Chemical Technology
Prof. Indra D. Mall
Department of Chemical Engineering
Indian Institute of Technology, Roorkee

Module - 1
Introduction
Lecture - 1
Introduction to Chemical Process Industries

Chemical technology is the course that is the integral part of the B.Tech program in India and other part of the country, where have been the two courses on the chemical technology, one is the inorganic chemical technology, another is organic chemical technology. NPTEL is developing the two courses on the chemical technology; one is the inorganic chemical technology and other is the organic chemical technology. I am supposed to discuss about the organic chemical technology, and before going to the actual the organic chemical technology of course, I would like to introduce myself.

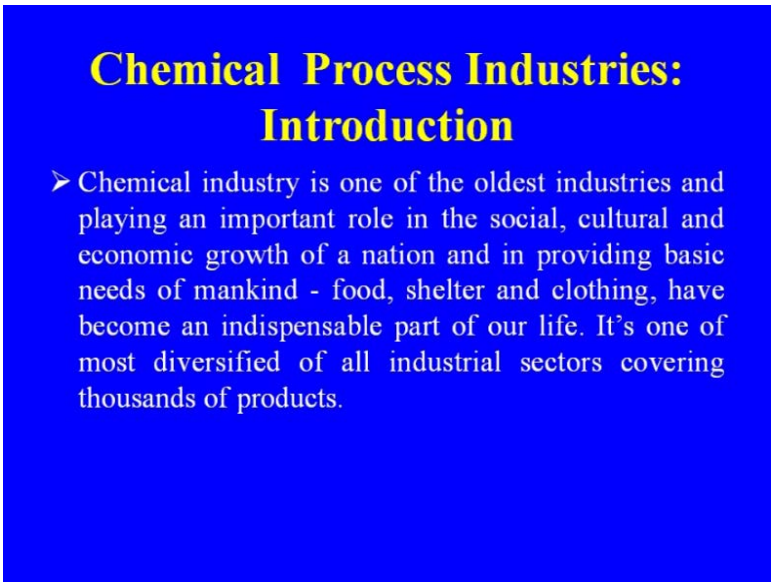
Myself doctor I. D. Mall from department of chemical engineering IIT Roorkee , I did my B. Tech, M. Tech and PhD from Banaras Hindi university in 1970, 1972 and 1993 it is (( )) and before joining university of Roorkee , now it is IIT Roorkee. I worked in Orion Paper Mill for long time that that is from 1977 to 1990 and since, 1990 I am here; I was also the professor in head department of chemical engineering.

I have my interest, my specialization is in the warm Intel engineering petroleum and petro chemical and the chemical technology. I have written one book on the petro chemical technology that is by Macmillan India in the second edition of the book that is coming I have published about 190 research papers, research project I have handled 73 projects are already I have completed, 5 projects and the rest of the projects are continuing.

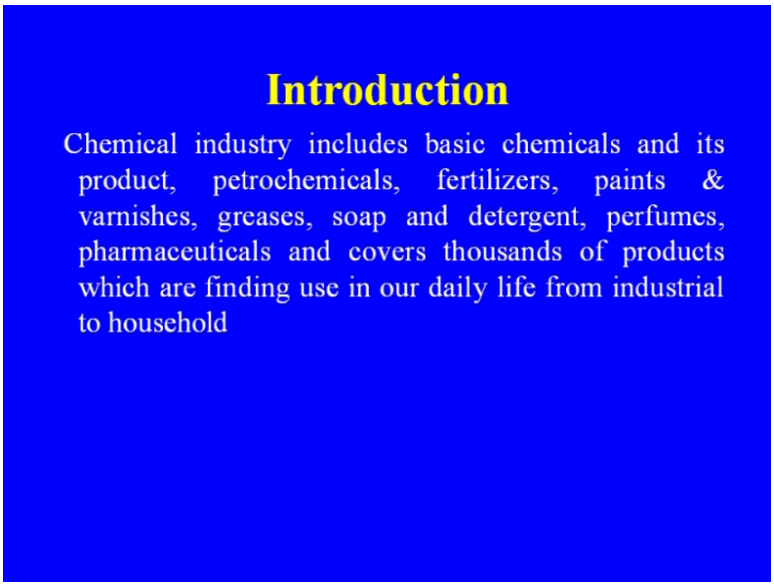
I have organized 21 short term courses and I have participated in the large number of the courses as resource person I have received some of the awards and two of my paper that was recognized. I got the best paper what is the institution of engineer the Nawab Jan Bahadur memorial medal and the second was that the best paper award from the from the Russel Ackford award, that was from on the journal of solid base technology in man and man. In the organic chemical technology course, first it is specific about the, we will be

discussing about the module 1 and the module 1 in the first lecture is on the chemical process industry.

(Refer Slide Time: 03:13)



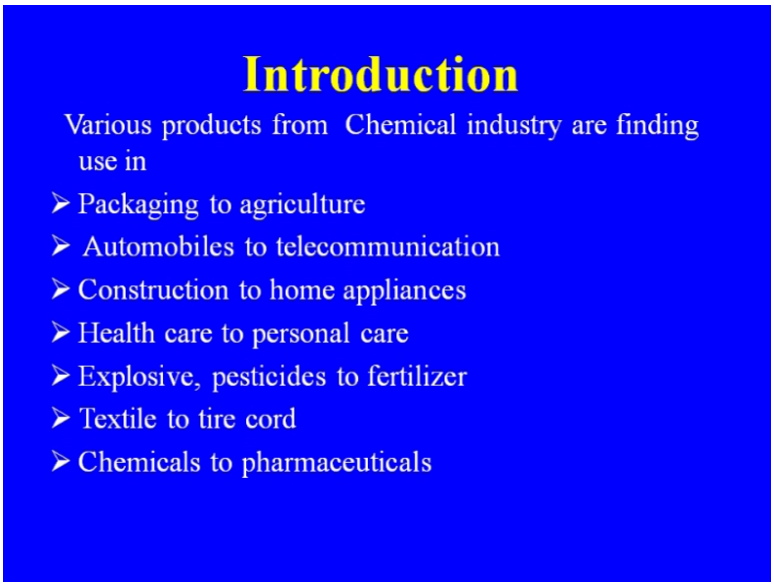
(Refer Slide Time: 03:43)



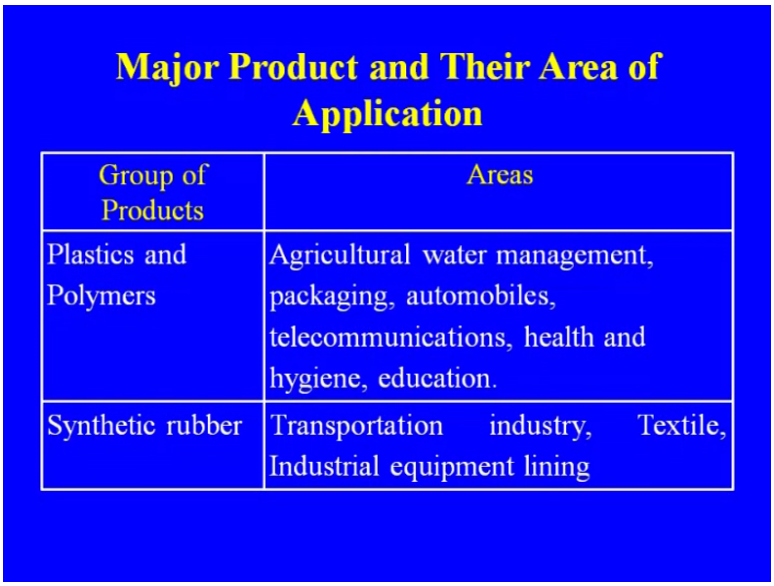
Before starting to the about the various development let me introduce something about the chemical process industry and its importance. Chemical industry is one of the oldest industry and playing an important role in the social, culture, economic growth of a nation and in providing basic needs of the mankind; food, shelter, clothing and have become an

indispensable part of our life. It is one of the most diversified of all the industrial sectors covering thousands of the products, which you are using in the daily life.

(Refer Slide Time: 04:12)



(Refer Slide Time: 04:40)

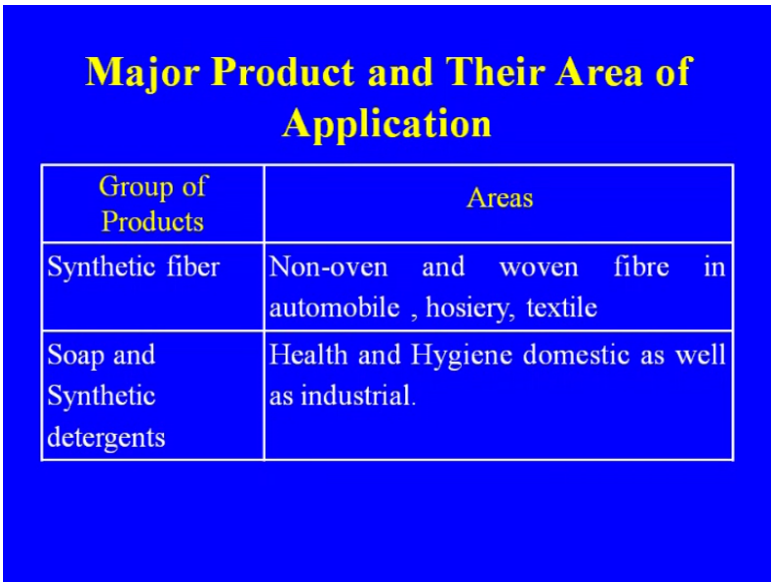


Chemical industry includes the basic chemicals and its products, petrochemicals, fertilizers, paints and varnish, greases, soap and detergent, perfumes, pharmaceuticals and covers thousands of products, which are finding use in our daily life from industrial to household. Indian chemical industry plays an important role in the overall

development of the Indian economy and contributes about 3 percent in the GDP of the country it comprises large scale, medium scale and the small units.

Various products from the chemical industry are finding use in packaging to agriculture, automobiles to telecommunications, construction to the home appliances, healthcare to personal care, explosive pesticides to fertilizer, textile to tire cord, chemicals and pharmaceuticals. So, if you see the broad range of the product which we are using in our daily life that is from the chemical industry. Major product and their area of application; first thing that plastic and polymer, that is that has played important, that has revolutionized the whole industry because the various sectors we are using the various polymers or the plastic materials in some or other form. And the one of the area where this has found the large application that is the agricultural water management in the pipes.

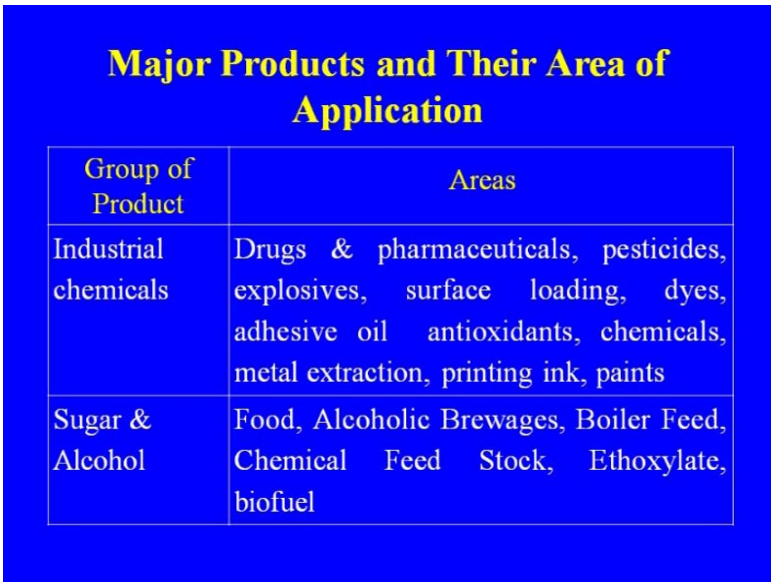
(Refer Slide Time: 06:17)



Another area packaging you see the polythene that is the poly bags very famous. The poly propylene that we are using in the hospitals automobiles, telecommunications, health and hygiene, and that is the because of poly propylene that has come in a big way and that has replaced most of the glasses that was being used or in case of the hospital education. Again that is very role of the education means the is the electronic industry that is because of the development of the polymer synthetic rubber in the case of the transportation sector, textile industrial equipment lining. We are using this synthetic

rubber in some or other form and the various quality of the synthetic rubber that is available that will be discussing in detail in the next few lectures.

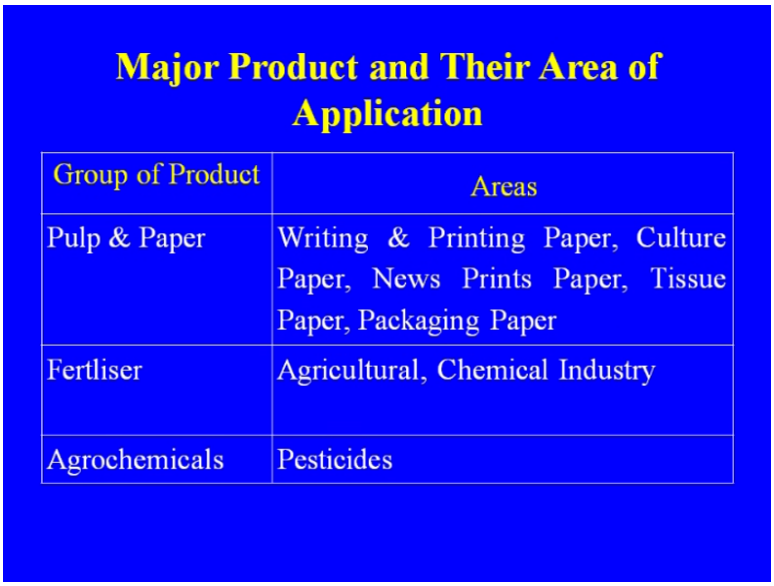
(Refer Slide Time: 06:27)



Synthetic fiber non oven and oven fiber, why the non oven and oven fiber means the we are also using the in the tire cord industry huge amount of the synthetic rubber which is been used for the lining of the tire. And the hosiery, textiles, soap and synthetic detergent, health and hygiene domestic as well as the industrial. Industrial chemicals, drugs pharmaceutical, pesticides, explosive, surface loading, dyes, adhesive antioxidants, chemicals, metal extraction. We are using the some of the chemicals in the metal extraction also printing ink, paint, varnish in all the area some of the organic chemicals that is being used. Sugar and alcohol for the food we are using the sugar because that is also without sugar.

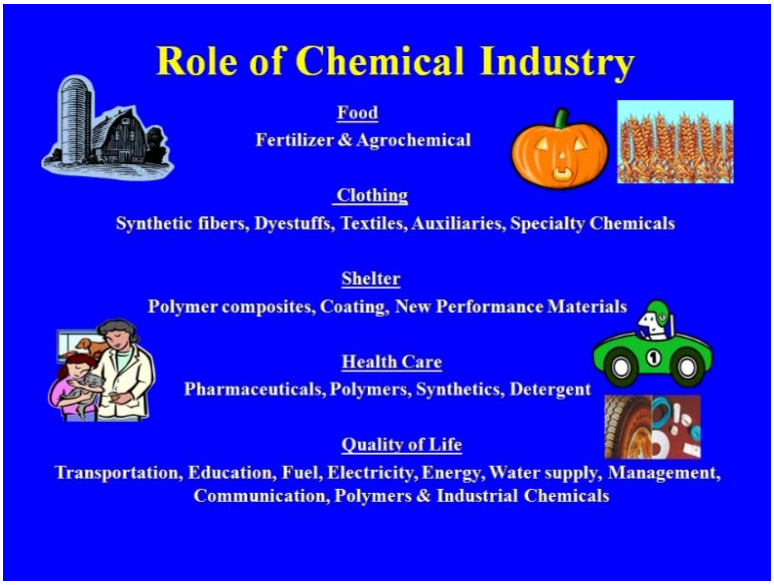
Now, the everywhere we are finding use of the sugar and the along with the sugar because in the production of the sugar we are getting this paint wash and sorry not paint wash molasses and we have producing the alcohol. And so, the sugar and alcohol industry they are providing the food, alcoholic beverage, boiler feed for a treatment chemical and then the ethylene. And the ethoxylate from the ethylene glycol, biofuels because the alcohol bend is there now the we are blending 5 percent alcohol ethyle alcohol produce from the molasses route in the also the other route of the alcohol is also there. But in India mostly we are producing the alcohol from the molasses route.

(Refer Slide Time: 07:42)



Pulp and paper industry; we are producing the various a large variety of the paper starting from the writing and printing paper, culture paper, coated paper, news prints, insulation paper, tissue paper, packaging paper. Fertilizer industry that is agri chemical and the your chemical industry they are also using ammonia and urea. Because, urea formal dehyde and then the ammonia that is also being used as a raw material which is producing the fertilizing the and of course, the last is the agri chemicals from where that is dealing with the pesticide.

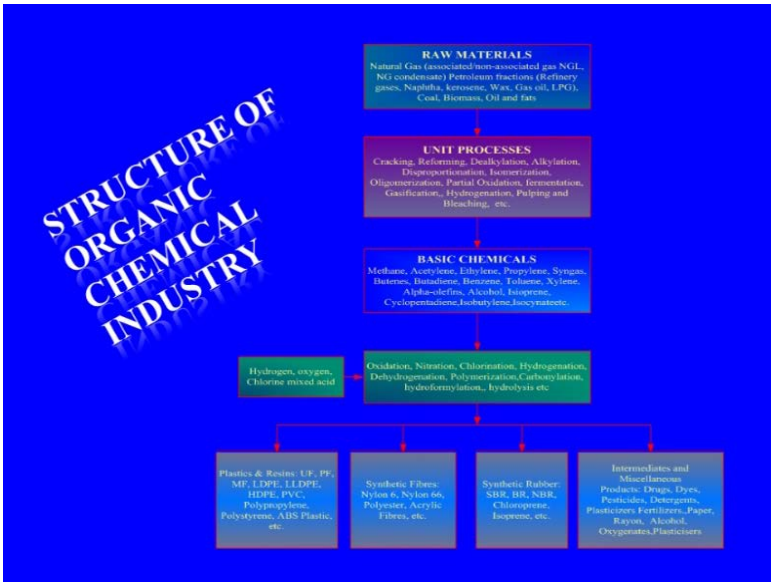
(Refer Slide Time: 08:51)



Now, we are having a large variety of the pesticide also it may be insecticide, it may be the orbicide, it may be the metacide. So, different variety of the just to meet the challenges, which are been posed by the various type of the insects, which are there and affecting the daily life as well as the food crafts.

This is the role of the chemical industry; for providing the food; fertilizer and the agrochemicals already we have discussed. Clothing - synthetic fiber, dyestuffs, textiles, auxiliary because, this dye… that is, in case of the synthetic fiber, auxiliaries, specialty chemicals. Shelter; polymer composites, coating, new performance material because, there will be continuous development in the… Now, we are having the various type of the composites also and one of the revolution that we are finding the in use of the polymer that is in case of the automobile industry; healthcare, pharmaceuticals, polymer, synthetic, detergent. Quality of life - transportation, education, fuel, electricity, energy, water supply, management, communication; and the storage of the packaging of the packaging industry also the polymers and industrial chemicals.

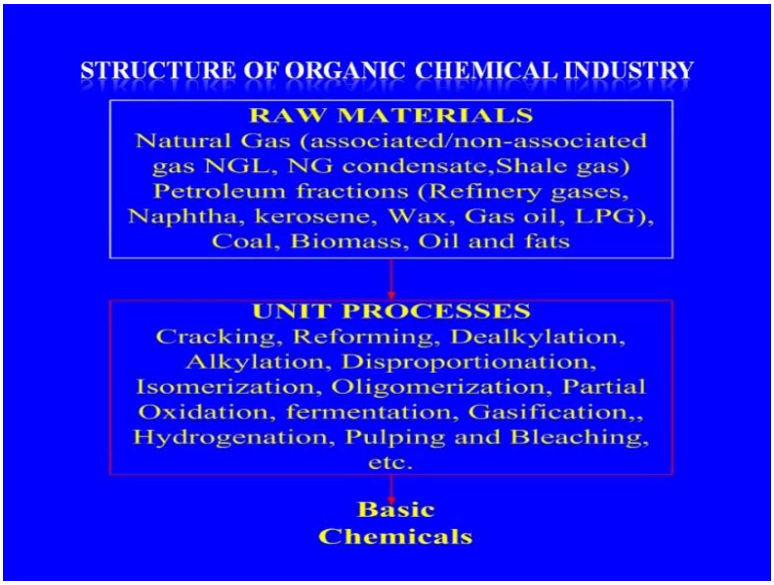
(Refer Slide Time: 10:03)



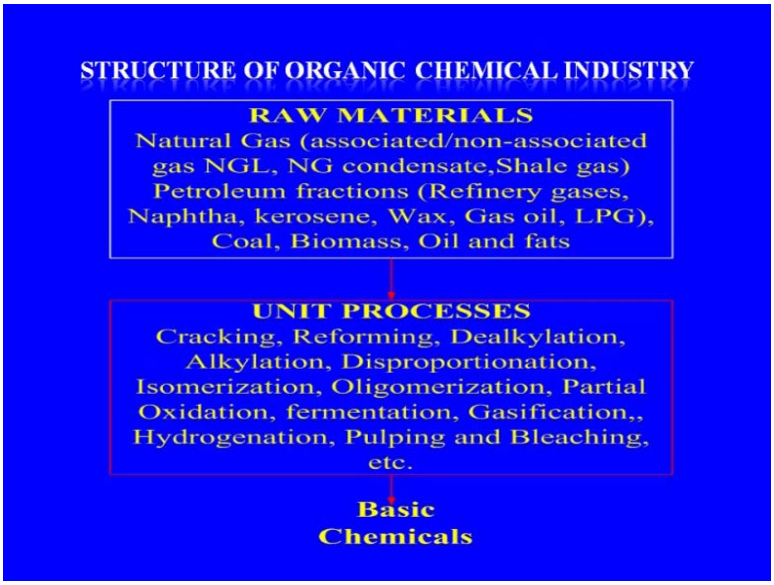
So, for the actually see the now we will be discuss about the structure of the organic chemical industry or you can say the chemical industry. First thing is the raw material because the raw material which is available for the chemical industry that is being processed by the various unit processor. And then we are producing some basic chemicals and from the basic chemicals again with a various unit processor like the

sulphonation, oxidation or it may be the introduction of the chlorine, introduction of the other sulphonic compounds. We are making large number of the intermediates, which are being used for producing the finished products.

(Refer Slide Time: 10:33)



(Refer Slide Time: 11:08)



So, various raw material which are available for the chemical industry or you can say the organic chemical industry, natural gas that may be associated gas or non associated gas, NGL natural gas liquid, natural gas condensate, shale gas. Earlier I told you about the shale gas because that has come in that is coming in a big way in providing a substitute

and the because the now it has been possible to get the shale gas by the… your horizontal daily. Petroleum fractions refining gasses naphtha, kerosene, wax, gas oil, LPG - another very important raw material for the chemical industry that is the coal, coal chemicals. Because, the birth of the chemicals that is started with the coal route. And the earlier lot of the work that was done in 1930 in Germany just to produce the chemicals only problem in case of the coal, even today it is also the economic part.

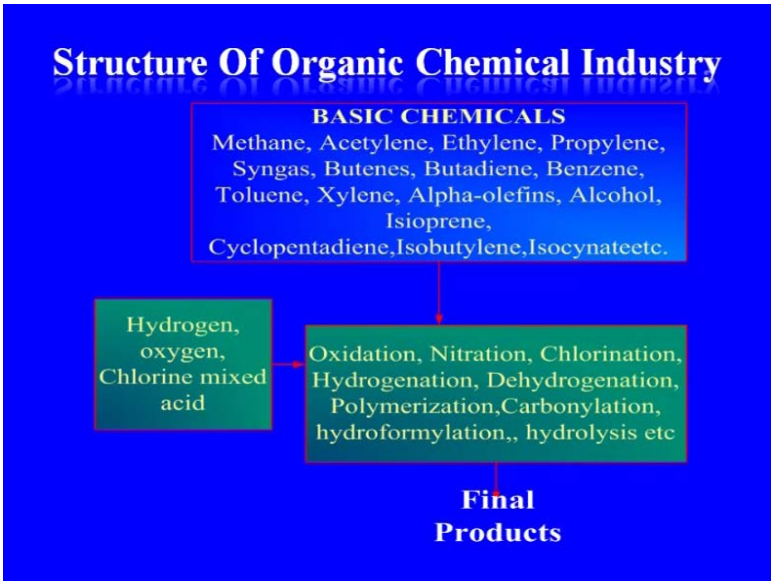
Because in case of the coal, the cost of the production that is high in comparison to the natural gas or the petroleum (( )). But as we are facing lot of the problem in getting the raw material, so there is always search for the alternative raw material. So, the coal bio mass that is coming in a big way and from the bio mass to ethanol bio mass gas application and all over the world people are working for the utilization of the bio mass, for production of the alcohol, for the production of the synthesis gas. And from the bio mass are the coal route to the production of the it will be synthesis gas to the liquid fuel or it may be the synthesis gas to methanol and methanol to olefins.

So, in case of the for producing various chemicals using these raw materials, we are having a large number of the unit processes and that is part of the either it will be petroleum refining or other chemical organic chemical industry, that is the some of the unit process are… These are the major unit apart from these unit processes there are other unit process also which is being used. So, this is the actually the major unit process that is the cracking, reforming, dealkylation, alkylation, disproportionation, isomerization, oligomerization, partial oxidation, fermentation, gasification, hydrogenation, pulping and bleaching. These are the some of the major actually the unit process that we are using and for producing the basic chemicals and the product, which are using for the producing the finished product.

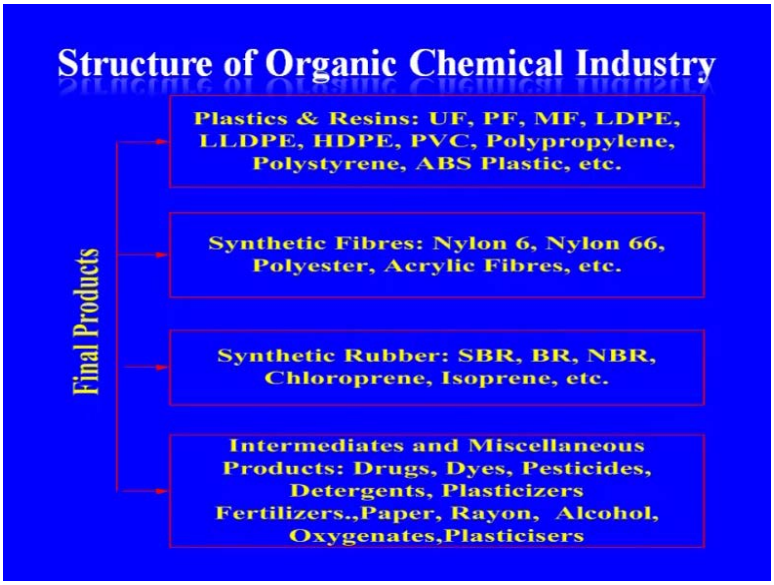
This is about the basic chemicals, which we are producing from the various unit process as I discussed earlier. That is the methane, acetylene, ethylene, propylene, synthesis gas, butanes, butadiene, benzene, toluene, xylene, alpha. Xylene means all the your artho, metha, para, all the xylenes that you are producing, alpha-olefins, alcohol isioprene that is for the rubber industry, cyclopentadiene, isobutylene, isocynate etcetera. These are the things that we are producing from the primary unit process, you can say; and these actually the intermediates, or you can say the basic chemicals that is being used for manufacture of the large number of the final products through the various processes, that

is the oxidation, nitration, chlorination, hydrogenation, dehydrogenation, polymerization, carbonylation, hydroformylation, hydrolysis, number of the process we are having using in industry.

(Refer Slide Time: 13:38)



(Refer Slide Time: 14:56)



And these process are being used for production of the some of the chemical feature finally, that is being utilized by the chemical industry for the production of the final product. And four major class are there, one is the polymer that is the plastic and resin and UF formal dehyde, phenol formal dehyde, milam formal dehyde. That is the thermo

set resin that we are producing and the you must be knowing about the phenol formal dehyde, that is the we call it backlight and that was being used for the electrical appliances. And so, the another major product from the polymer industry LDPE, LDPE means the linear, low density, poly ethylene and the high density… A wide variety of the polyethylene that is better than the PVC polyvinyl chloride, polypropylene, polystyrene, ABS plastic.

And like that a number of the plastic materials and the plastic composite that we are making from the this product, which are produced from the various unit process. In the case of the synthetic fiber we are having the nylon 6, nylon 66, polyster, acrylic fiber. In this case one of the another actually the major units are there in case of the synthetic fiber industry, that is based on the celerigic fiber that is the viscous dyon and the acetate ion. Another important product that we are getting that is find wide application that is synthetic rubber that is styrene butadiene rubber, butadiene rubber and nityle butadiene rubber, chloroprene, isoprene.

And of course, the poly butadiene because some of the units which are having the naphtha cracker. So, they are produced in they are getting butadiene as a byproduct from the naphtha cracker and that is being used for the production of the poly butadiene. Because, they are the actually the entire part is eliminated because, incase of the SVR we need this styrene and butadiene both.

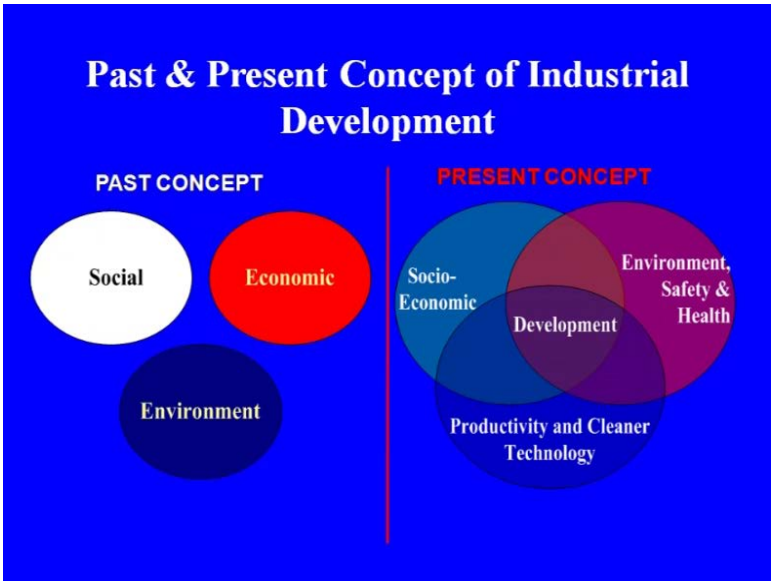
(Refer Slide Time: 17:19)

And so, then for a styrene you will have to have the ethyl benzene and ethyl benzene for… So, that part is so directly they are using the poly butadiene. Another important product that is your, intermediates miscellaneous products, drugs, dyes, pesticides, detergent, plasticizer, fertilizers, paper, rayon, alcohol, oxygenates and plasticizers.

This is the now, I will be discussing before going detail of the status, it is the evolution of the chemical industry. You see the ancient time when you compare the ancient times and the present and the future, wat we are doing? In the ancient time what was the churning of the ocean that was just to get some of the resources from the ocean. And what we are doing today we are today also we are doing the churning of this ocean, in other form that is the acquisition, oil and gas acquisition. We are getting a large number of the minerals and chemicals, which are derived from the sea.

Sea's are that is a very important source of the a large number of the chemicals and one is your important sector that is the caustic chlorine soda, ash probene all those thing iodine that you are getting from the sea. So, the quest of more and more resources that was from very beginning from the ancient time to the modern era, where we are using huge amount of the natural resources for the production of the various products and just to meet our rising demands of the various things that we are using in our daily life. The concept of the development earlier even in our country we have seen that the era of after the independence the that was the era of a industrialization.

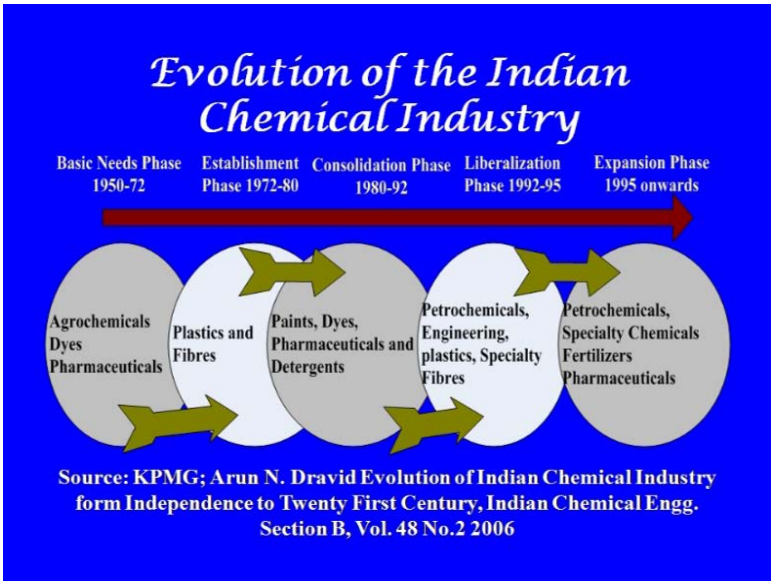
(Refer Slide Time: 18:45)



There was the actually the past concept for the social development, the economic development and environment, all the three that was looked separately. Nobody was bothering during the fifties about the environment, it was the more the economic development just to meet the demands of the people, to meet the food and grain that was the important part in case of the earlier development. Present, the present concept is the so, that the development is just to consider all integrated approach, that is the social economic development environment safety and health. Even in case of the environment earlier it was the only environment then it came the environment health and safety and that was the HSE.

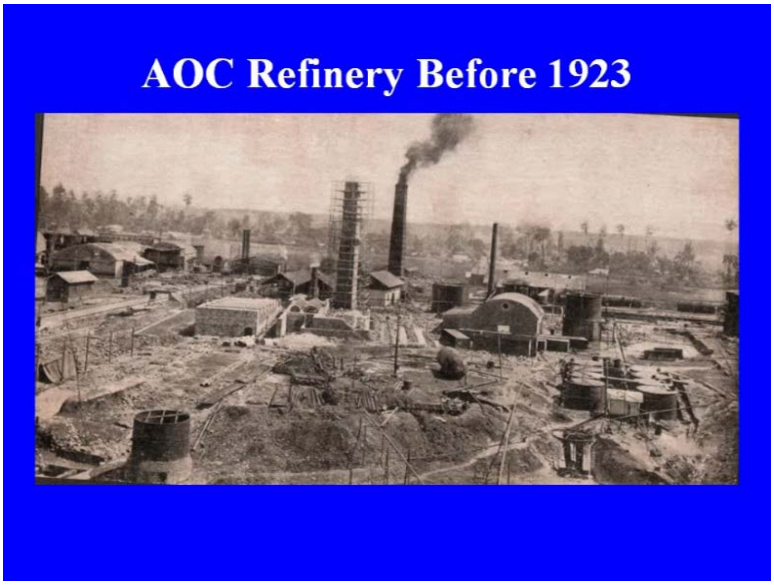
Now, we are talking about the sea, means safety first then the safety health and the environment. And the productivity and the cleaner technology because, the productivity that is also very important if you are having the lower of cost productivity then definitely whole economic of the production that will be affected. Similarly, just to meet the challenges posed by the environment now we are having the number of the cleaner technology, just to have cleaner or the greener technology that is coming in the future. And already that has been implemented in many industry just to face the challenges posed by the environmental pollution and just to reduce the your consumption of the natural resources.

(Refer Slide Time: 20:23)

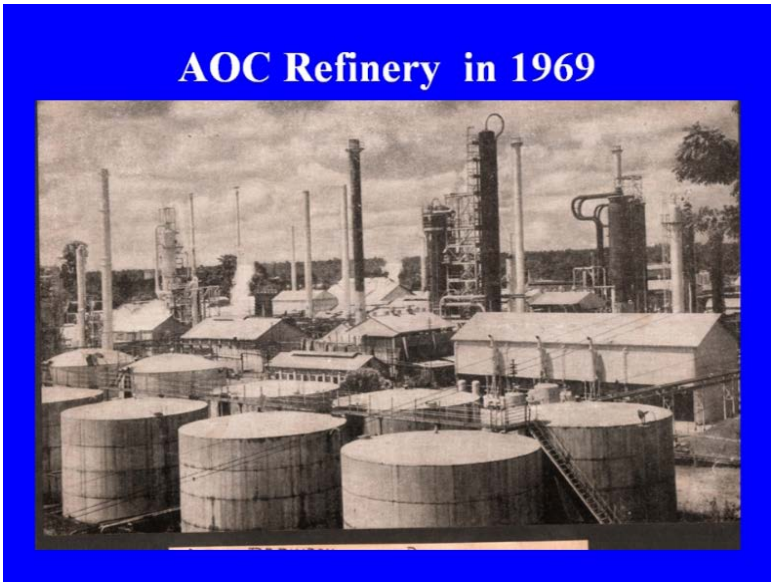


This is the evolution of the Indian chemical industry, which started the basic needs phase that was the era when the basic just it was the prime object of the or country or the government was just to provide the food shelter, roti, kapra and machan there. So, agriculture dyes and pharmaceuticals we started with this, because dyes where earlier from the other sources it was mostly the coal chemical that was being used, then it can the plastic and fibers, paint, dyes, pharmaceuticals and detergent.

(Refer Slide Time: 21:40)



(Refer Slide Time: 21:59)



And then the liberalization, the number of development that took place that was the petrochemical, engineering, plastic, specialty fibers and chemicals. Then the expansion phase that was the petrochemical, specialty chemical, fertilizer and the pharmaceuticals.

(Refer Slide Time: 22:11)

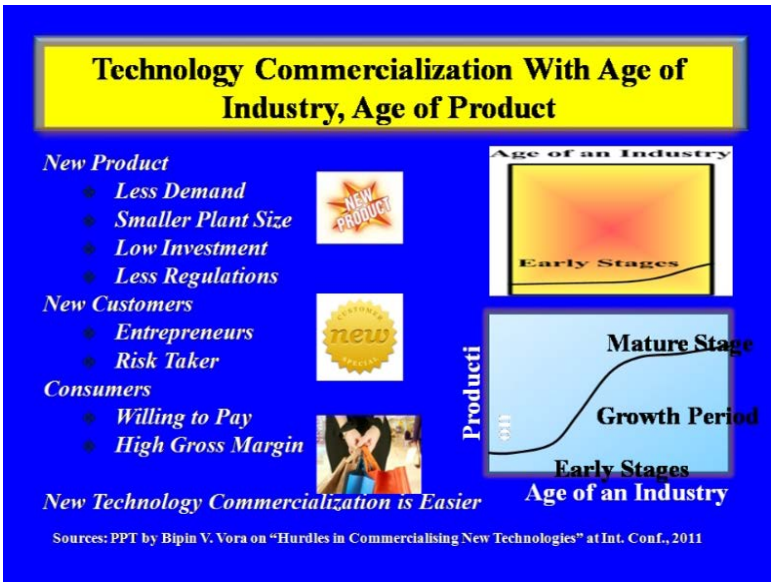
Fig. 2. Reliance Jamnagar Complex (The Reliance Petroleum at Refinery Jamnagar, Gujrat, the worlds largest gross root refinery with capacity of 27 million tonnes(540,00 barrel per day)
Courtesy: Reliance Industries Ltd. Mumbai

Now, the you see the earlier it was the number of the fertilizers found that was we started with a naphtha and the coal. Now, the natural gas that has come in a big way in the development of the fertilizer industry; so this is how the evolution of the Indian chemical industry that has taken place. Just I am, I want to show one how the development that has taken place in a (( )) that is the Assam oil company, that was before 1923, you can see the how the they started the refinery at that time. That was the first refinery that was the started in India with a little resources and that was in the remote area you can say at that time the thing, that was not available at that time. And so, the then it was the after in the 1969, I got an opportunity to take training in the Assam oil company and so, this is the actually during that (( )) the Assam.

And now, if you see the a new refinery that is the Jamnagar refinery of the reliance and you see the type of the development that has taken place in the various. Because, in case of the Assam it was the mostly the thermal cracking and little bit the catalytical. Now, the lot of the development that has taken place in the thermal cracking or the catalytic cracking or the other processes that is involved the desulphisation process because, the removal of the sulphur. So, all those things that has been included now, the refinery is

much more complicated than the what it used to be earlier. Now, the refinery newer concept is the integration to refinery that will be discussing while discussing the petro and the petrochemical part of this module. This is again the old sulphuric acid plant of the Assam oil company.

(Refer Slide Time: 23:07)



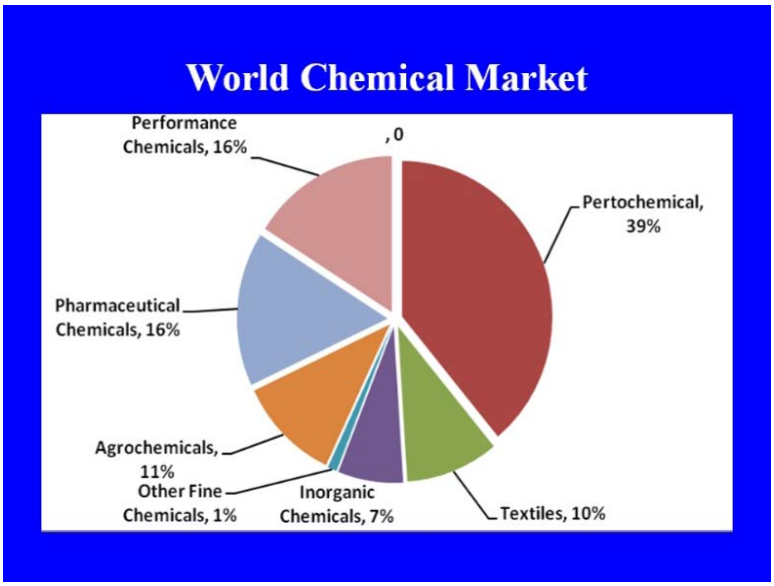
This is the technology and the commercialization with the age of the industry age of product at least this is the our requirement was less population was there. And so, the development if you are seeing here, the development was like this. Now, the requirement, early stages, growth phase and then the mature stage. So, this is the how the new products less demand earlier it was the smaller plant size, low investment, less regulation, new customers, entrepreneurs, risk taker, that was the problem in case of the early stages the consumers willing to pay. Now, the what has happened petrol cost is increasing, in cost of the various product increasing still the people are buying, where people are running with vehicle or they are using the two wheeler or the four wheeler they are using the costlier material now.

Because now, they are they can pay the money, our income… one more thing that was the because of the limitation in the raw materials availability of the energetic sources, the cost of production that was less during the initial stage. Now, the margin is much higher than the what earlier used to be, because there has been continuous development in the

products also, in the quality of the product and the in the manufacture this specialty product.

(Refer Slide Time: 24:31)

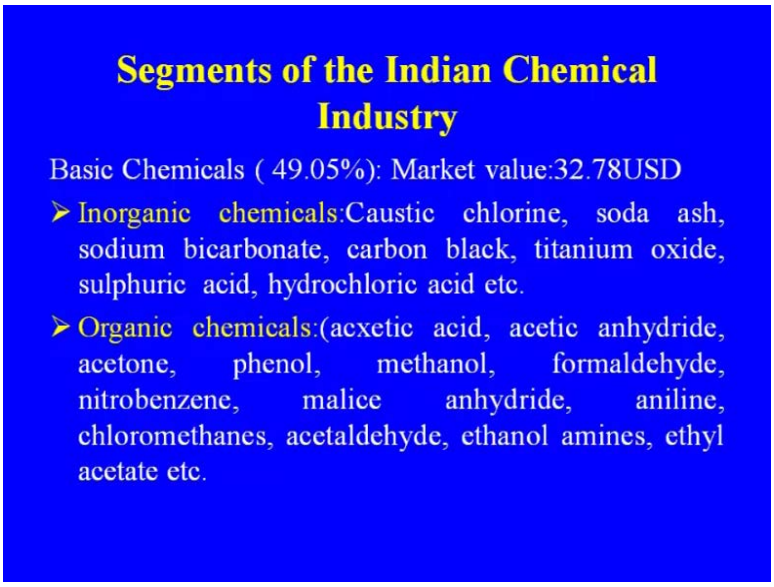
(Refer Slide Time: 25:06)



Global and Indian chemical industry is one of the world largest sector of the economy. In 2008, that is the its sales exceeded 3 trillion US dollars and more than 20 million people around the globe have job connected to the chemical industry and just imagine the role of the chemical industry. World chemical market that was the 2 trillion USD global

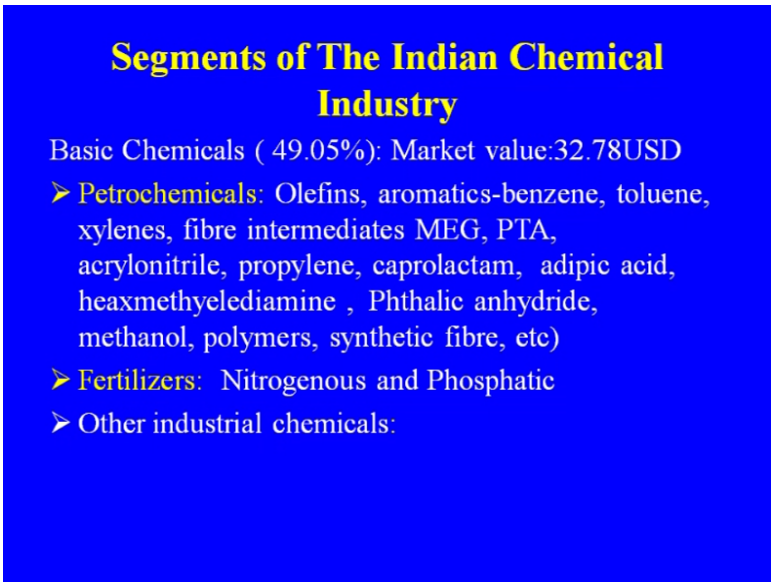
chemical market growing at the rate of 1.5 times the GPD petrochemical dominate with the share 40 percent in case of the organic chemical industry or the chemical industry.

(Refer Slide Time: 25:38)

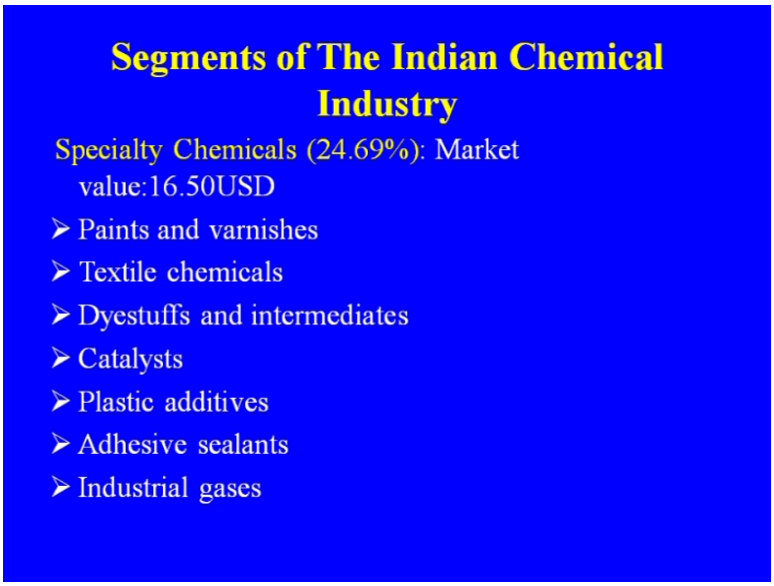


This is the world chemical market you see the major is the petrochemical, pharmaceutical and the chemicals, performance chemicals, agrichemicals 11 percent, inorganic chemicals 7 percent, textile 10 percent. Segments of the Indian chemical industry we are having the basic chemicals, in the basic chemicals about the around 49 percent market value is 32 US dollar.

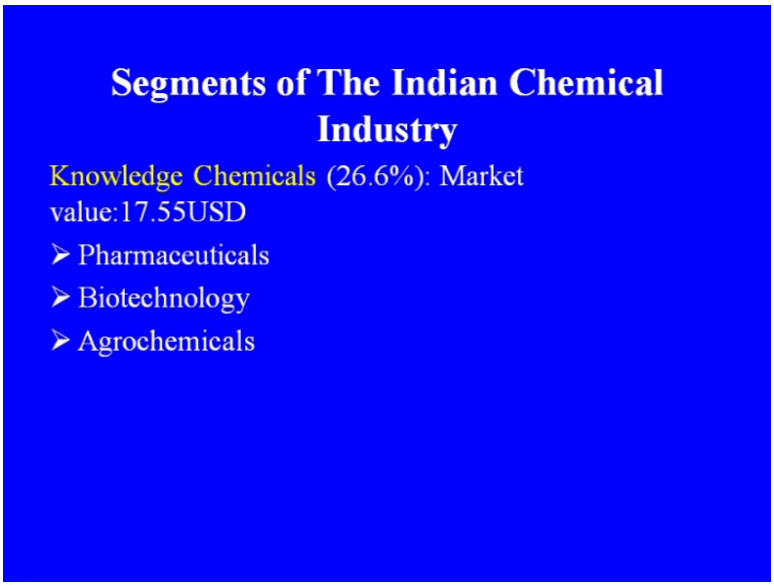
(Refer Slide Time: 26:31)



(Refer Slide Time: 27:00)



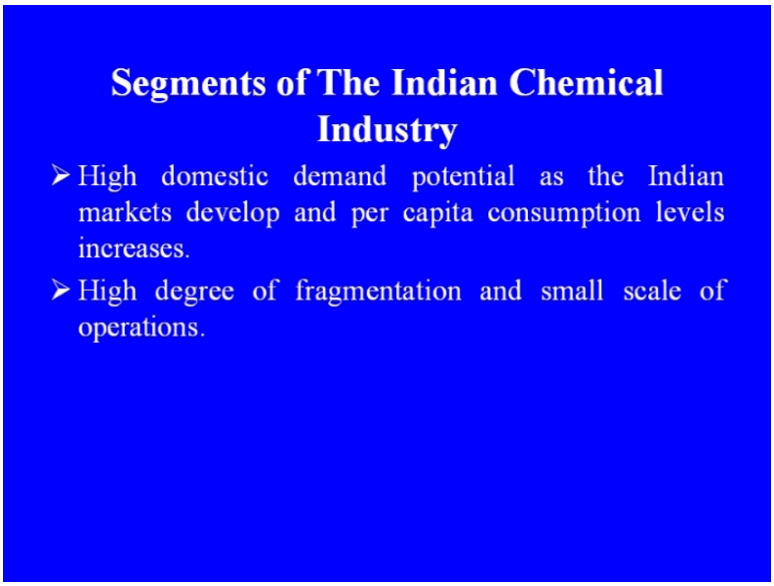
(Refer Slide Time: 27:25)



The inorganic chemicals which deals with the caustic chlorine, soda ash, sodium bicarbonate, sodium carbonate, carbon black, titanium oxide. Because, titanium oxide that is we use in large number of the application even as a catalyst in the paper industry, sulphuric acid, hydrochloric acid, nitric acid etcetera. This is communication. Organic chemicals; organic chemicals we are having the acetic acid, acetic anhydride, acetone, phenol, methanol, formaldehyde, nitrobenzene, malice anhydride, aniline, chloromethane. It is a large number of the chemicals that is coming in the category of the organic chemical.

Basic chemicals that is 32 US dollars that is the that is in the petrochemicals; olefins, aromatics-benzene, toluene, xylenes, fiber intermediate MEG, purified telic acid, acrylonitrile, propylene, caprolactam, adipic acid, heaxmethyelediamine, phthalic anhydride, methanol, polymer, synthetic fiber and so on. Fertilizers, nitrogenous phosphatic fertilizer, other industrial chemicals that is common in case of the basic chemicals. The specialty chemicals market value is 16.50 USD that is in the million dollars and the paints and varnishes, textile chemicals, dyestuff and intermediates, catalysts, plastic additives, adhesive, industrial gasses; these are coming in the category of the specialty. Another categorization that has been done this is the knowledge chemicals that is pharmaceutical, biotechnology, agrochemicals, these are all coming in so, that is 26.6 percent.

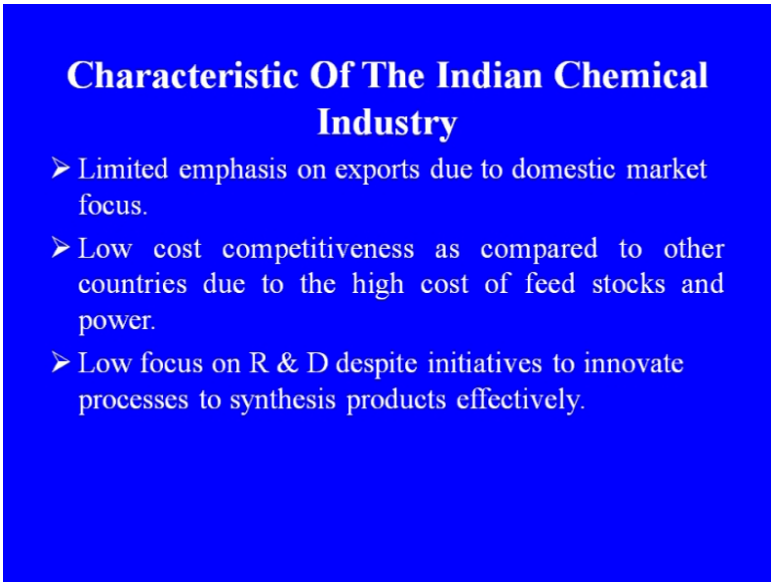
(Refer Slide Time: 27:34)



Segments of the Indian chemical industry, high domestic demand potential as the Indian markets develop and the per capita consumption levels increases. Because the always the as you know the wherever the increase in the population demands are increasing. So, with the per capita consumption, although the per capita consumption in the developing country is much less than the developed country. But the requirement total requirement is high only because, of the large population that the power per capita consumption is less, high degree of fragmentation and a small scale operation.

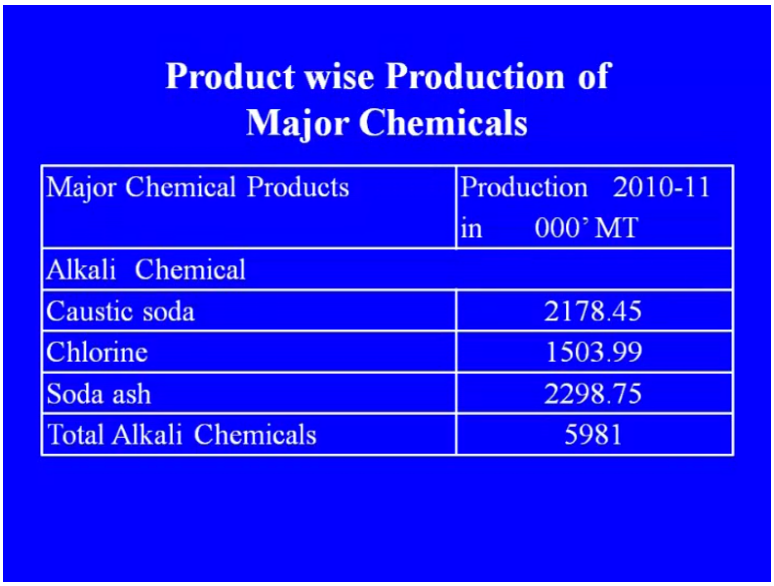
That has been a big problem in the initial stage of the development a large number of the smaller plant came into existence. It may be the mini cement plant, it may be the mini fertilizer or any other industry and so, the even in case of the pulp and paper industry also the mini paper mills came into existence. So, high degree of fragmentation and small scale operations are there which is also affecting the overall economy.

(Refer Slide Time: 28:42)

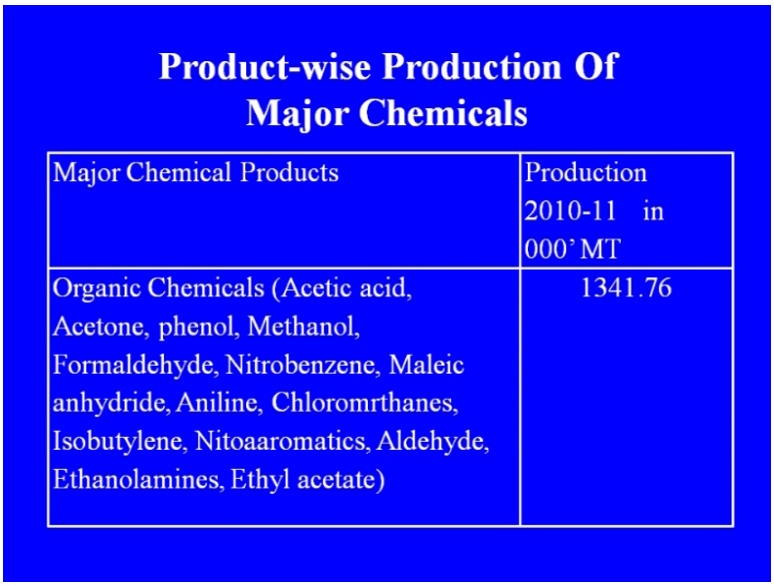


Limited emphasis on the export due to the domestic and market focus earlier. Now, there has been, but still our export is less low cost competitiveness as compared to other country to the high cost of the feed, feed stock and the power. Because, these are the two very important, if you see the power energy consumption in a chemical process industry that is varying very widely 32 it may be as high as 50 percent of the total cost of the… So, cost of the fuel that is very important electricity cost or the coal cost that is in that is increased like anything. Even in case of the petroleum products also the cost is rising. Low focus on the R and D despite of the initiative to innovate the process to synthesis product effectively because, you see the what has happened incase our R and D expenditure is much less as compared to the other developed country. Even that was a survey in the 500 countries in the world only name of the three four industry was there who are investing for the R and D.

(Refer Slide Time: 29:56)



(Refer Slide Time: 30:35)



So, this is the situation in case of R and D (( )). These are the some of the major products and knowledge information about the status of the chemical industry, organic chemical industry, what are the product that you can get from the annual report of the ministry of chemical and fertilizer are the mystery of natural gas, oil and natural gas. So, there all those data that is available even on the website you can see. So, we are have been the alcoholic chemicals and this caustic soda, chlorine, soda ash, total alkali these are the figures multiply by 1000 that is the as written there. So, this is the status of the your

alkali chemicals, this is the major chemical products that we are producing incase of the organic chemicals you can say.

That is the acetic acid, acetone, phenol, formaldehyde, nitrobenzene these are the some of the organic chemicals which are producing, this is the production figure. Similarly, the aromatics incase of the aromatics, benzene because benzene we are using in the various products for making of the cyclohexane. Which is being used in the caprolectum, caprolectum to nylon are written by the mixed xylenes, incase of the mixed xylenes that is the it may be the mixture of the mix para, ortho and the meta are the in most of the cases that is been separated to ortho, para and the meta. And again meta is converted to para because meta (( )) less application. Similarly, in case of the toluene, toluene is also converted to benzene and the xylene and so, the aromatics incase of the aromatics the earlier the source of these aromatics that used to be the your coal.

(Refer Slide Time: 31:42)

Product-wise Production Of Major Chemicals

Polymers(Polyehtylene, polystyrene, Poly vinyl chloride)	5292x 1000
Elastomer (Styrene butadiene rubber, Polybutadiene rubber, Ethylpropylene dimmers, Ethyl vinyl acetate, Nitrile rubber)	94x1000
Synthetic Detergent Intermediates	
LAB	475x1000
Ethylene oxide	164x1000

Polymer different type of the polymers we are producing that is polyethylene, polystyrene, poly vinyl, chloride. Elastomer that is the styrene butadiene rubber, polybutadiene, ethylepropylene dimmers, ethyle vinyl acetate, nitrile rubber. Synthetic detergent that is the LAB linear alchyl benzene, in short form we are calling as the LAB, and the that is linear means the linearity is related to bioof the detergent. Ethylene oxide because incase of the LAB the detergent industry now, oxalate that has been used for the more actually, the greener detergent. And so, the oxalate that is from the ethylene oxide

that we are making. And some of the your organic chemical industry though based on the they are making the ethanol and from the ethanol they have gone for the oxalate also just to have the more valuated product from the ethylene oxide than the what the ethylene oxide that will be used, will be used for the MEG, DEG, TEG.

(Refer Slide Time: 32:54)

Product-wise Production Of Major Chemicals

Performance Plastics(ABS resin, Nylon-6 , polymethylacrylate, Styrene acrylonitrile, nylon6)	192x1000 Tonnes
FibreIntermediates(Acrylonitrile, caprolactam, dimethyl terephathalate, monoethylene glycol, Purifiedterephthalic acid)	4098x1000 Tonnes
Olefins(butadiene, ethylene, propylene	4837x1000 Tonnes

Performance plastic these are the some of the specialty plastic because nylon are also that is been used in place of the some of the polymers like backlight. And other things in case of the electrical appliances, polymethylacrylate, that we are using what we call is styrene, acrylonitrile rubber and that is the not nylon 6, nylon 66. Fiber intermediate, acrylonitrile, caprolactum, dimethyle terephatalate, DMT, earlier actually we started polyster manufacturing with the DMT. Now, most of the polyster plant based on the DMT that has been closed. Now, we are using the terepthalic acid purifier you can say the TPA or the PTA means purified terepthalic acid for manufacture of the polyster molehtylene glycol that is used in the manufacture of your purified terpthalic acid. Olefins, butadiene, ethylene and propylene because, this is the availability of the olefins that is in case of the coming of the large number of the naphtha cracker and the gas cracker.

(Refer Slide Time: 38:49)

Product-wise Production Of Major Chemicals,000 tonnes

Synthetic Fibres	2343.38
Other petrobased chemicals (Butanol,C4 raffinate, diethylen glycol, Diacetone alcohol, 2-ethyl hexanol, methylemetha acrylate, Phthalic anhydride, Propylene oxide, Propylene glycol, polyvinyl acetate resin, vinyl acetate monomer)	94

Because, earlier it was the only five we are going to have one big cracker plant in Assam that is Brahmaputra cracker. So, with the coming of some of the crack, even reliance jamnagar they are also going to have the cracker plant. So, sometimes in the future because, you see the ISC Panipat, they have integrated their refinery with the petrochemical they are having the cracker network.

(Refer Slide Time: 35:32)

Productions and Growth of Major Chemicals in India (fig in '000 tonnes)

Sector	Production		Compounded annual growth(CARG) 2009-10/2005-06
	2005-06 x1000	2009-10 x1000	
Alkali chemicals	5475	5602	0.58
Inorganic chemicals	544	518	-1.2
Organic chemicals	1545	1280	-4.6
Pesticides	82	82	0.0
Dyes & Dyes stuff	30	42	8.8
Total Major chemicals	7676	7524	-0.5

So, with the coming of the new your cracker plants more and more olefins means ethylene and propylene and butadiene that will be available. Other petro based chemicals

that is butanol, C4 raffinate, diethylene glycol, diacetone alcohol, 2-ethyl hexanol, methylemetha acrylate, phthalic anhydride. Because, phtalic anhydride that is one of the very important product that is being manufactured from the arthoxylene, which is again the bi product from the paraxylene plant. Because, coming with the coming of the DMT and TPA huge amount of the paraxylene that we are.

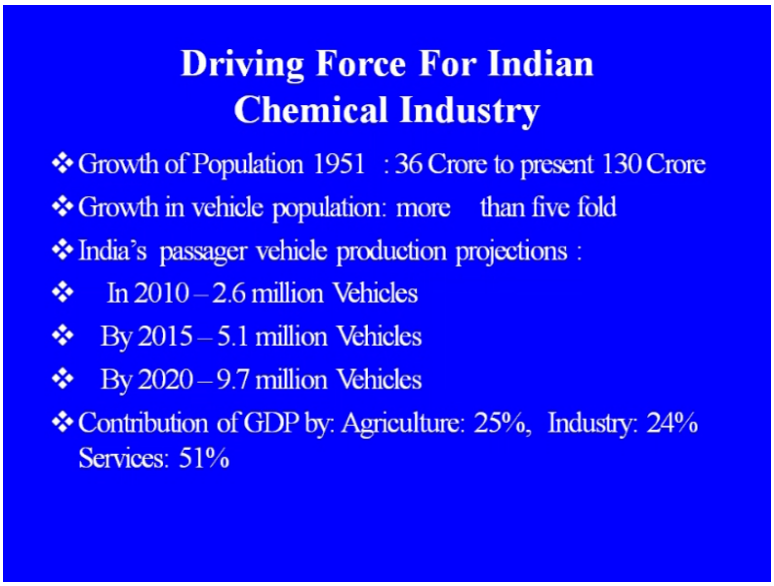
(Refer Slide Time: 35:39)

Productions and Growth of Major Chemicals in India (fig in '000 tonnes)

Sector	Production		Compounded annual growth(CARG) 2009-10/2005-06
	2005-06 x1000	2009-10 x1000	
Synthetic Fibres	1906	2601	8.08
Polymers	4768	4791	0.12
Elastomers9Synthetic rubber)	110	101	-0.92
Synthetic Detergent Intermediates	556	618	2.68
Performance plastics	127	172	7.88
Total Major chemicals	7467	8288	2.64

So, that phthalic anhydride that we are using as a plasticizer in the paint industry propylene oxide, propylene glycol, polyvinyl acetate and vinyl acetate monomer. This is the product wise distribution of the various summary of the actually the production figures. This is also the summary of the production figure you can go through the synthetic fiber, polymers, elastomer, synthetic detergent intermediates, these are the from the 2005-06 to 2009 and 10, some of the production figure that is given there. Now, we will discuss about the, what are the driving forces for the development of the Indian chemical industry. Some of the figures you see the driving force any development, which is taking place that is the just to meet the requirement of the people with the increasing population and another development which is taking place.

(Refer Slide Time: 36:23)



So far India is concerned which in 1951 our population was around 36 crore. Now, we are having around 1.3 crores and the similarly, growth in the vehicle population more than five times. In India's passenger vehicle that has increased 2010 to 2.6 million vehicles, 2015 – 5.1 and by 2020 it is we are expecting that with the 9.7 vehicles that will be there.

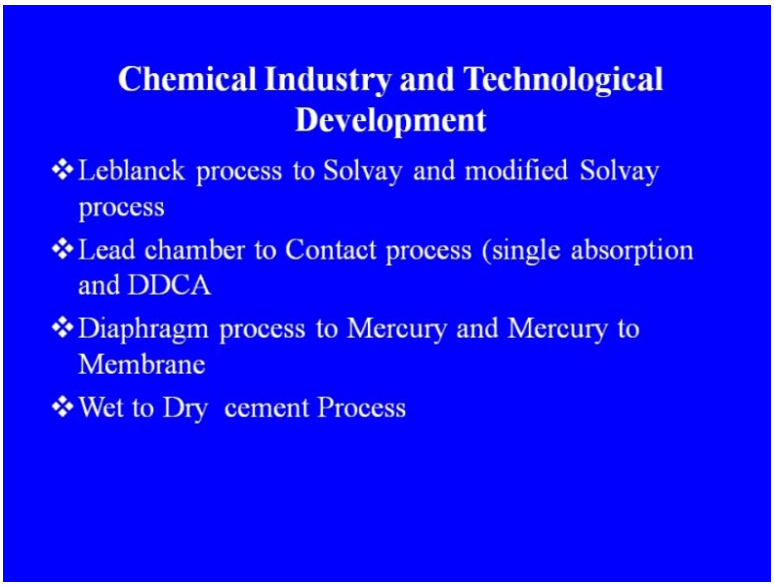
(Refer Slide Time: 37:47)

So, here if you see the figures because the incase of the automobile industry you are using huge amount of the now, the petroleum products that is the polymer, synthetic

rubber for the manufacture of the various products. Now, the conventional cars that is the weight of the material plastic that was less. Now, it has actually increased the your metallic part and many of the even the metals that is into a place with the your specialty polymers or the polymer composite. And so the now we are having the lighter weight vehicles in comparison to earlier where the major portion was the from the metallic part. And so this is the how it has contributed in the growth of the chemical industry also.

So, the chemical industry that has the has evolved considerably over the last century largely in response to the changing societal requirements and the change in the raw material availability and the environmental. You see all the three aspect that is very important our requirement that is being changing and always I quoted dil mange more and more. So, the same thing is happening in case of the our requirement, the requirement this was 1950, 1970. Now, changed many of the things which you are using in the daily life it it was considered a luxury. Now, it has become your necessity. Similarly, the raw material, cost of the raw material that is changing very you see the now we are mostly dependent upon the petroleum product.

(Refer Slide Time: 39:48)

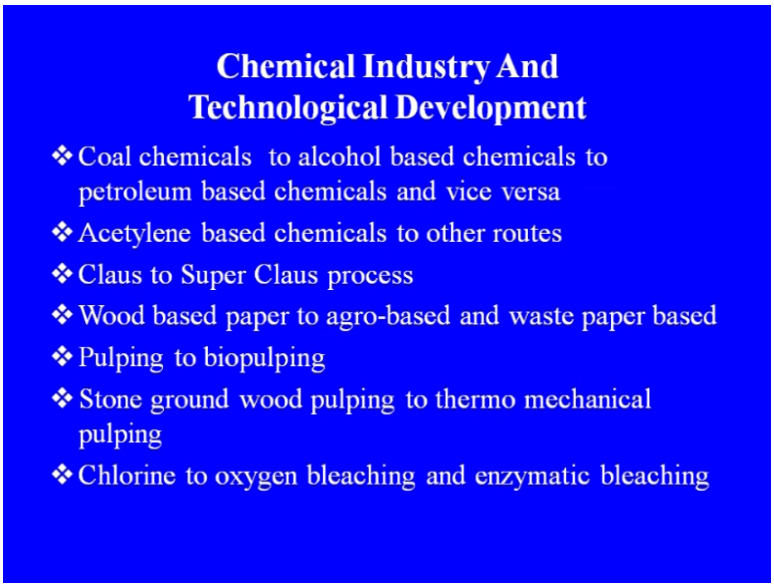


And the cost of the petroleum product that is varying very widely fluctuating there have been the change in the vast change in the cost of the crude oil every day. The cost of the crude oil because of the your if you because of the your, because huge amount of the petroleum crude oil 70 percent that we are meeting from the import. And so, the

environmental issues that is also becoming more and more stringent because environment standard. All environmental standards are at par with any developed country and just to meet that environmental standard.

We will have to we all the industries they have been forced to make the change in their process technology and some of the process that has been added. So, that the release of the polythene that is minimized, there has been the continuous development in the chemical industry. So, some of the technology major technology or development which has taken place, we started this soda, ash with the leblanck process to solvay process and modified solvay process. Lead chamber process, then the contact process that was the single absorption. And now, we are talking about the DDCA and the SO 2 free atmosphere. Diaphragm cell we started the caustic chlorine in the diaphragm process. now, then it was coming to mercury cell process because some advantage was there and again because of the mercury process. Now, we are all the caustic chlorine plant they are based on the membrane plant.

(Refer Slide Time: 40:56)



Similarly, incase of the see if you see the cement plant there you may see change in the process technology and the overall economy of the cement plant. Because, earlier we used to have the wet process now we are having the dry process. And wet process that used to be very small of capacity 500 ton capacity, 500 tons per day capacity. Now, nobody will talk about the 500 or the now they are having the dry cement plant that is the

3 million tons capacity, dry cement plants are there in the whether it is the grinding part or the pile up processing use change that has taken place in the technology. Similarly, in the coal chemicals to alcohol based chemicals to the petroleum based chemicals and the vice versa because again we are thinking of going to the coal and the alcohol based raw material because of the increasing cost of the and at the same time.

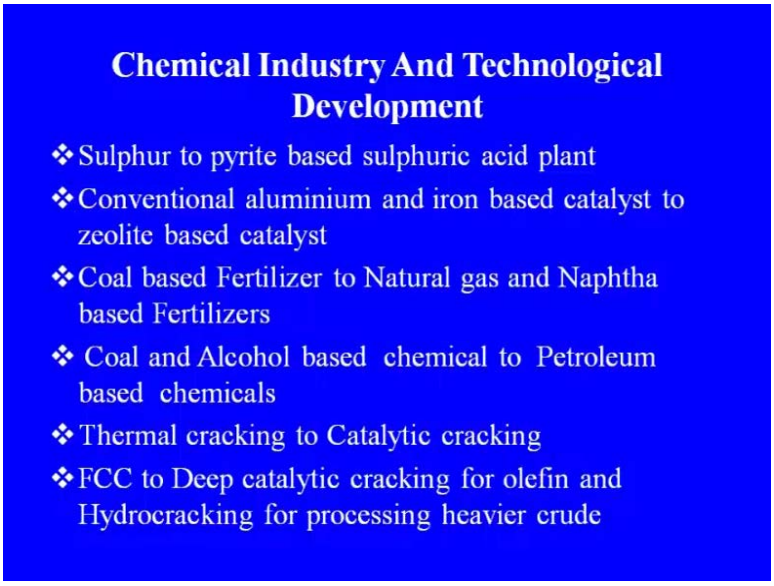
Whatever the petroleum raw material is there petroleum based raw material is there that is not unlimited. So, we will have to think of acetylene based chemicals to the other routes because, earlier whatever the many of the chemicals. Now, we are producing through the it may be your this heclonitrile or it may be estel dehyde or it may be your vinly chloride all they were produced with the calcium carbon. A long list is there the product, which you are the chemicals we are deriving from this thing. Even one plant in India that you are producing the vinyl chloride, and then the polyvinyl chloride based on this (( )). Then the clause to super clause process because, the sulphurmision that has been a big issue in the refinery and the power sector because, of the increasing sulphur content of the raw material.

Then the wood based to the agro based, then the waste paper based mills because, the wood base material because of the deforestation the people safety. And government give lot of the incentive for the and the still they are giving for the agro based and waste paper based mill. They are the waste paper one of the major is problem constraint that has been in our Indian paper industry the recycling part which was poor. But there has been lot of the improvement in the recycle part but, a still there is lot of a scope in the recycling of the waste paper, pulping to bio pulping. Because, the biotechnology that has been that has come in a big way it is not only the paper industry, but in other industry also. Now, we are talking about the bio pulping, bio bleaching, enzymatic pulping, enzymatic bleaching.

Similarly, in case of the bio desulphization similarly, incase of the mechanical pulp. because, which is the major lions here you can see incase of the news feed earlier we used to have this stone ground pulp pulping. Now, we are having the thermo mechanical pulping or the thermo chemical pulping. Chlorine to oxygen bleaching enzymatic bleaching because, the in chlorine that is one of the most hazardous bleaching agent which we are using incase of the earlier.

Because, we are using the chlorination or the hyprocryle that is that was injurious to the pulp also and at the same time the effluent which was desired from the chlorine based bleaching that was having very high toxicity; so because of that reason oxygen bleaching. Now, that has become and the chlorine to chlorine dioxide, elemental chlorine to chlorine dioxide, oxygen because all these things that will be discussed in case of the while discussing the pulp and paper making. So, oxygen bleaching ozone bleaching that has come and in the paper industry. So, these are the some of the major development.

(Refer Slide Time: 44:06)



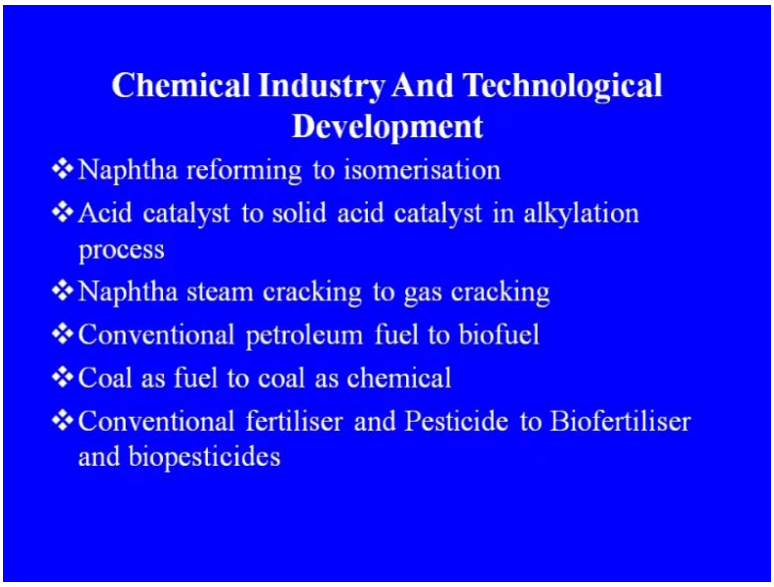
Similarly, sulphur to pyrite based earlier we used have the sulphur for sulphur. But now, the some of the units, which are using the pyrites in case of the copper industry, in case of the iron industry. So, we are making the sulphuric acid from the pyrites also, conventional aluminum iron based catalyst to zeolite based catalyst that we are using. Because, the there is continuous development in case of the catalyst and the because of this catalyst conversion yield of the product coal, based fertilizer to natural gas and the naphtha based fertilizer. Because, the earlier we started when we started mapping to at a two units where have been the coal base, but because of the economic point of view, because it was less economical of producing synthesis gas in compared to natural gas and naphta.

These units are closed again we are reviving just to start this that was one at Ramakundam in fertilizer coal and alcohol based chemicals to the petroleum based

chemical. This already we have discussed how the change in now again we are taking, now we are talking coal and alcohol based to petroleum base and again back to the coal and alcohol base. This is the how the development that is taking place thermal cracking to catalytic cracking. Because. we start with the thermal cracking with the development of the catalytic cracking and the various actually the catalyst the reactor configuration.

Now, the catalytic cracking that has become either it is the FCC or it may be the hydrocracking. FCC to deep catalytic cracking actually the, what has happened in case of the FCC the yield of the propylene that used to be 6 percent, 7 percent. Now, we are talking about 20 percent propylene for the FCC and so, there have been changes in the FCC catalyst also just to produce more and more olefins. Similarly, the hydro cracking many of the refineries now, they are having both the FCC in hydrocracking for the processing of the heavier coal.

(Refer Slide Time: 46:18)

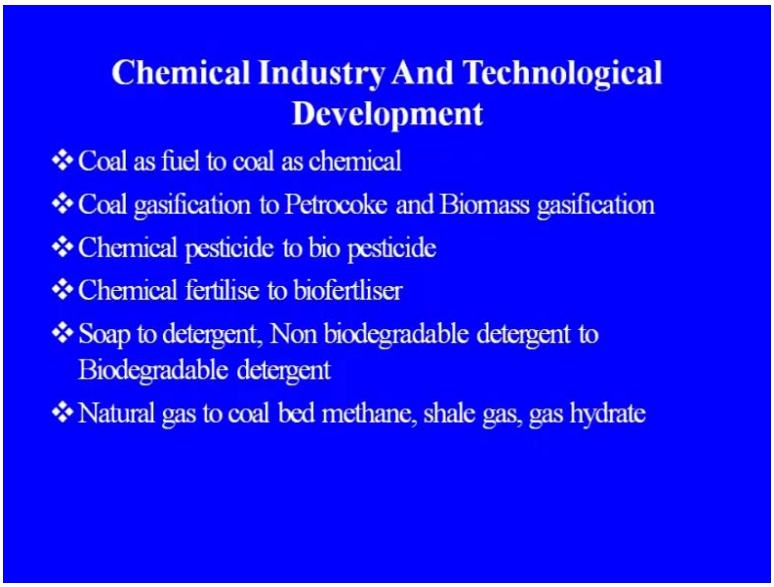


Then the naphtha reforming to isomerisation because the low naphtha which have low octane number, we are and number of the new refinery, they are having the isomerisation plant also. Acid catalyst to solid acid catalyst earlier for the alkylation process used to have the sulphuric acid hydrofluoric acid because of the high cost of the and very cold nature of the sulphuric acid, hydrofluoric acid. Now, the most of the alkylation process which are coming they are based on the solid is acid catalyst and even the incase of the whether it is alkylation. Because, the alkylation process where is in case of the refining

for improving the octane number of the some of the actually the product which are getting from the refinery.

And at the same time for the manufacture of the naphtha steam cracking to gas cracking. Because, the always because with the availability of the natural gas and the now the shale gas the cost of production in case of the gas cracking that is less than or the steam consumption that is less than in the naphtha cracker. So, the now the units number of units are also coming based on the gas cracking conventional petroleum fuel to bio fuel again as I told you the now we are talking about the bio all means the blend of the alcohol and the gasoline or the bio diesel.

(Refer Slide Time: 47:43)



Coal as a fuel to coal as chemicals that is the if your see many of the big business houses they are working on the how to economically produce chemical from the coal. Similarly, conventional fertilizer and pesticide now, because of the toxicity, bio fertilizer and the bio pesticide. That is alnow again earlier it was the bio fertilizer or the bio pesticide, which was being used before coming of the fertilizer point it was the compose, it was the (( )) that was being used as a pesticide. But again we are talking about the another bio fertilizer and bio pesticide that is being used just to reduce the hazards of the chemical pesticide and fertilizers. Another development coal as already I have discussed coal gasification to petrocoke and biomass gas. Because, the coal gasification that has been used from the very beginning either for the production of the synthesis gas or the

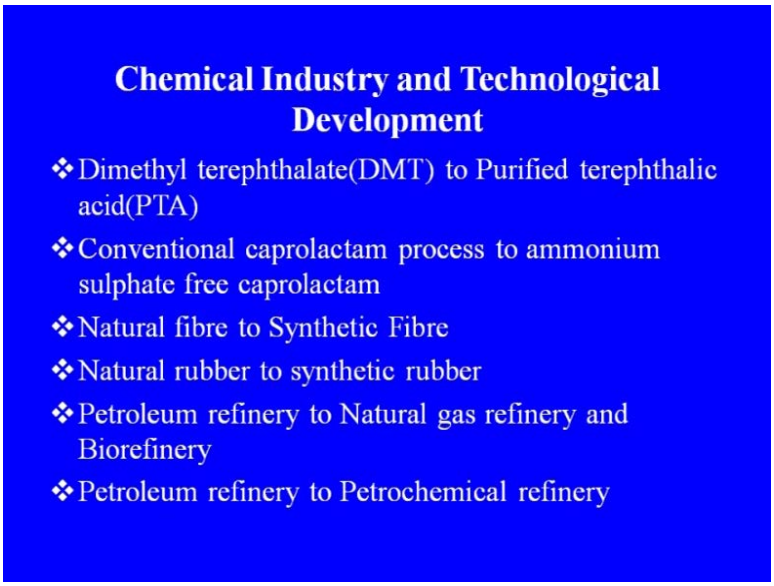
production of the producer gas, water gas, stone gas, or it may be for the production of the some of the fertilizer also.

Because, synthesis gas to the India, but the petrocoke that has coming in the big way because now, the petro coke because of the use of the more and more heavier your crude oil. And the more coke that is being produced in the various processes in case of the petroleum refining in the especially in the thermal cracking process. So, the petro coke gasification in the future because earlier they used to have the naphtha reforming or the gas reforming for production of the hydrogen. Because, hydrogen there is one of the very important you can say the raw material in the various stages we are using the refinery. So, the petro gas coke gasification for production of hydrogen and the another area which are the development that is taking bio mass gasification. Because, the bio mass gasification again because the with the availability of the huge amount of the agro based material the bio mass gasification or the bio mass paralysis, for the production of the fuel or the for the production of the alcohol through the fermentation role.

And that is the one of the thing that is we are going to see in the future changes in the future. Chemical pesticide to already I have discussed about the chemical pesticide to fertilizer and the and the fertilizer to bio fertilizer, soap to detergent, non biodegradable detergent to biodegradable detergent. Because, these were the earlier problem when you were you were using the bio non bio degradable detergent and that was coming in the your municipal waste water. And so just to avoid now the we are having the bio degradable gate of the detergent and more greener detergent that is… Then the coal gas, coal bed methane or the shale gas or the gas hydrate. They are going to be the future source of the natural gas already coal bed, methane in some of the area of the raniganj area, we are working and the just to trap this methane.

Shale gas in US and the Canada that has come in big way and because of the availability of the shale gas the cost of the natural gas has gone down. And ultimately that has affected the whole cost of the product olefin that we are getting. Similarly, gas hydrate because still we are having the not much development that has taken place in case of the utilization of the gas hydrate, which is much richer in the methane than the other sources. But lot of scope is there just to trap this methane from the gas hydrate and the allover the more people are working to utilize the gas hydrate.

(Refer Slide Time: 51:52)



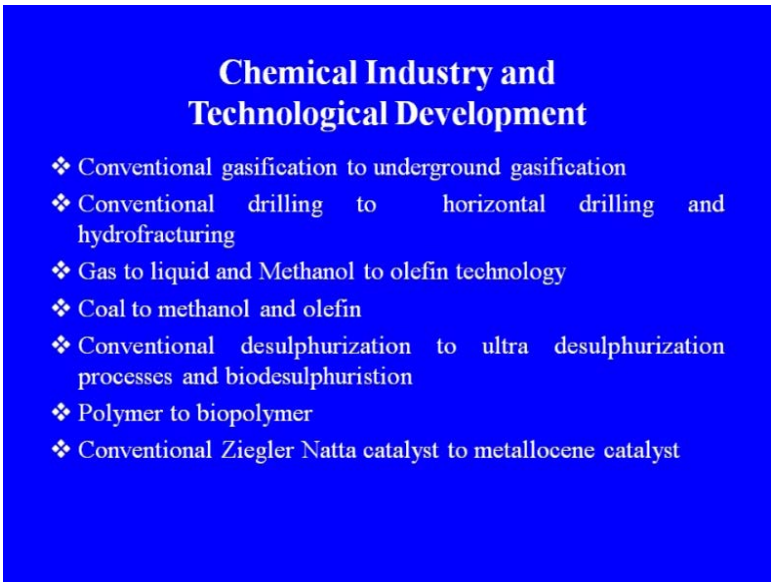
Similarly, the in other area also lot of the development that has taken place in the chemical industry that is the DMT to purified terephthalic acid. Because, of the quality of the product consumption of the raw material that is much about 10 to 15 percent this is less incase of the terephthalic acid. And now, we are having a large number of the larger capacity terephthalic acid plant, earlier the DMT plants where low capacity. And that was the actually the how the development that has taken place in case of the reliance industry. Because the Bombay dyeing were first to manufacture the polyster from the DMT role and after coming of the patal ganga plant of the reliance and then the hajra plant, the most of the dye methyle terephthalic plant that is been closed. And the now, whatever the plants are there they are based on the TPA or the PTA, and the many of the units which were based on the DMT that has been taken over by the reliance.

Another changes that is taken place in case of the caprolactum to ammonia sulphur because, normally in the conventional process which are using for the caprolactum three times of that caprolactum we are producing the ammonia sulphur. And this is the reason why the caprolactum which is being manufacture in India by the two fertilizer plants, one is the GCFC and other is the fact seventh core they are making the caprolactum. So, there is the now people are working and the some of the plants are already here in other part of the ammonia free caprolactum. Natural fiber to synthetic fiber that was the changes that has taken place and still actually the earlier it was the only the cotton that

was being used. But now, the it has been mostly the synthetic fiber that we are using for some.

Because, we are the cotton producing area the still role of the cotton is there and the people are preferring the cotton over the synthetic fiber because of the comfort natural rubber, synthetic rubber. Again some of the country they are not making the having the natural rubber plantation or the natural or the cotton plantation. So, they are totally depend upon the either synthetic fiber or synthetic rubber. Petroleum refinery to natural gas refinery this is the or the bio refinery, this is coming this is the new development in case of the petroleum refinery just to integrate the refinery with the natural gas based material also or the petroleum refinery to petro chemical industry. Because, if you are having in the same premises both the things that the raw material from the petroleum refinery that can be used for the production of the petrochemical more economically.

(Refer Slide Time: 54:41)

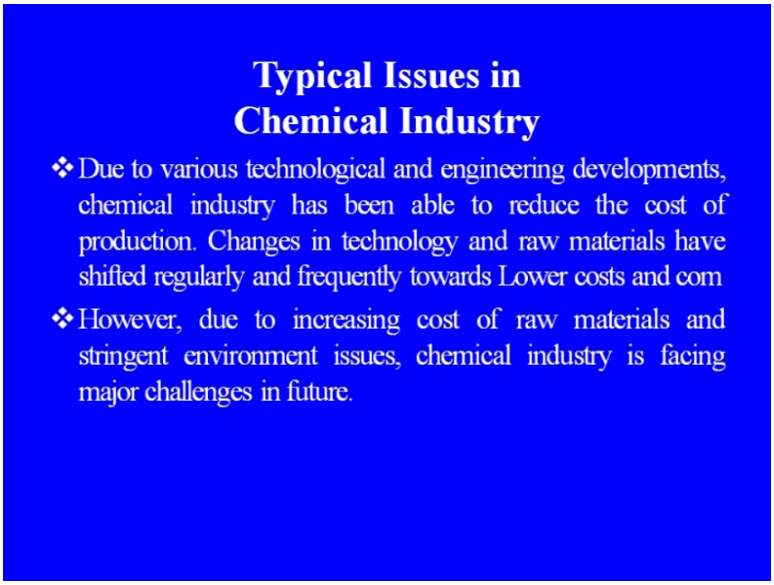


Another actually the conventional gasification to underground gasification, conventional drilling to horizontal drilling and the hydrofracturing. Which I told you because the development that earlier it was the vertical drilling now with the horizontal drilling and the hydrofracturing the cost of the drilling of the shale gas that has reduced. And so, the shale gas that has become one of the very important raw material and substitute for the conventional natural gas. Gas liquid and methanol to olefin technology that is also now the big way because the gas natural gas is available, from the natural gas to the process

you can go for the liquid, for the fuel or to the methanol and methanol that can be converted to methane olefin.

Coal to methanol and olefin that is also one of the upcoming technology and the china they evolved because they are having the huge resource of the code. And they have already started one plant based on the coal to olefin. Conventional desulphurization, ultra desulphurization process and bio desulphurization because, the sulphur that is creating lot of the problem in the environment. And so, the our standards for the fuel that is becoming more and more stringent and just to meet that standard we will have to go for the ultra desulphurization. And in many case the bio desulphurization that also that is being used even the bio technology application is there in the bio degradation the oil also.

(Refer Slide Time: 56:45)



Polymer to biopolymer because of the only thing the constraint in going from polymer to bio polymer that is the cost of the production is much higher. Conventional ziegler natta catalyst to metallocene catalyst for the propylene production, for the polypropylene that has come in a big way and the quality improvement is there in case of the polypropylene. Due to the various technological and engineering developments, chemical industry has been able to reduce the cost of production. Changes in the quality and raw materials have shifted regularly and frequently towards lower cost. However, due to increasing cost of

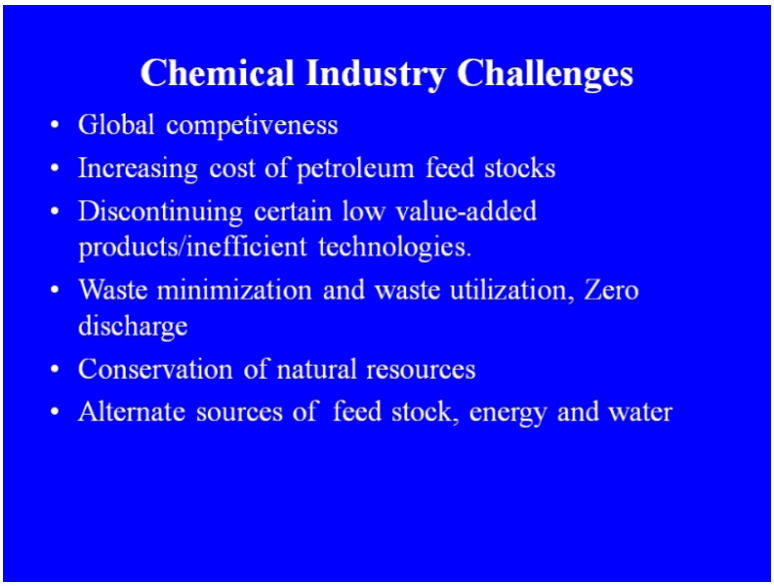
the raw materials and stringent environment issues, chemical industry is facing major challenges in the future.

(Refer Slide Time: 57:10)

These are the some of the typical issues which a not the chemical industry, but other industries are also facing that is the environmental point of view. Reduce emission, reduce waste, minimize the waste water, use increase the thorough output, better productivity, meet the new product specification. Because, unless until there is continuous development you will have to go for the more value added products and this is what the refinery and the petrochemical industry are doing.

They are going for the more value added product then the save water because, the water that is more and the you see the that as that is being quoted as next war will be not for the oil. But it will be water because the water scarcity that is increasing we do not have the safe drinking water for our, not only in India in other part of the world also the same problem that is being faced. Reduce operating cost that is very important for improving the economy, improve the efficiency, introduce new plant, improve the utility system and performance.

(Refer Slide Time: 58:21)

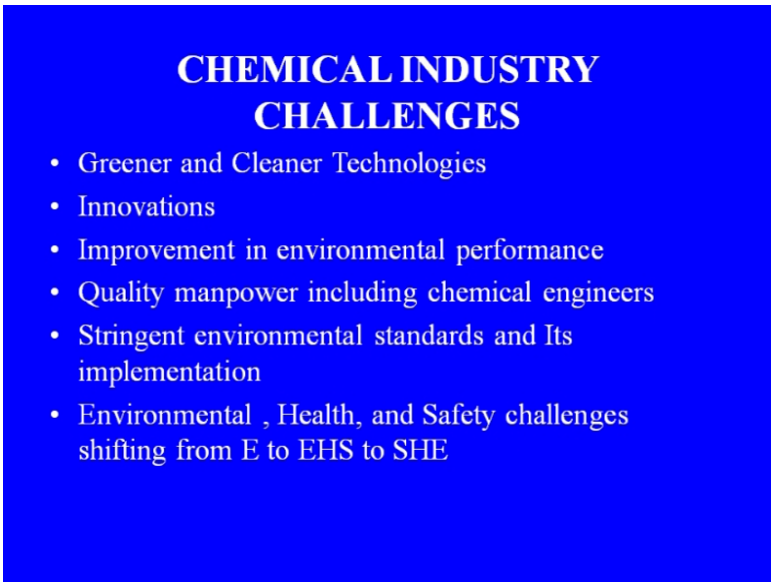


Chemical industry these are the some of the challenges grow global competitiveness. Because now, what about the production if you want to go for the export then your cost will be at par with any developed country or the developing country. And then only you can compete in the even some of the from the environment point of view from the carbon trading point of view also some of the big challenges there. How to capture the CO 2? How to reduce the cost and just to meet the quality? Because, the quality nobody is going to compromise even you see the you will have to produce the quality at par with any advanced or the developed country.

Increasing cost of the petroleum feed stock, discontinuing certain low value added products in inefficient technology. Because, still in India we are having the large number of the smaller plants they are based on the older technology they are running, even you see the vehicle there has been lot of the improvement, but still we are running the older vehicles.

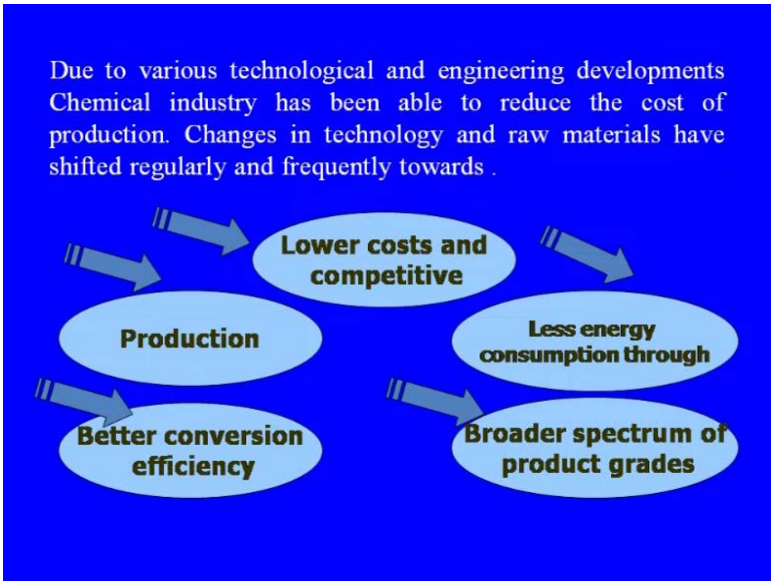
Similarly, the waste minimization and the waste utilization and now the concept of the zero discharge, total recycle that is there. It was the recycle we started with the recycle only 1 hour, 2 hour, 3 hour, 4 hour. So, this is the how the development conservation of the natural resources that is very important because you cannot depend because whatever the resources you are having that is not unlimited. So, you will have to go for the alternative source of feed stock energy and the water just to meet the future challenges.

(Refer Slide Time: 60:14)



Greener and the cleaner technology, innovations, improvement in the environmental performance, quality manpower including chemical engineers, stringent environmental standards and its implementation, environmental, health and safety challenges. As I told you the shifting from environment to EHS to SHE earlier it was the because the after the environment EHS word came in the industry and there people are talking about the EHS. Now, the people are talking about the see means safety first, health is first and then the environment.

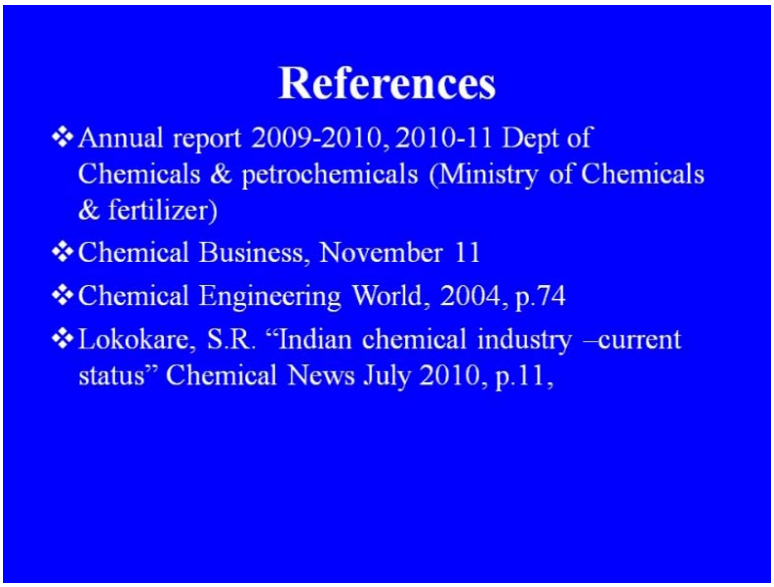
(Refer Slide Time: 61:27)



And so, if you are controlling environment and if you are having the better safety means you are the environmental condition good and you are providing better health to the people who are working. Because, the two types of the problem that is there in case of the environment, one is the people who are working there and the other is the people who are exposed to these products. Because, of the contamination because, of the some problem because, of the wastage and recycling is poor all those problems are there.

So, just to in the last just to conclude due to the various technological and engineering developments chemical industry has been able to reduce the cost of production changes in technology. And the raw materials have shifted regularly and frequently towards lower cost and competitive, production, more production, better conversion efficiency, just to improve the yield less energy consumption, broader spectrum. Because, you see the energy there have been lot of the changes in the fertilizer industry, cement plant or the paper industry, petroleum industry and we have been able to reduce our energy consumption by 10 to 20-30 percent less.

(Refer Slide Time: 62:39)



Even with the there has been general survey that the energy consumption that can be introduced by good house coupling 10 to 20 percent of we are wasting the energy. So, that can be same thing is happening in case of the industry also there lot of the improvement is there because, of the higher capacity plant. Because, of the improvement in the various equipment higher capacity equipments because the better efficiency of the

equipment. So, this is very important so this is the how the development that has taken place. Some of the differences are there you can go through and regarding the status of the chemical industry lot of the information is available in the annual report of the ministry of the chemicals and petrochemicals and the oil and natural gas you can go through.