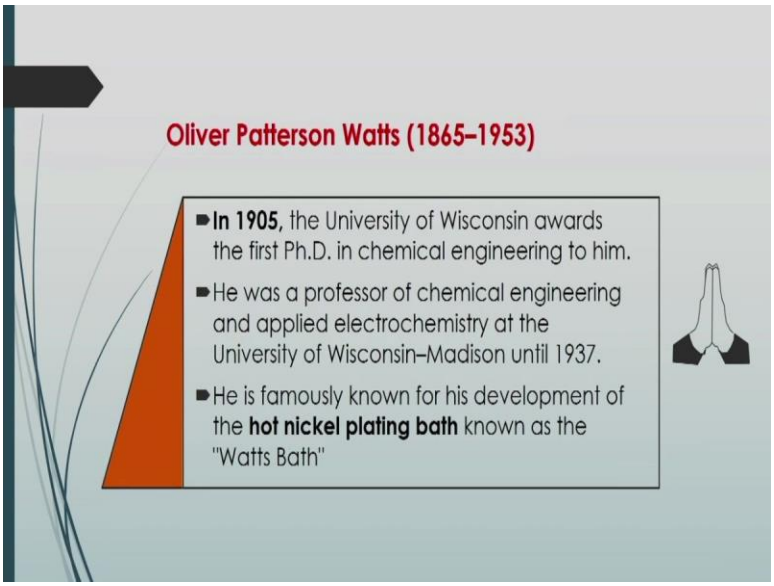

After that at the very beginning of 20th century Oliver Patterson Watts, the University of Wisconsin awarded the first Ph.D. degree to him in chemical engineering and he was a professor of chemical engineering and applied electrochemistry at the University of Wisconsin Madison until 1937.And he is famously known for his development of the hot nickel plating bath and this is known as that “walls bath”.

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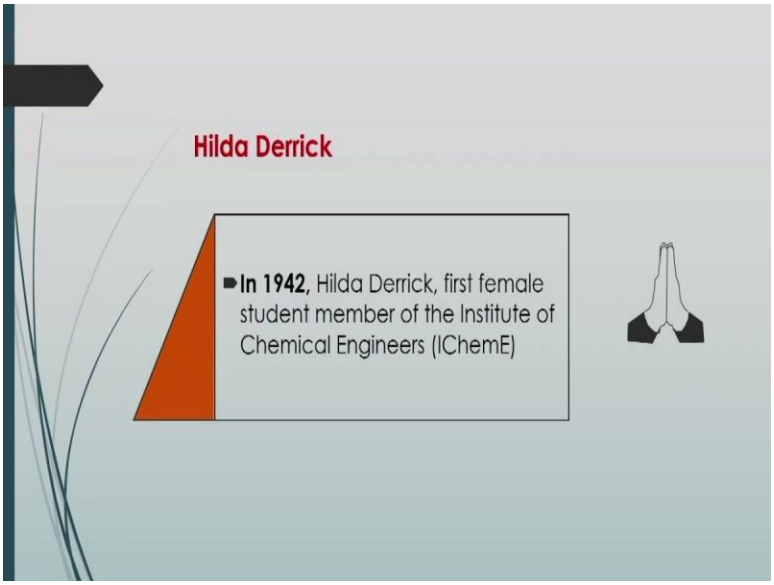

After that this Hilda Derrick, she was also chemical engineer and she was the first female student member of the institute of chemical engineer. So these chemical engineers were their renowned chemical engineers who have got that basic degree and science of chemical engineering and they were building pillars of these chemical engineers and they were renowned historical chemical engineers there.

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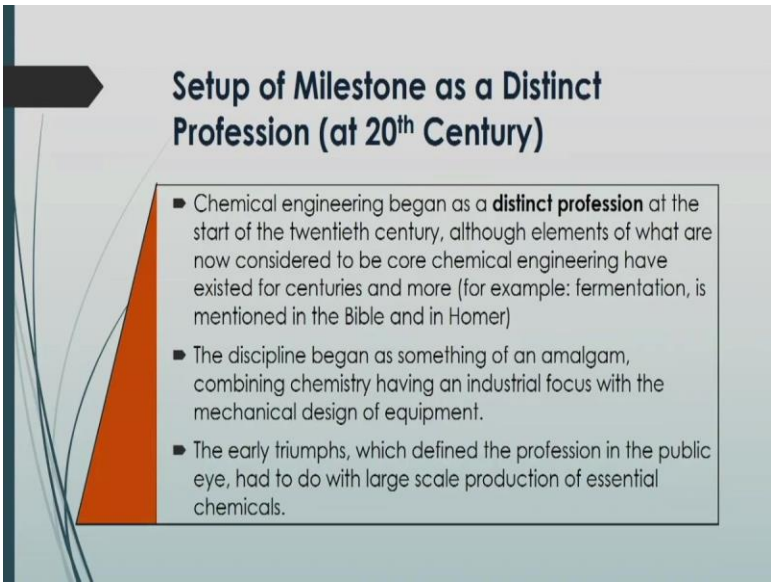

From 1945 onwards, that is in 20th century there are several worlds, there are several scientists, they were scientist, they were working in chemical engineering and they were several research were actually done on the chemical engineering development of chemical engineering professions and based on this now it is society are being developed based on this chemical engineering processes in different ways.

Now if we actually look back on that milestone of that chemical engineering professions at 20th century will see that several aspects of chemical engineering development. And from then onwards will see that this chemical engineering begin as a distinguished profession at the start of that 20th century. Although elements of water now considered being core chemical engineering have existed for centuries and more and also you can say that it began as something amalgam, combining chemistry, having an industrial focus with the mechanical design of equipment

But you can see that this beginning of the chemical engineering you can also say that fermentation is also developing processor at that century of that beginning. So this fermentation not only that period but it was also earlier stage in Bibles also it is mentioned that this fermentation process and also in Homer, it is mentioned that fomentation process so this discipline began as something of that fermentations process.

Other some chemical processes based on that knowledge of chemistry, which have some industrial focuses with the mechanical design of equipment and if we say that early triumphs, which defined profession in the public high to do with the large scale production of that essential chemicals based on this chemistry of this in amalgam even fermentations processing. Even other forces based on the knowledge of those things and also idea development.

And also concept of those basic things and later on and also now the knowledge has been opened up for the development of the further process based on the chemical engineering aspects.

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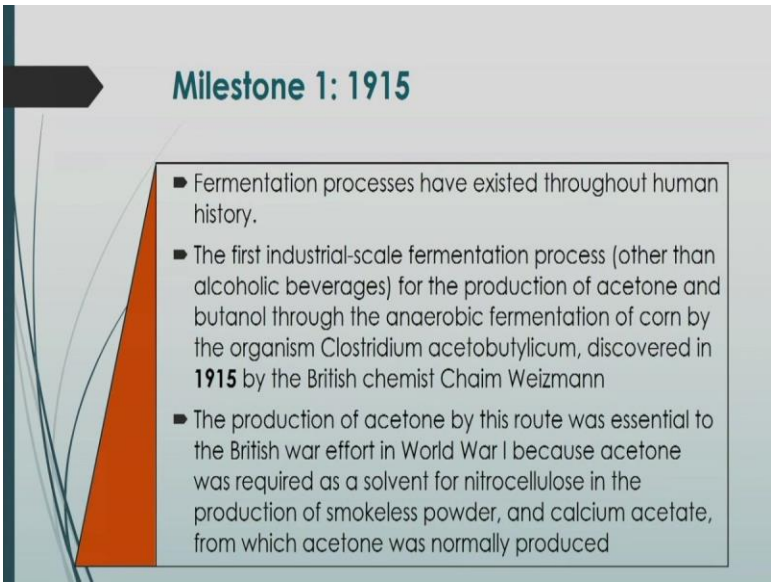

Now if you talk about that that 1915, in it was regarded as a milestone 1 in that case fermentation processes have existed throughout human history and the first industrial scale formation process other than alcoholic beverages for the production of acetone and butanol through the anaerobic fermentation of corn by the organism that is called clostridium acetobutylicum,

That is discovered in 1915 by the British chemist that is Chaim Weizmann and the production of that is acetone by this route was actually essential to that British war effort in first world war because that acetone was required as a solvent of nitrocellulose in the production of smokeless powder. So in that case calcium acetate from which acetone was normally produced based on this fermentation processes. So this is regarded as milestone one of the chemical in a process.

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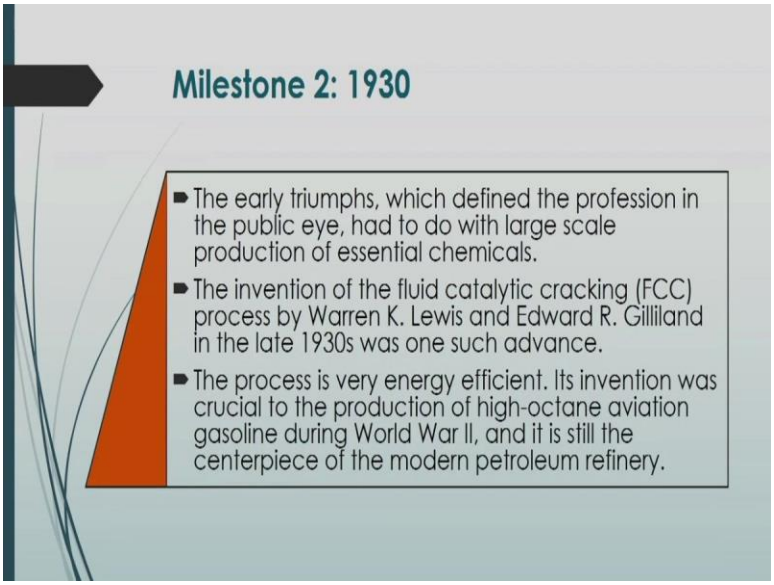

Whereas later on this 1930, the early triumphs defined the profession in the public eye had to do with large scale production of essential chemicals and the invention of the fluid catalytic cracking in today's date in the chemical engineering aspects can say that process developed by Warren K.Lewis and Edward R. Gilliland in a late 1930's,

In that case it was one of chemical engineering advanced process development and that process is very energetic and also you can say that it will be economic and also efficient its invention was crucial to the production of high obtain Aviation gasoline. During second world war and also it was actually the heart of that Centre fees of the modern petroleum refineries still it is center peace of the modern petroleum refinery and so this is actually this invention is regarded as a milestone two and that was actually discovered in 1930.

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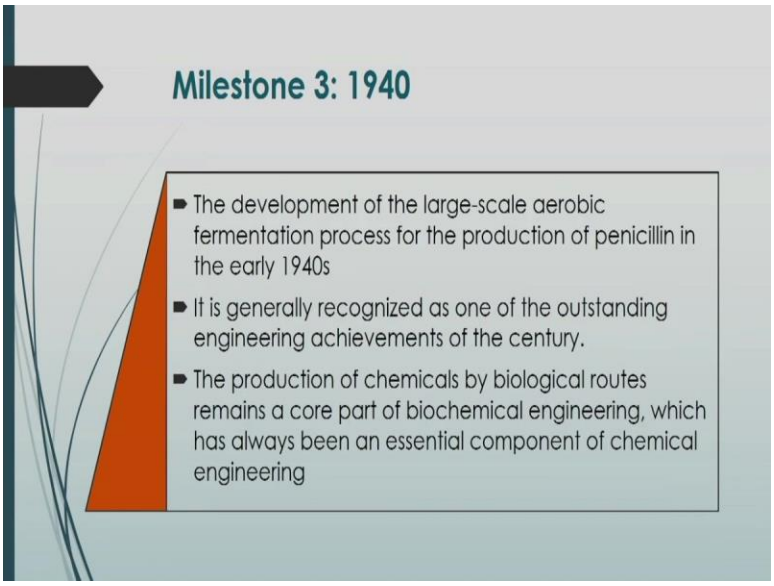

After 10 years in 1940, as you say that the it was one of the important milestone and in this case development of the largest scale Arabic fermentations process for the production of penicillin in early 1940's it was required because it is one of the outstanding engineering achievement of the century where that production of the chemical by the biological roots that remains a core part of the biochemical engineering and which has always been an essential component of the chemical engineering there.

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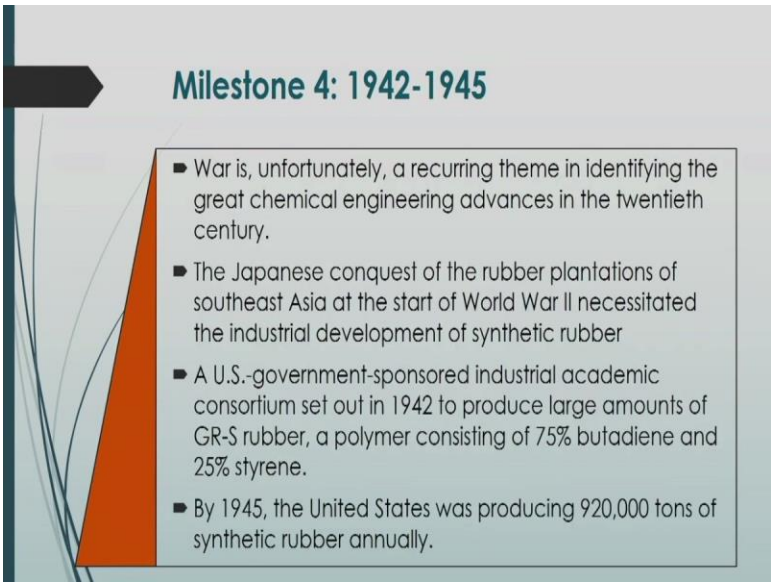

After that 1942 to 1945, you can say that this is the war period, of course! That is unfortunately a recurring theme in identifying the great chemical engineering advances in the 20th century. At that period the Japanese conquest of the rubber plantation of southeast Asia of the start of 2nd

world war necessity, today industrial development of the synthetic rubber and in 1942 US government sponsored academy consortium and also they are the set out was required to produce large amounts of synthesis rubber it is called GRS rubber which is mixture of 75% of butadiene and 25% styrene and by 1945 for the United States was producing around 1 million tones of synthetic rubber annually.

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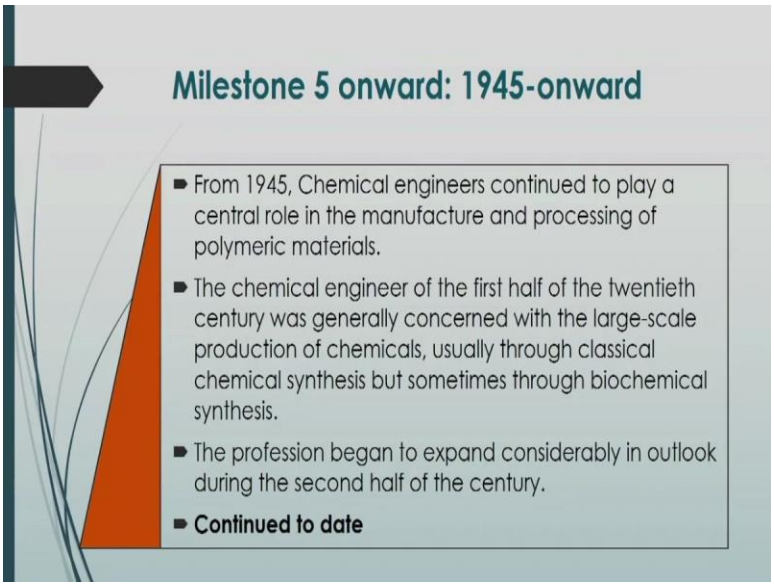

Then 1945, onwards you can say that chemical engineers are continued to play a central role in manufacture and processing of polymer materials and the chemical engineer of the first half of the 20 century was generally concerned with the largest production of chemicals usually you can that say through classical Chemical synthesis and also you can say that the beginning of that the profession of chemical engineering expanded considerably in Outlook during the second half of the century, so from then onwards this chemical engineering progress continued to date.

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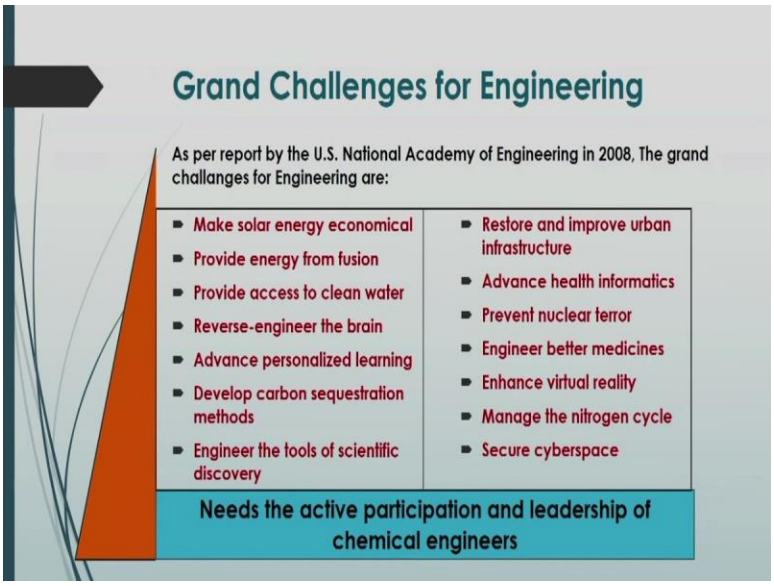

From 1951 onward, that is later half of this 20th century several chemical engineers they were working, when now a day's also renowned chemical engineers they are working in different that process development based on the chemical engineering science knowledge in that case by they were facing a lot of challenges for the development of the process based on this chemical engineering knowledge's.

Different challenges like: how to make the solar energy economical? How to provide energy from fusion? How to provide access to clean what you they are given reverse engineer the brain even you can say that advance personalized learning developed carbon sequestration method.
Even how to develop it tools for scientific discovery even restoring and improving the urban infrastructure? How to do that advanced health Informatics?

How to prevent nuclear reactor or even you can say that how to engineer better medicine? How to enhance the virtual reality how to manage the nitrogen cycle? How to secure you know cyberspace engineering challenges are coming from then onwards for the betterment of our human life? So for those challenges from different engnineers,from different streams but in that case this part of this universe challenges are you know taken by active participation that is active participation and leadership of chemical engineers.

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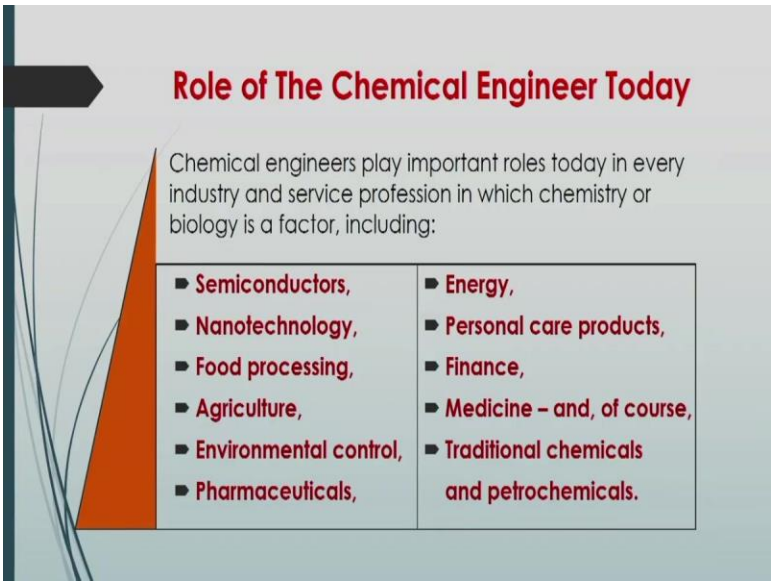

Now then what should be the role of that chemical engineer today? Based on the walls engineering challenges for chemical engineers playing important roles. Today in every industry and you can service profession in which chemistry or Biology, where those factors including you can say that semiconductors, nanotechnology, food processing, agriculture, environmental control, pharmaceuticals energy, even personal care products, finance medicine and of course! You can say traditional chemical and petrochemicals.

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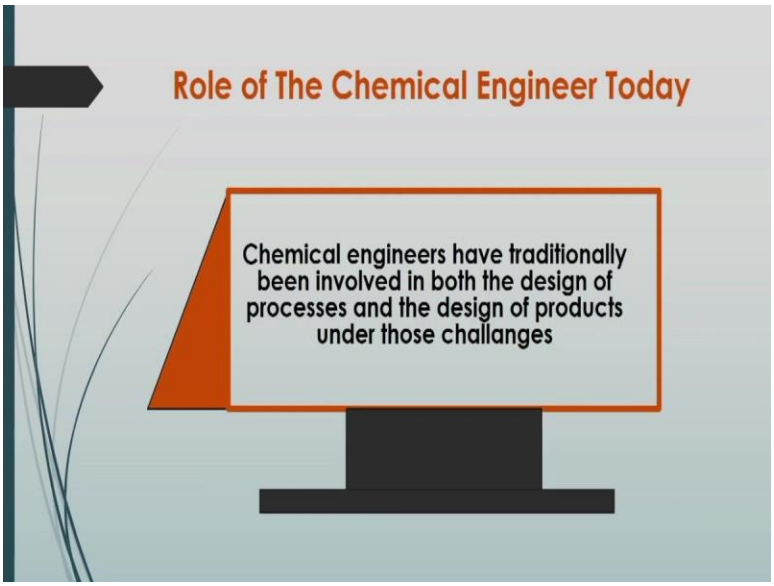

So, all those challenges are taken by chemical engineers for the better and better way to give essential chemicals as well as some other services to the human development and also growth of

our society in better way. So chemical engineers have traditionally been involved in both the design of process and design of products under those challenges.

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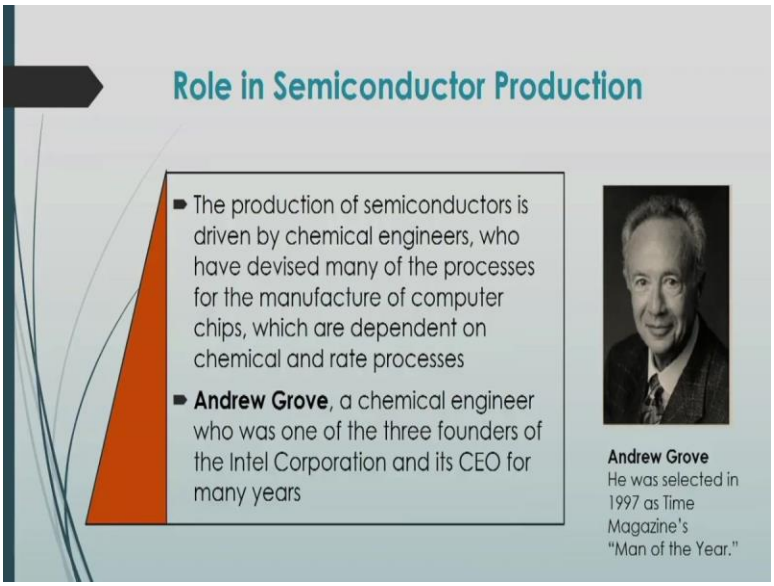

Now if we talk about how that chemical engineers role on this particular semiconductor production? Let us look back on those parts as a modern chemical engineer. How they are doing this year production of semiconductor? How those chemical engineers are actually important on this particular production semiconductor production? So in this case production of semiconductors is given by the chemical engineers who have had derived many of this process for the manufacture of computer seeds which are dependent on chemical and red process.

In this case and you grow a chemical engineer who has one of the 3 founders of the Intel corporation and its CEO for many years so he was basically chemical engineer, he was working for the development of the semiconductor based on their some idea which is development of the basic sciences and as a chemical engineer he has contributed a lot for the idea for the development of semiconductor production.

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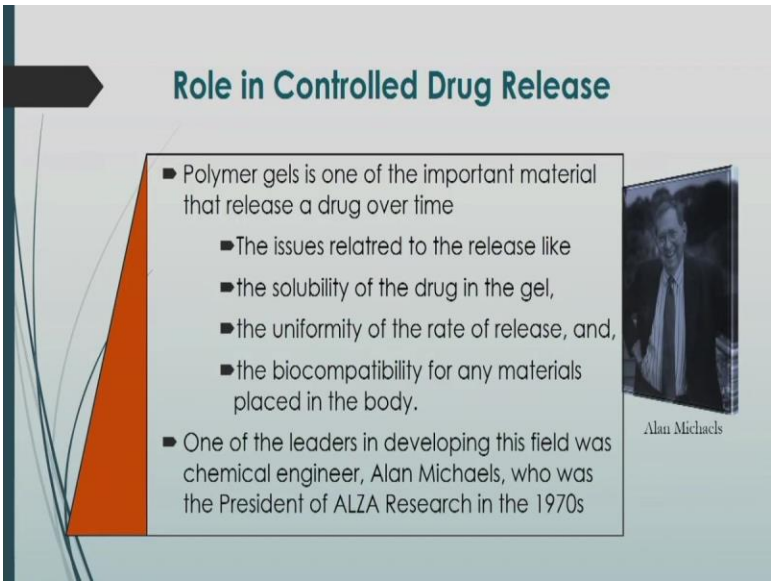

Now its chemical engineers also are working in controlled drug release in this case. Alan Michael's, his one of the pioneer chemical engineers where he contributed lot as a chemical engineer in this control drug release, where Polymers gels is one of the important material that releases a drug over time and that issues related to the release like the solubility of the Drug in the gels and uniformity of the rate of release and also biocompatibility for many materials that is placed in the body.

Now this aspects of this factors how actually affects on these polymer gels production stage and in that case this Alan Michael, He has given some Idea even he developed this basic fundamentals of these no polymer gels production to control that drug release and in this case he was one of the leaders in developing this field but he was a chemical engineer and who was the president of also alter research in 1970 there.

So, that is why this chemical engineer can work in a different way out of this chemical process but he can work on other process development biochemical process like computer chip production, semiconductor production, all those things even synthetic biology in that filed also chemical engineers play important role like synthetic.

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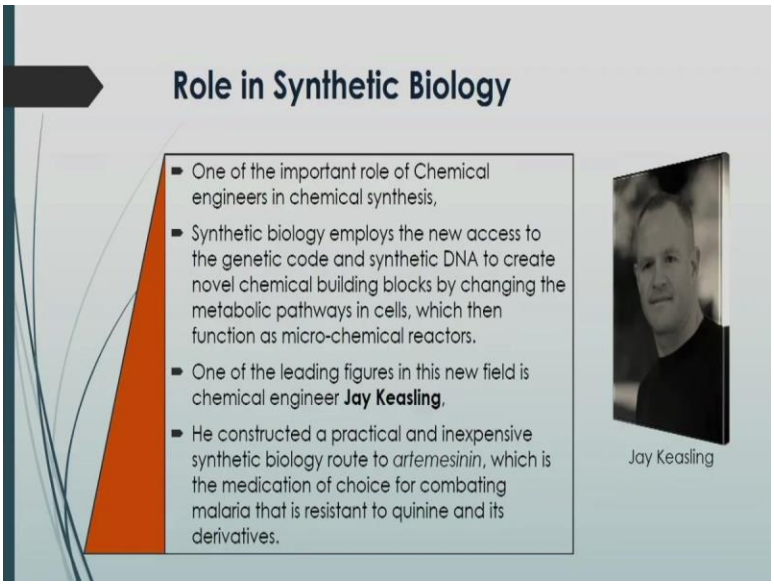

Biology that employees the new access to the genetic code and that synthetic DNA to create novel chemical building blocks by changing the metabolic Pathways in cells within function as micro chemical reactors so one of the leading figures in this new field is chemical engineer Jay Keasling, he constructed a practical and inexpensive synthetic Biology root to admission in which is actually the medication choice for combating

Malaria that is Resistance to quinine and its derivatives so this is one of the important that filled where this chemical engineers can give some idea for the synthesis of Chemicals for this I think that synthetic biology of it.

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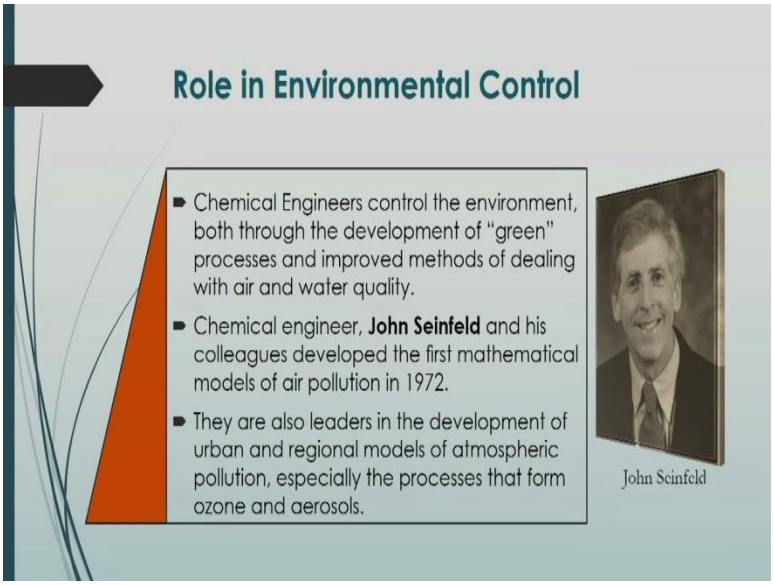

And also chemical engineer play important role in environmental control in this case chemical engineers control the environment both through the development of green processes and improve methods of dealing with air and water quality. In this regard chemical engineering John Seinfeld and his colleagues developed the first mathematical models of air pollution in 1972 and they were are also a leader in the development of Urban and regional models of atmospheric pollution especially the process of that phone Ozone and aerosols.

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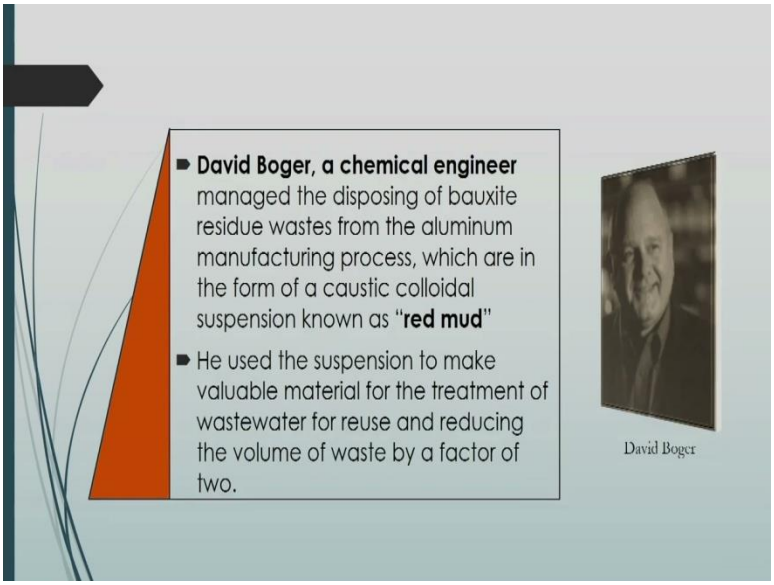

Later on David Boger, a chemical engineer managed to the disposing of bauxite residue waste from the aluminum manufacturing process, which are in the form of a caustic colloidal suspension, which is called red mart and huge red mart actually were produced at that processing of that caustic soda in even some other bauxite field there whenever depositing of bauxite assiduous received us from the aluminum.

Manufacturing processes so he has actually managed this colloidal suspension that is called red mart. Just by converting this red mart to valuable products so he used the suspension to make valuable materials for the treatment of wastewater for reuse and reducing the volume of waste by a factor of two.

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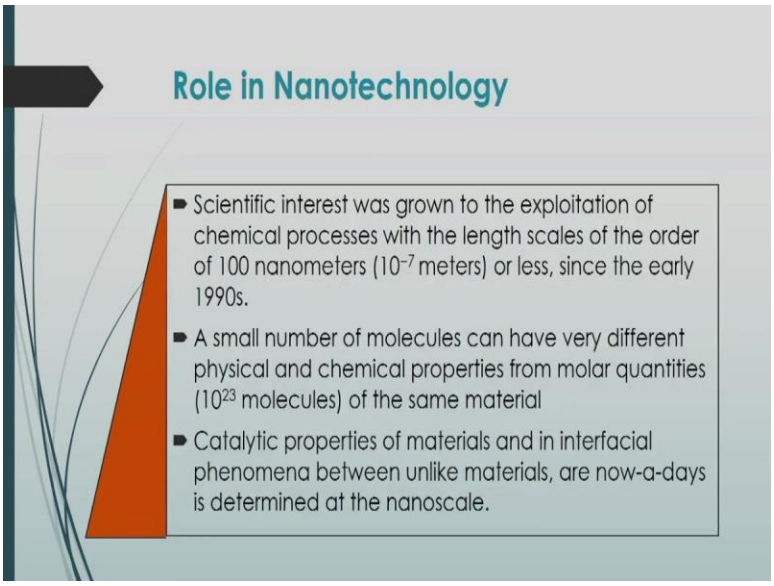

Chemical engineers also work in nanotechnology, like: you can say that the scientific interest was grown actually to the exploitation of chemical processes with the length of scales of the order of 100 nanometers or less since early 1990's so from then onwards you will see that there will be huge change of process development from this macro to the nanoscale range to better process will to get the intensification of the process based on this nanoscale processes.

Thinking of that nanoscale a processes chemical engineers, they have actually did lot of research on this nanotechnology based chemical process development process intensification just by based on the different physical and chemical properties from the molar quantities of the same material in that case catalytic properties of the materials and interfacial phenomena between unlike materials are now it is determined at this nanoscale for the for the intensification of the process in chemical engineering.

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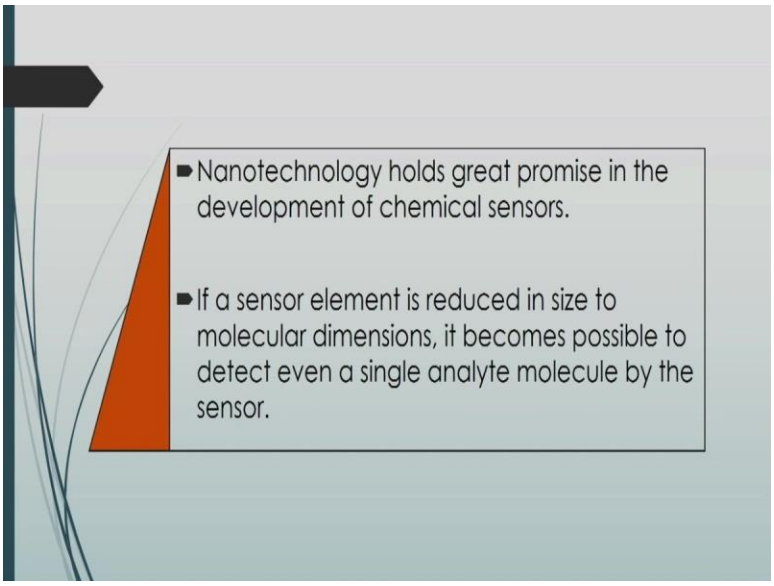

Now nanotechnology holds great from this in the development of chemical sensors also if sensor element is reduced in size to molecular dimensions, it becomes possible to detect even a single analyze and allied molecule by the sensor development based on this you know that the molecular properties and in the nanoscale range and how this nanoscale range properties of the molecules can be utilized to development of this sensor by this analyze molecule by the sensor .so this sensor development it is actually being developed by this chemical engineers also.

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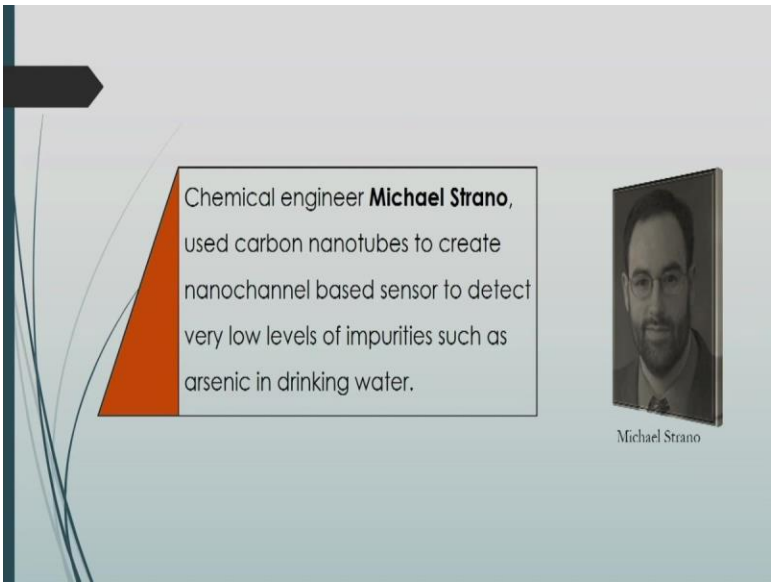

Chemical engineer Michael Strano, used carbon nanotubes to create nanochannel based sensor to detect very low levels of impurities such as arsenic in drinking water. So, his contribution is one of the important developments in this nanotechnology based chemical processes.

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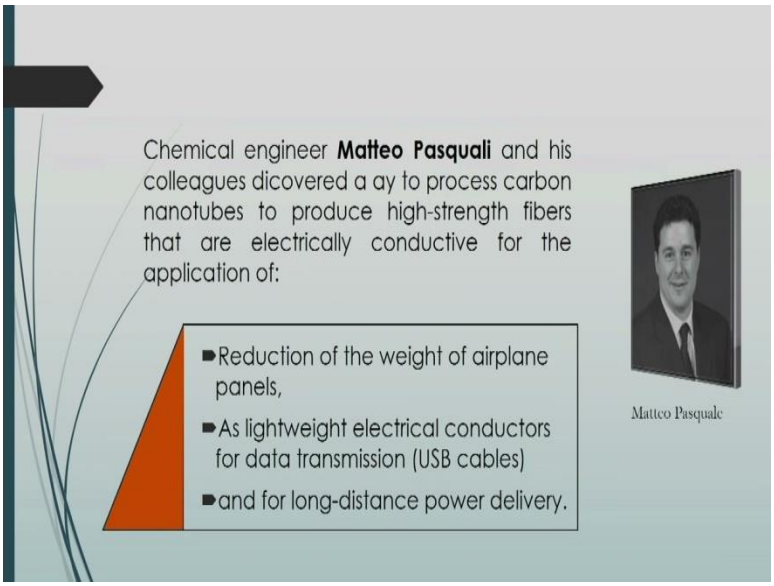

Chemical engineer Matteo Pasquali, and his colleagues they are also chemical engineers discovered a process a way you can say to process carbon nanotubes to produce high-strength fibers that are electrically conductive for the application of reduction of the weight of aero plane panels as lightweight electrical conductors for data transmission and for long distance power delivery so this chemical engineers they are also working and when they have developed a nano tube based high-strength fibers for the design of aero plane for its reduction of the weight.

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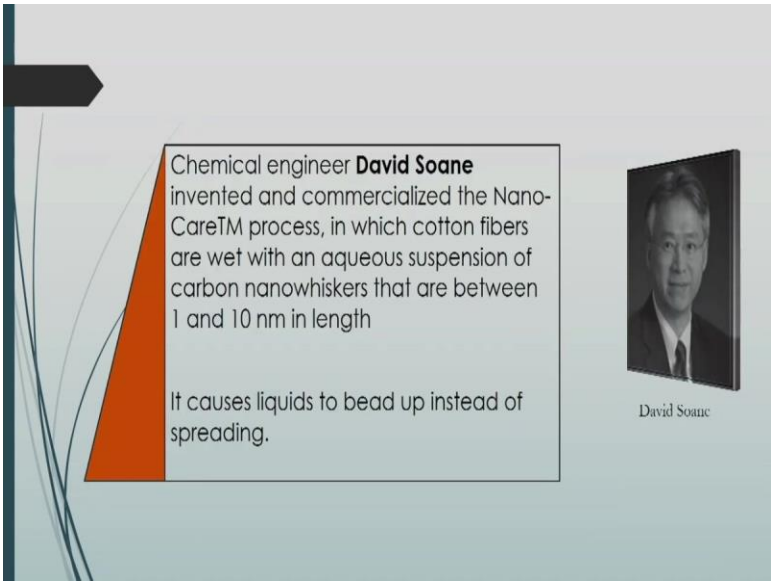

Chemical engineer David Soane, he is also one of the renowned chemical engineer who has invented and commercialized the nanocareTm processes in which cotton fibers are wet with an aqueous suspension of carbon nanowhiskers that are between 1 and 10 nm in length, it generally causes liquids to bead up instead of spreading there.

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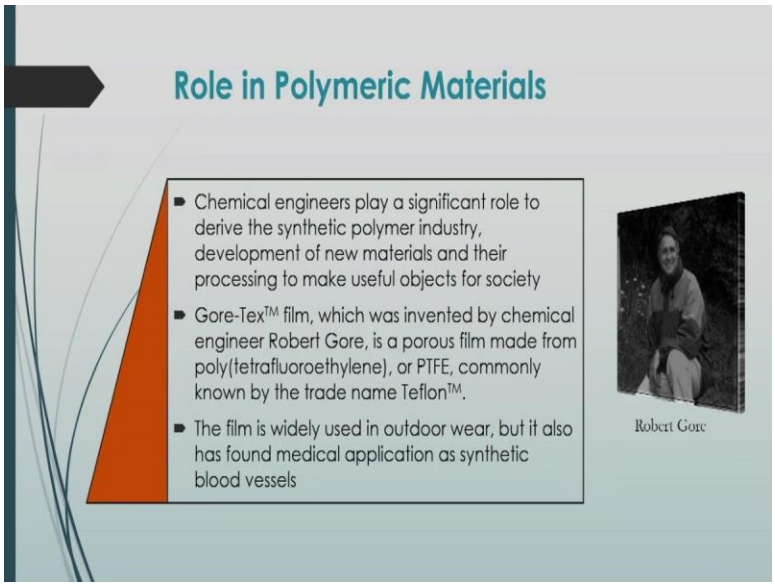

Chemical engineers also play a significant role to derive the synthetic polymer industry development of new materials and their processing to make useful objects for the society in this case Gore-Tex to the power film which was invented by chemical engineer Robert Gore. It is actually Porous Film that made from polytetrafluoroethylene or you can say it is and short discord PTFE and is commonly known by trade name Teflon and this film is widely used in outdoor wear, but it also has found Medical application as synthetic blood vessels, so in this Robert Gore's contribution as a chemical engineer is remarkable.

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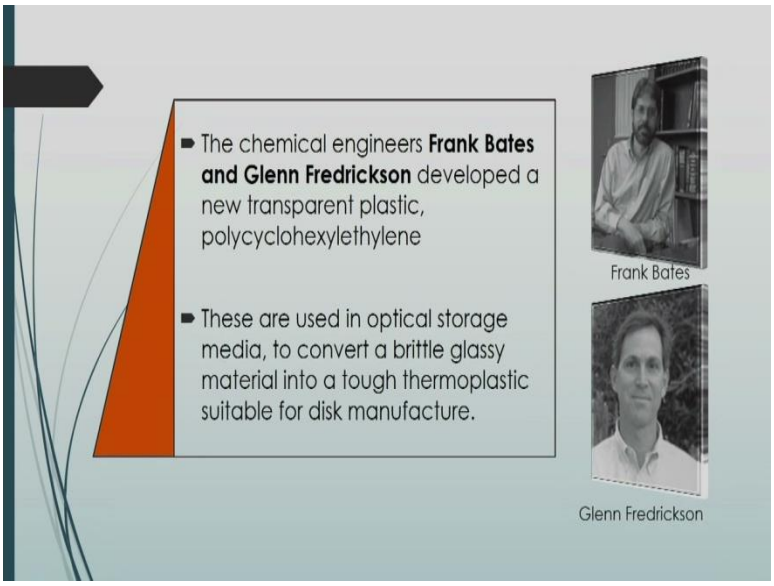

The Chemical engineers Frank Bates and Glenn Fredrickson, those are also contributed a lot for the production or development of a new transport plastic polycyclohexylethylene.These are generally used in optical storage media, to convert a brittle glassy material into a tough thermoplastic suitable for disk manufacture.

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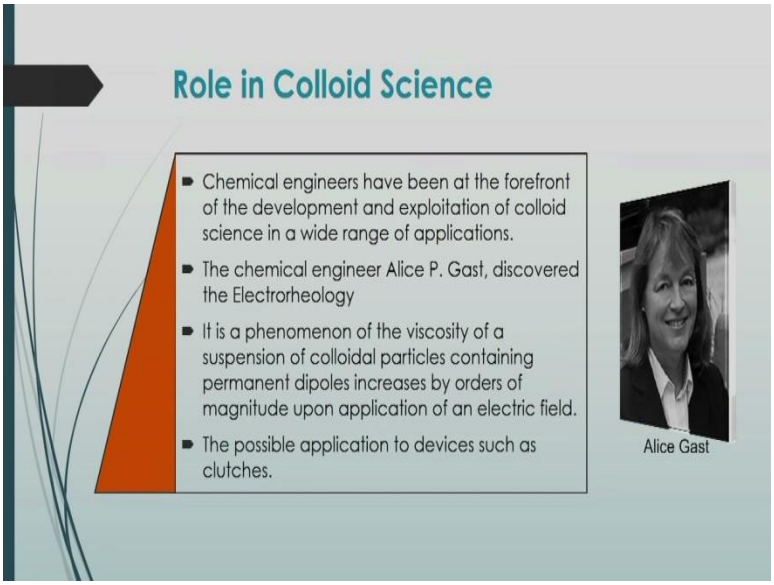

Now in colloidal science which is process of the hardcode chemical engineering in that case we have to remember this Alice Gast, who was the forefront of the development and exploitation of wide range of applications she discovered the electrorheology and this the phenomenon viscosity of the suspension of the colloidal particles containing permanent dipoles increased by orders of magnitude upon application of an electric field.

The possible application to devices such as clutches one of the important you can say that application where colloidal science is knowledge is required in that case the theory for this of viscosity change of the suspension of colloidal particles which contents that permanent Dipoles how it can be applied to the application for the development of the device for the clutches, so in this case Alice Ghat, that one of the important scientist in chemical engineering background.

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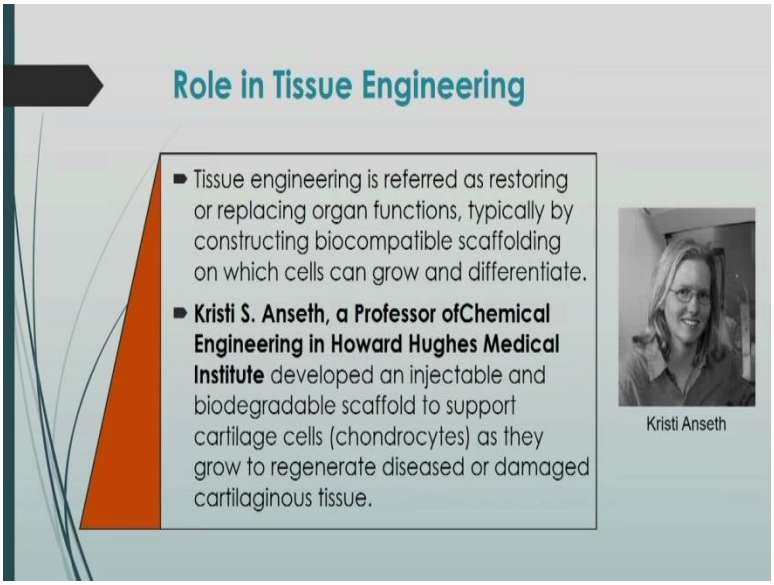

Also a significant role in tissue engineering given by this chemical engineers in this case, Kristi Anseth, who is a professor of chemical engineering in Howard Hughes Medical Institute .who has developed,injectable and biodegradable scaffold to support cartilage cells as they grow to regenerate disease or damaged cartilaginous tissue, where are they have developed a process how these tissues can be engineers for the replacement of the organ for its respective functions typically by constructing biocompatible scaffolding on which cells can grow and differentiate.

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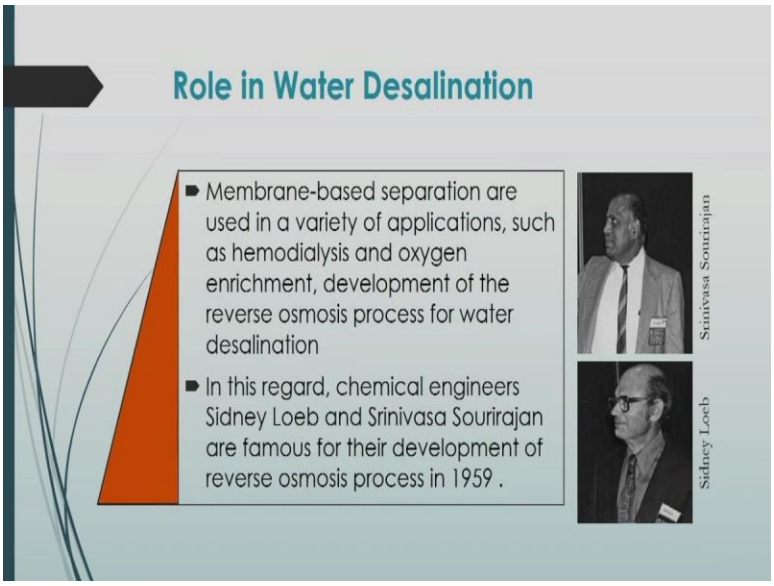

The treatment of water one of the important chemical engineering process where chemical engineers play important role for the water desalination membrane-based separation is one of the important process in chemical engineers where you can say this membrane is being used in a variety of applications for the water treatment characteristics like hemodialysis even oxygen enrichment development of reverse.

Osmosis process for the water desalination, in this regard this chemical engineers Sidney Loeb, and the Srinivasa Sourirajan, are famous for the development of Reverse Osmosis process which was actually developed in 1959, So, this process is still important for the water distillation process for our drinking water system.

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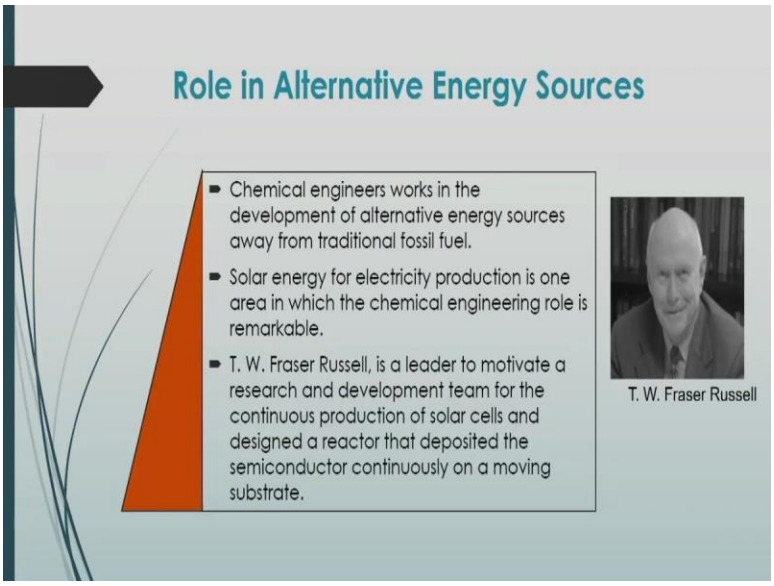

Now chemical engineers works in the development of alternative energy sources away from that traditional fossil fuel and this case solar energy for electricity production is one area in which the chemical engineering roll is remarkably you can say, in this regards we have to remember T.W Fraser Russell, which is a leader to motivate a research and development team for the continuous production of solar cells and also he designed a reactor that deposit a semiconductor continuously on a moving substrate. So In this case his name of course! Is a Chemical engineer is remarkable.

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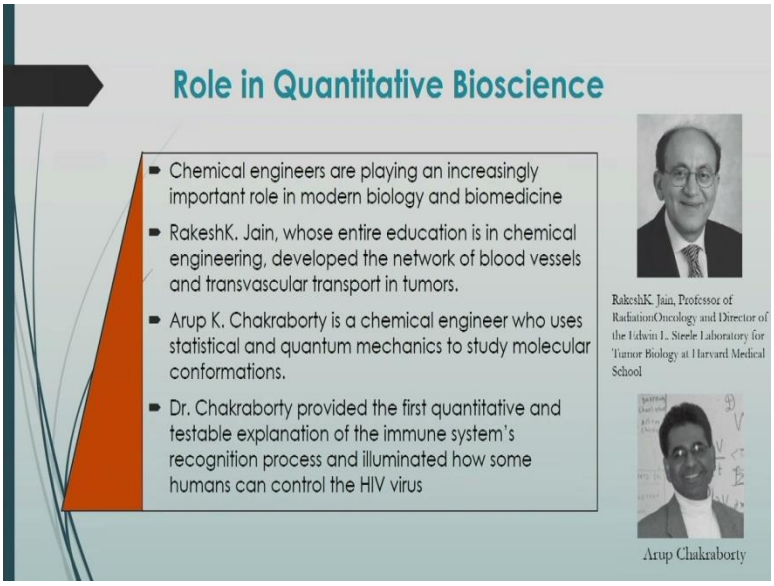

Also you can say that role in the quantitative bioscience; In this case chemical engineers are playing an increasingly important role in modern biology and biomedicine. So chemical

engineers play a important role in alternative energy sources also in that case chemical engineers works on the development of the alternate energy source away from the traditional fossil fuel in this regard T.W Fraser Russell is a leader to motivated research and development in for the continuous production of solar cells .So this regard he is one of the pioneer chemical engineer for the development of alternative energy sources.

Other than these chemical engineers also play a significant role in quantitative bioscience, bioscience research in this case Rakesh. Jain whose contribution in chemical engineering developed the network of blood vessels and transvascular transport in tumors and it is of course !remarkable to say that doctor AK Chakraborty is a chemical engineer who uses a statistical and Quantum Mechanics to study molecular conformation.

He gave the first quantitative and testable explanation of the immune systems which is you know optician process and illuminated the process which give how much only some humans can control HIV virus so other than this chemical process development even role in chemical, biochemical processes even in other of engineering field.

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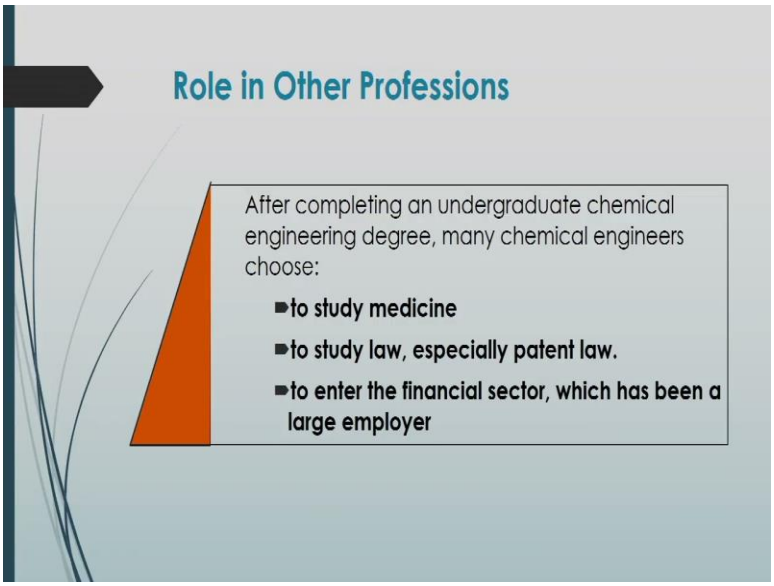

Chemical engineer can you know plays an important role in public services also like which is a recognition process, elimination process which give some humans can control HIV virus. So other than this chemical process development even roll in chemical biochemical process even in

other engineering field chemical engineers can play an important role in public services also like :chemical engineers can act as an administrator of environmental protection agency, he can be a secretary of energy sector, he can provide expert advice to the government for the research and development in science and engineering he can act as an evaluator of processor for destroying stores of Mandvi forms loaded with different essence.

So, other professions can act like: to start the medicine, even to study law, specially patent law, to enter the financial sector which has been a large employers in this case this chemical engineers can give a beater contribution also in different other professions.

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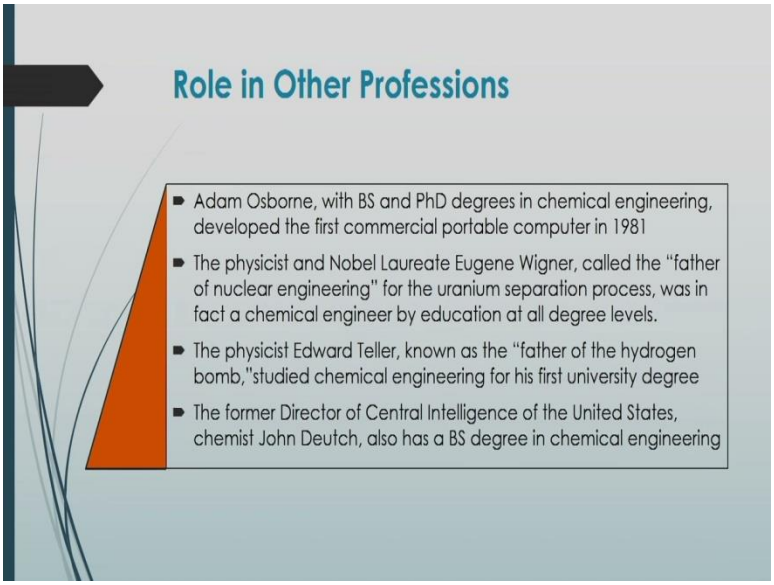

In this case you have to remember some renowned person who where chemical engineers but they have contributed lot in other professions like Adam Osborne, he also developed the first commercial portable computer in 1981, chemical engineering background the physicist and Nobel Laureate using now we are called father of the nuclear engineering has contributed a lot for the uranium separation process.

He was in fact chemical engineer by education at his all the levels and a physicist Edward teller he is no one of the unknown persons as the father of hydrogen bomb and he also started the chemical engineering for his first university degree. So this chemical engineer works not only the chemical engineering professions, he can act keep a contribution to the other profession also. So

we have discussed several aspects of that chemical engineering development history and role of chemical engineers in the process development and also history of chemical engineering development and also aspects of different other professions how chemical engineering act.

So, thank you for your attention for giving this lecture, I would suggested to go further reading and I have given some text books reference book here and next lecture will be on basic future of chemical process, so please follow those lectures for the principle and also basic future chemical process and that will be played in the next lecture.

THANK YOU!

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