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

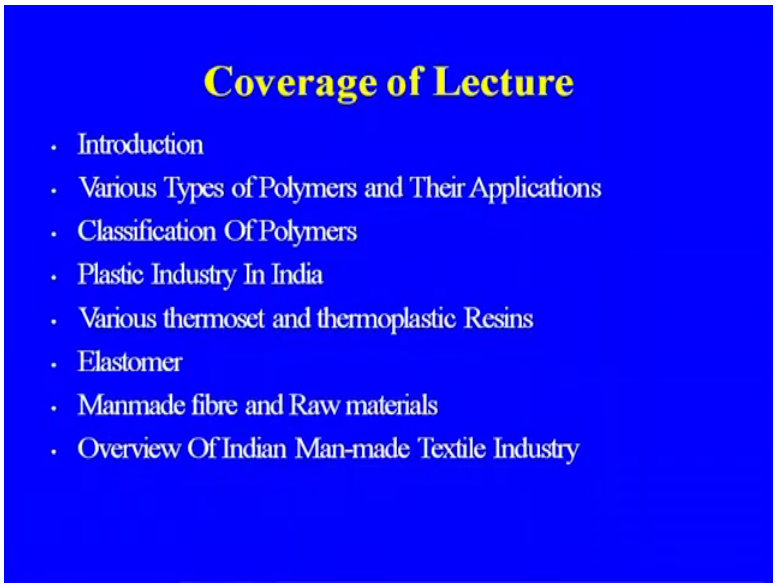
Module - 8
Polymer
Lecture - 1
Introduction to Polymer, Elastomer and Synthetic Fiber, Polymerization

We are discussing the organic chemical technology course, today we will be discussing module eight of this course and here we will be discussing about the polymer industry. Already, we have discussed about the various petrochemicals major feed stock and the intermediates some of the intermediate, which are finding use in the manufacture large number of the product.

So, in the polymer we are having lecture one, lecture one will be on the introduction to the polymer, what are the various type of the polymers we are manufacturing over the classification of the polymers and importance of polymer. As you know that in daily life, everything that we are using some other form that and that is from we are using that polymeric compounds.

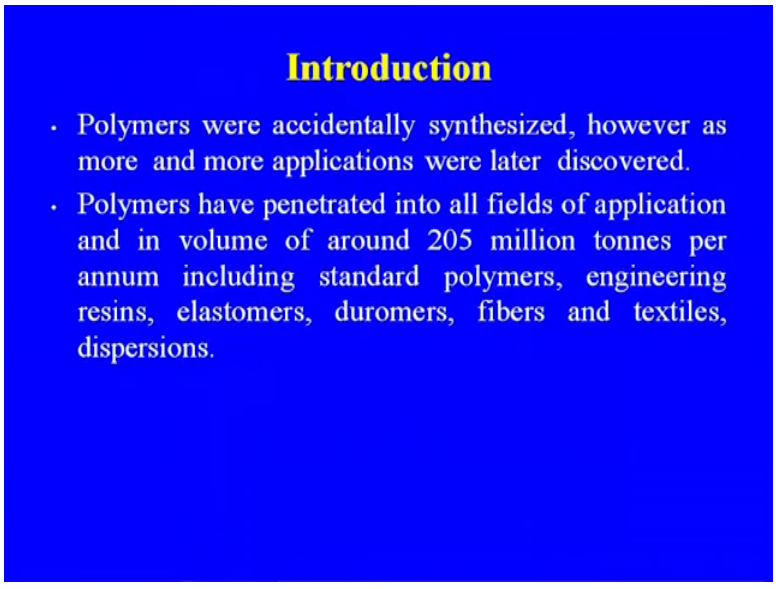
So, today this module eight is on the polymer elastomer and synthetic fiber, so that will be the coverage will be the end eight lecture because first few lecture that will be on the polymer part. Then, elastomer and then the synthetic fiber in the synthetic fiber we will be also discussing the viscose rayon which is one of the important sector in case of the synthetic fiber. Today, we will be discussing in general about the polymers elastomers and synthetic fiber. If you see here, the product which you are getting from the polymer and their application so wide application of the polymeric compounds are there whether in the form of the plastic in the form elastomer or in the form of the synthetic fiber.

(Refer Slide Time: 02:27)



So, this is as I told you this is the only just introduction about the polymer elastomer and synthetic fiber and about the polymerizing in general. So, this will be the coverage of the lecture introduction, various types of the polymers and their application, classification of the polymers plastic industry in India. Various thermo set and thermoplastic resins, elastomers, manmade fiber raw material and overview of the Indian manmade fiber textile industry. As I told you the polymers they are playing very important role in all sectors.

(Refer Slide Time: 02:58)



So, polymers where actually accidentally synthesized however as more and more application where later discovered. So, polymers have penetrated into all fields of application and volume of around 205 million tons per annum including standard polymers, engineering resins, elastomers, duromers, fibers, textiles, dispersions and so on. So, you see the in case of the engineering plastic and one of the very important sector you saw the automobile sector where, or even the in case of an appliance and communication polymers that has played important role.

(Refer Slide Time: 03:50)

So, this if you see the various product profile of polymers we are using the building construction packaging electric and the electronics agriculture medicinal automotive. So, no area is left where in some or other form we are not using here in case of the building and construction. Now, the various actually the starting from the window door and the other application we are using the plastic pipes are now being used extensively, which have replaced the conventional pipe line for the water supply even in case of the agriculture also.

In packaging, you are seeing the revolution; it has replaced the conventional glass which is being used for the packaging and the carry bags which was made of the people. Similarly, electronics and so innovation energy efficient, then miniaturization that is the one of the area that the most of the part, whether it maybe the computer laptop or the any electronic devices we are using the polymeric compound in some or other form.

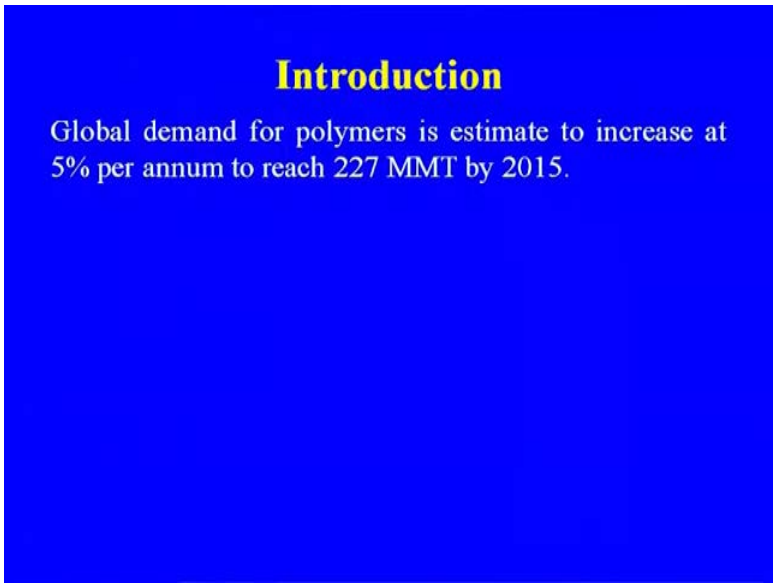
Similarly, the agriculture food and water supply, now the poly bags we are having big bags which used to be bags. Now, it is the polymers the we are using the poly propylene bags and for the storing cement and other raw materials also the sugar and the fertilizer this all being now packed in the polymeric bag.

Similarly, the medicinal aspect, the poly propylene that is finding use, other polymers are also finding use in automotives. Now, you see the weight of the light weight vehicles high speed vehicles and they have a major portion of it may be in the form of the polymers poly propylene bumper. Another thing that we are that is made up poly propylene and tire that is also synthetic rubber that we are using tire card lining synthetic fiber. So, these are the broad application and if you see how the polymer is playing important role in our daily life.

(Refer Slide Time: 06:06)

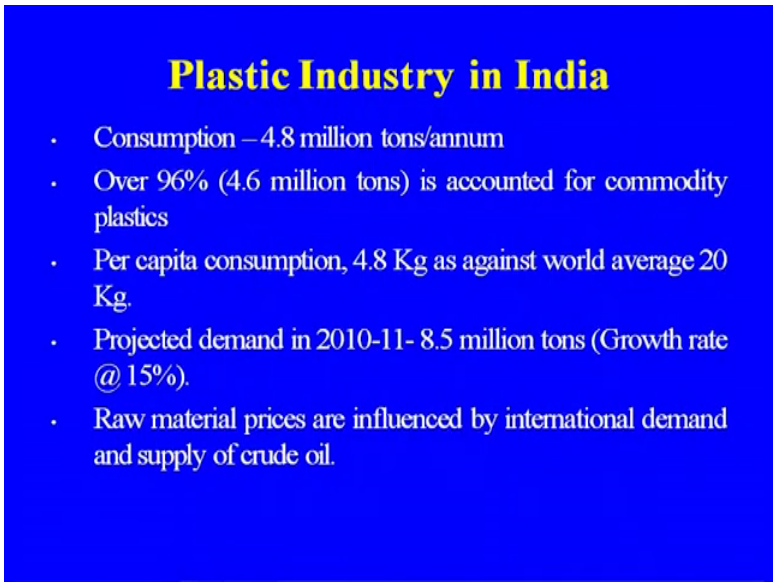
These are the other some of the major application, even you see the badminton racket are the in the sports shoe, poly carbonate and the toes of the shoes that we are using high impact synthetic there. Similarly, now the conventional there football that is also there we are using now the new weight of the material that we using the packaging. Then, the container and then you are saying this is the in automobile sector chairs plastic chairs that is available in the market. So, this is the broad view how the polymer consumer application of the polymers are there.

(Refer Slide Time: 06:57)



Global demand for polymers is estimated to increase at 5 percent per annum, here actually this is the only this figure, it is not for the synthetic fiber or the elastomer.

(Refer Slide Time: 07:11)

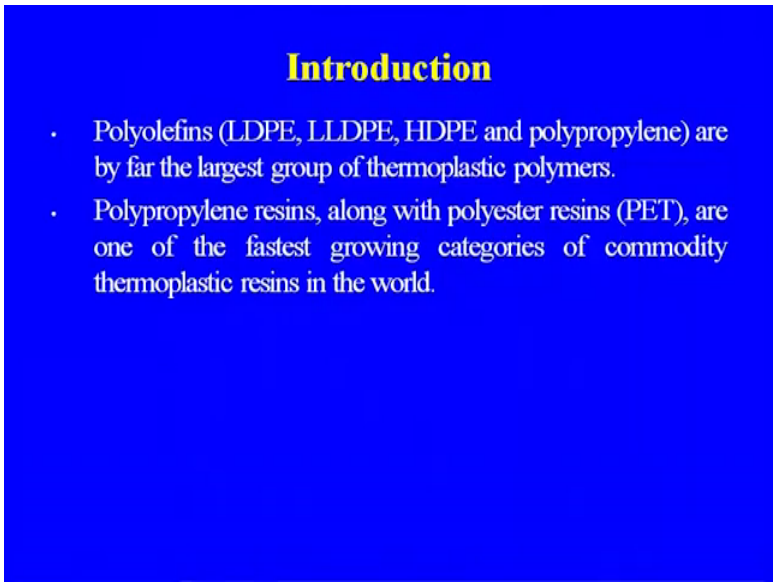


Plastic industry in India consumption about 4.8 eight million tons per annum over 96 percentage accounted for commodity plastics per capita consumption 4.8 kg against the world average of 20 kg 20 kg. So, our per capital consumption, but you see the always the per capita consumption is not exact figure which you gave because our population is more. So,

though per capita consumption that is less always, here wherever the population is projected demand that is around 8.5 million tons in 2010-11.

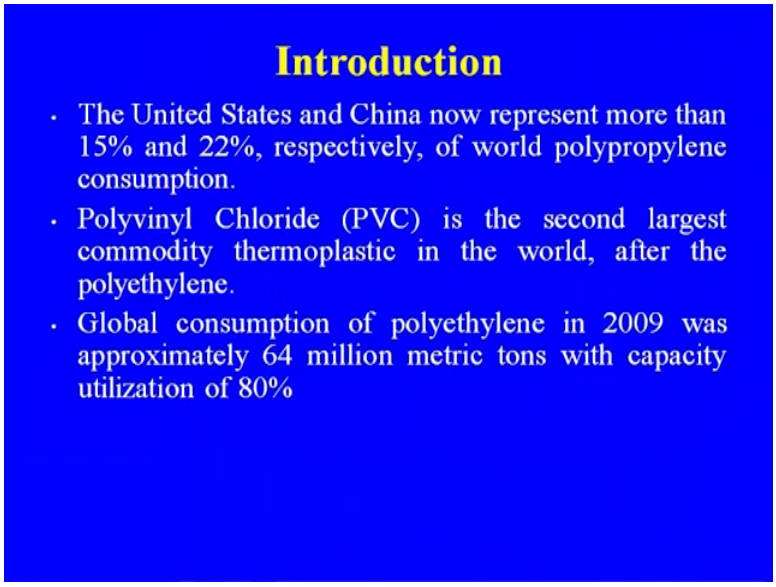
Raw material prices are influenced by international demand and supply of the crude oil because the basic raw material which we are using for making of the polymer. It may be the ethylene propylene or it may be the xylene whatever the styrene from the ethyl benzene benzene. This is influenced by the international demand and the supply of the crude oil because the always we are interested for the export of material. The price will have to meet the international market with the international price international quality if you want to import. So, these are the some of the factors which are influencing the raw material prices and at the same time growth of the polymer industry amongst because the poly olefins.

(Refer Slide Time: 08:43)



Various forms of the poly olefins are low density poly ethylene linear low density or high density polythene or propylene or by for the largest group of the thermo plastic polymers. We are using polypropylene resins along with the polyester resins are one of the fastest growing categories of the commodity thermoplastic resin in the world. We are having the two types of the plastic, one is the thermoplastic, another is the therosetresins.

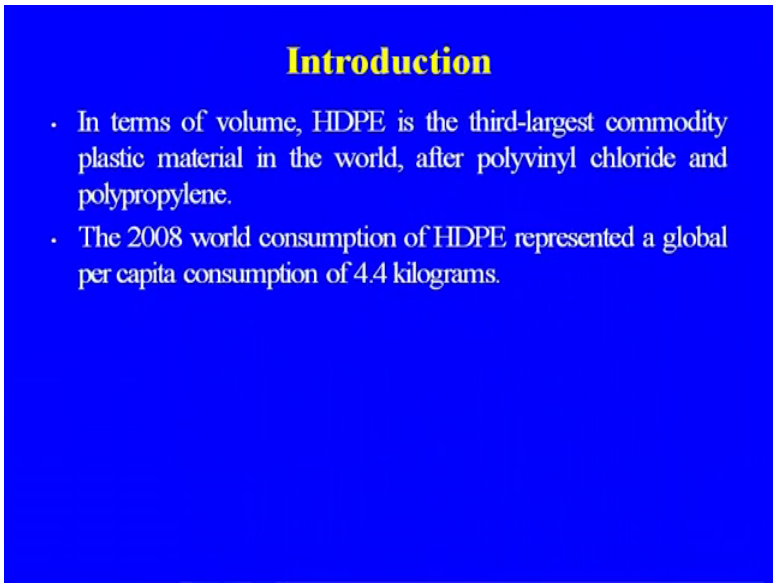
(Refer Slide Time: 09:27)



This is about the global picture of the polymers, the United States and China, now represent more than 15 to 22 percent of the world propylene consumption because the propylene. This was the reason why the high propylene is in high demand and the refinery they are operating or even the cracker plant they are operating more in the propylene. So, polyvinyl chloride is the second largest commodity thermoplastic in the world after the polyethylene because the PVC. Earlier, many of the application have been replaced with other polymers because of the some problem in case of poly environmental because the toxicity of the vinyl chloride leather problems is there.

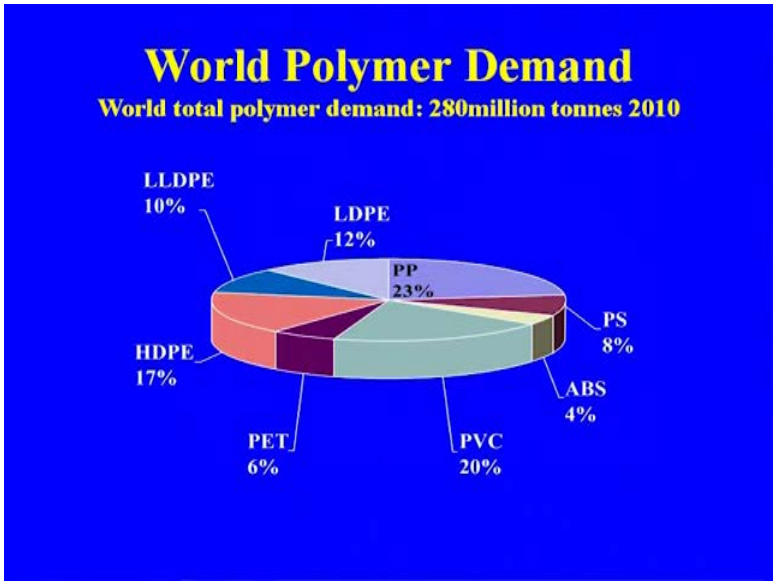
So, poly, but still the poly PVC even the growth of the petrochemical industry in this middle stage another part that was with the production of the PVC and where the large amount of the chlorine that was being used. So, that was also the reason of the development caustic chlorine industry the global consumption of the polyethylene in 2009 was approximately 64 million tons with capacity utilization of 80 percent.

(Refer Slide Time: 10:40)



In terms of volume HDPE, the high density polyethylene is the third largest commodity plastic material in the world after PVS, and poly propylene the 2008 world consumption of the HDPE represented a global per capita consumption of 4.5 kilo gram.

(Refer Slide Time: 11:00)

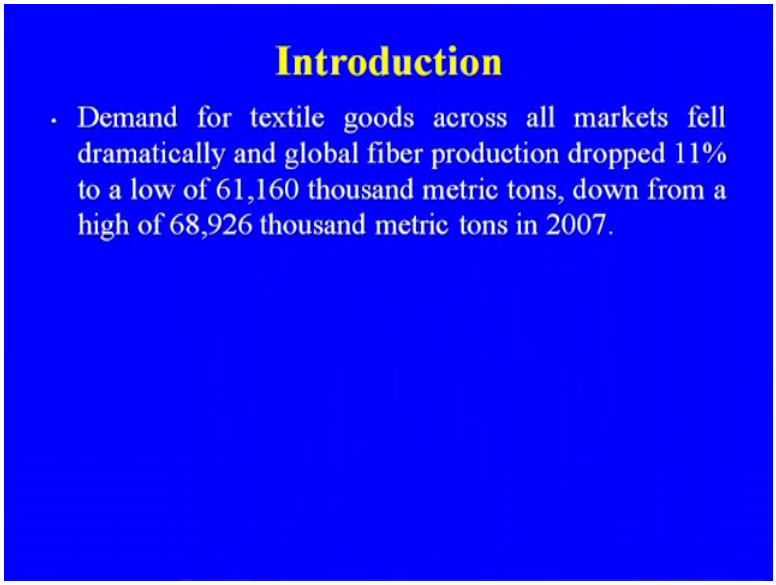


This is the world polymer demand in 2010 and LLDPE, poly propylene and the PVC, these are the two major things, but if you combine this LLDPE, LDPE, HDPE. So, that is also application come other type of the polyester ABS plastic or the PVC, PET resins because now the PET resins the polyester that was only come fine to this into the fiber manufacture. Now,

the PET resin same raw material with the some modification the process now we are making the PET resin which has replaced most of the glass which have been used for the packaging of mineral oil and other thing.

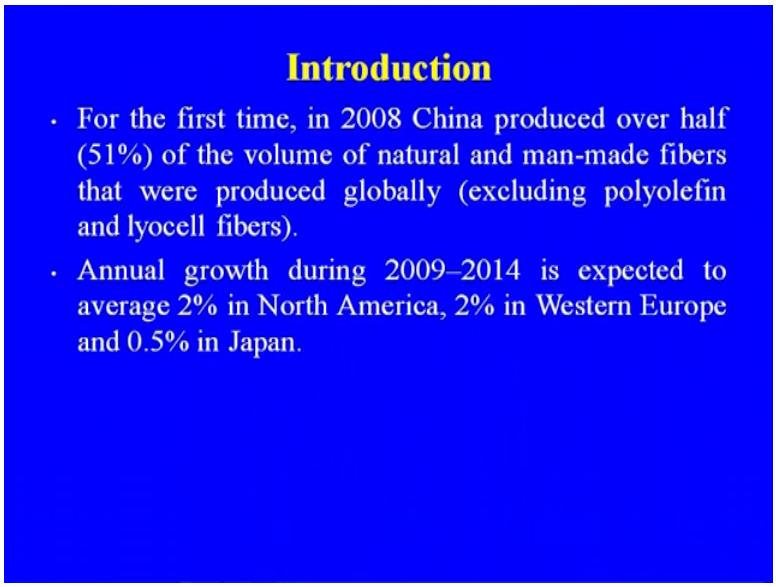
So, PET resin that is coming in a big way and already reliance, they are having two plant, another plant also they are going to have there. Now, let us discuss something about the fiber industry because synthetic fiber elastomer, these are all coming in one form of the polymer. Here, the polymerization of the monomer that you have, monomer of the may you are making the polymer, so the elastomers and your this synthetic fiber, they are also the polymer.

(Refer Slide Time: 12:28)



So, demand of the textile good across all markets fell dramatically and global fiber production dropped from 11 to a low of 61,000 metric tons down from a high 68926 in 2007, so that is some figure about the synthetic fiber, but synthetic fiber.

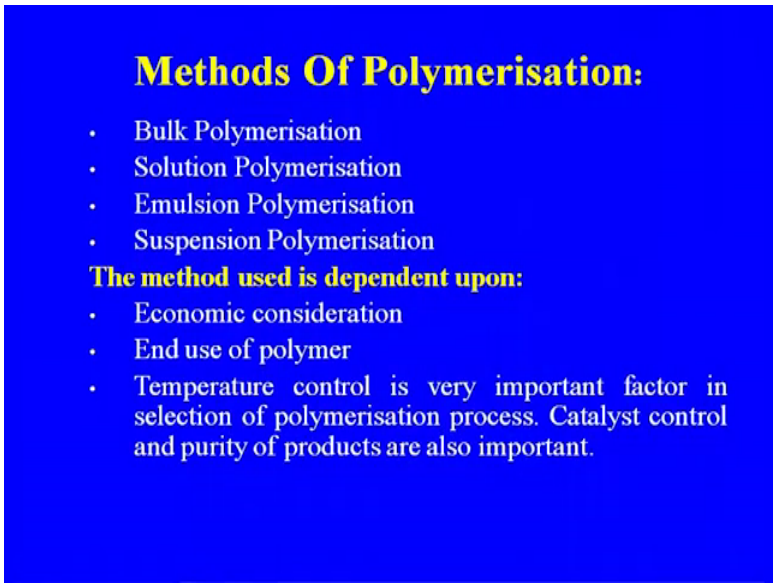
(Refer Slide Time: 12:50)



For the first the first time in 2008, China produced over half 51 percent of the volume of the natural and manmade fibers that were produced globally. So, this is the how the changes that has taken place in case of the synthetic fiber because China in the polymer industry in other development that has come in a big way.

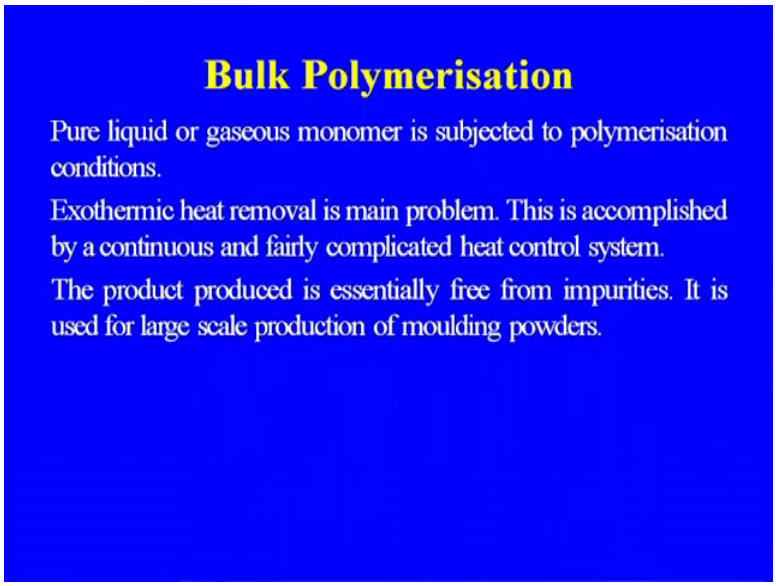
You see now the whole market that is capture by the Chinese, so annual growth during 2009 to 2014 is expected to average 2 percent in North America, 2 percent the Western Europe and 0.5 percent in Japan. These are because we are talking about in general about the polymers, so what are the methods for polymerization because these are the some of the method which are being use in all the three category of the polymer that the plastic, then the synthetic fiber.

(Refer Slide Time: 13:50)



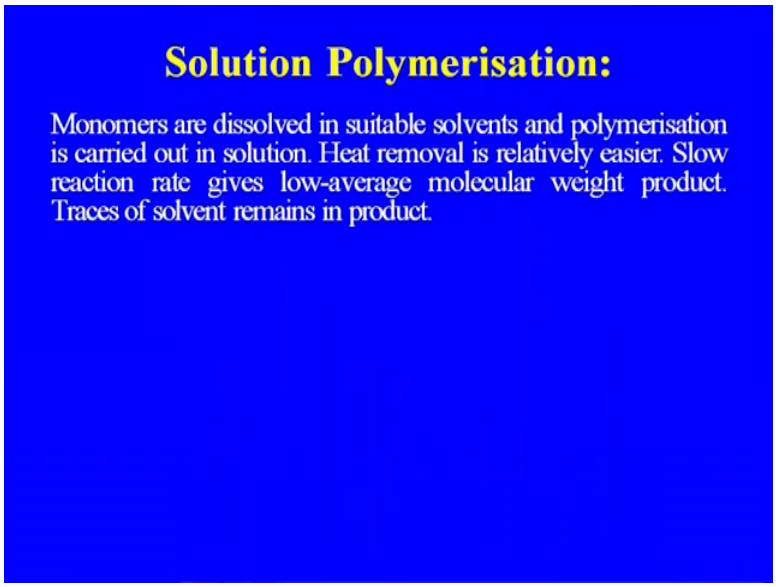
Bulk polymerization, solution polymerization, emulsion polymerization and the suspension polymerization are the four major type of the polymerization process that we are using. Depending the method uses dependent upon the economic consideration end use of the polymer temp control is very important factor in the all the polymerization reaction in selection of the polymerization process. Catalyst control and purity of the product are also important and so this is the reason how continuous development that has been there in the development in the catalyst, which you are using in case of the various polymerization reactions.

(Refer Slide Time: 14:36)



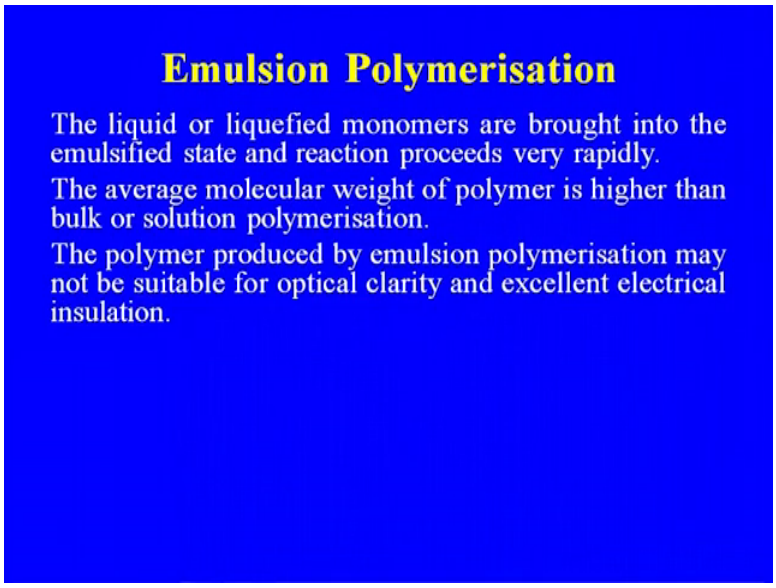
Bulk polymerization, here pure liquid or gases monomer is subjected to polymerization condition exothermic heat removal is main problem. This is accomplished by continuous and fairly complicated heat control system; the product produce is essentially free from impurities it is used for the large scale production of the molding powders.

(Refer Slide Time: 15:05)



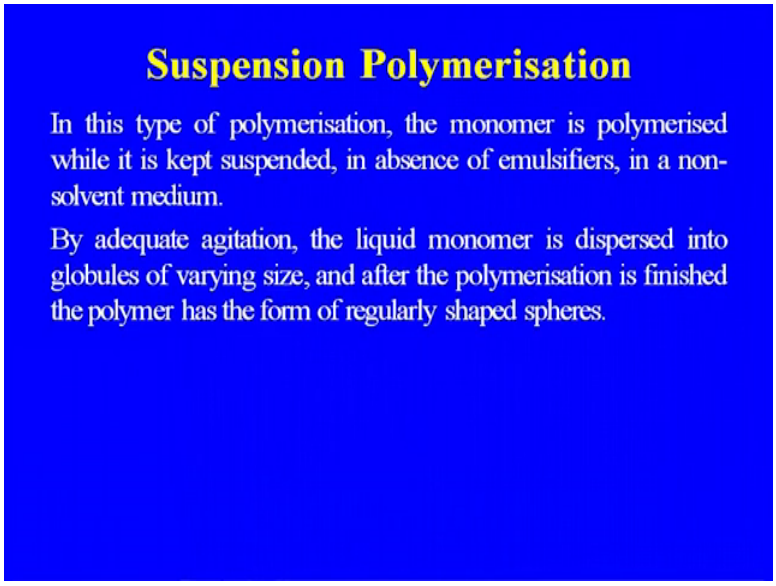
Monomers are in case of the solution polymerization monomers are dissolved in suitable solvents and polymerization is carried out in solution. Heat removal is relatively easier slow reaction rate gives low average molecular weight product traces solvents remains in the product this is about the solution polymerization. These are the various polymerization reactions that are taking place before going to the polymerization reaction.

(Refer Slide Time: 15:36)



Let us discuss other method of the polymerization also the emulsion polymerization the liquid or liquefied monomers are brought into the emulsified state and reaction proceed very rapidly the average molecular weight of the polymer is higher. Then, the bulk or solution polymerization, the polymer produced by emulsion polymerization may not be suitable for optical clarity and excellent excellent electrical insulation.

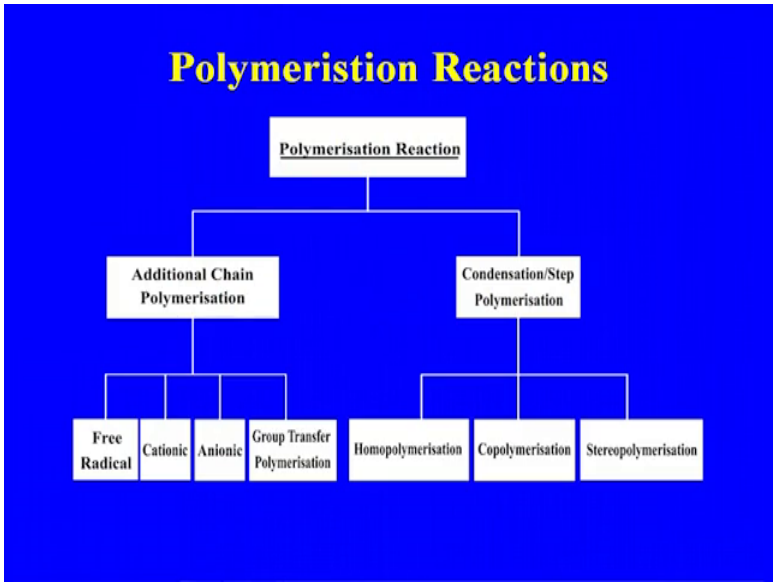
(Refer Slide Time: 16:07)



Suspension polymerization as the name itself such is the in this type of the polymerization the monomer is polymerized while it is kept in suspension it is suspended in absence of

emulsifiers in a non solvent media by adequate agitation. The liquid monomer is dispersed into the globules of varying size and after the polymerization if any polymer has the form of regularly shaped spheres.

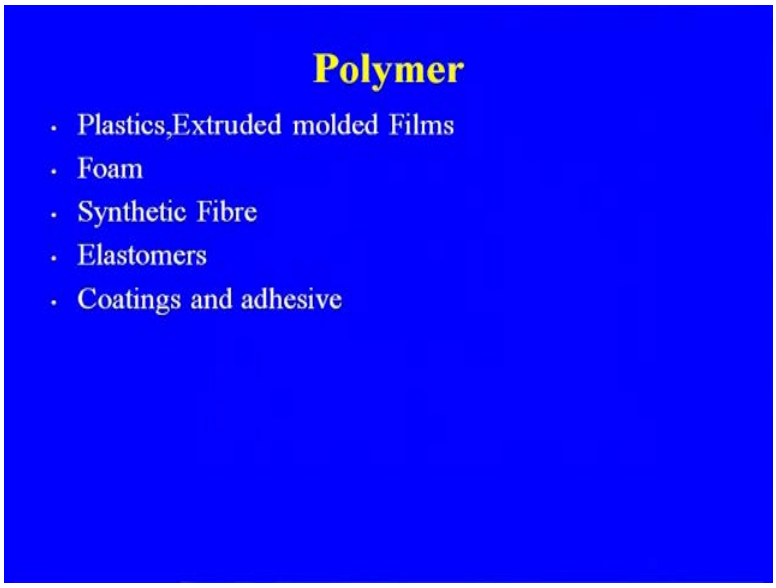
(Refer Slide Time: 16:36)



So, this was about the various type of the polymerization that we are performing in industry and this is the just what are the various polymerization reactions. As you know, then we are having the two type of the polymerization reaction that is the addition chain polymerization condensation or the step polymerization condensation. Always, some release of the additional molecules is there as in case of the some of it may water ethanol one process.

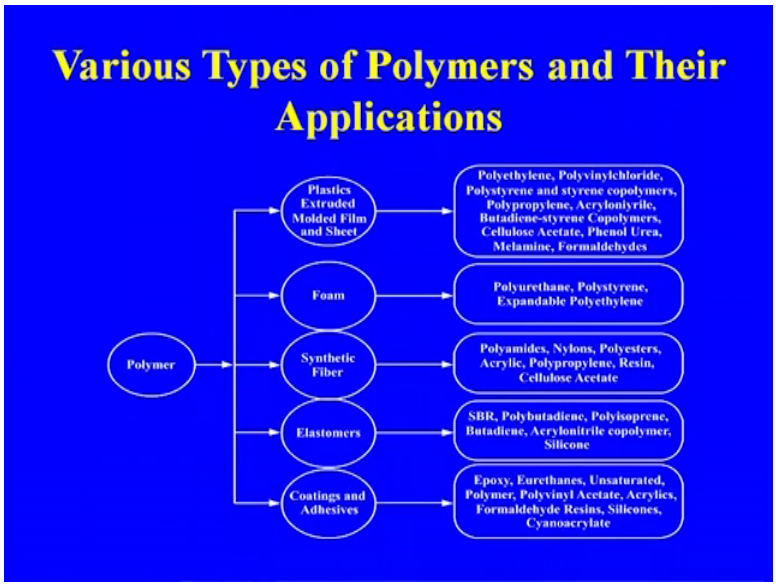
So, depending upon that the some release of the additional then the main product is there, so additional that may be the free cationic anionic group transfer polymerization in case of the condensation homo polymerization co polymerization or stereo polymerization. So, these are the different type of the polymerization reaction that is taking place.

(Refer Slide Time: 17:43)



So, polymer plastics extruded molded films foam as i told you the polymer is the general name we are using for all the weather is the plastic or the synthetic because the plastic as a polymer . After addition of the after addition of the various actually other materials that when we are it is going for the molding, so we called the plastic so plastic extruded molded films foam synthetic fiber elastomer coatings and adhesive. There, we are using the poly vinyl chloride poly vinyl acetate, so these are the coming in the in case of the coating and adhesive.

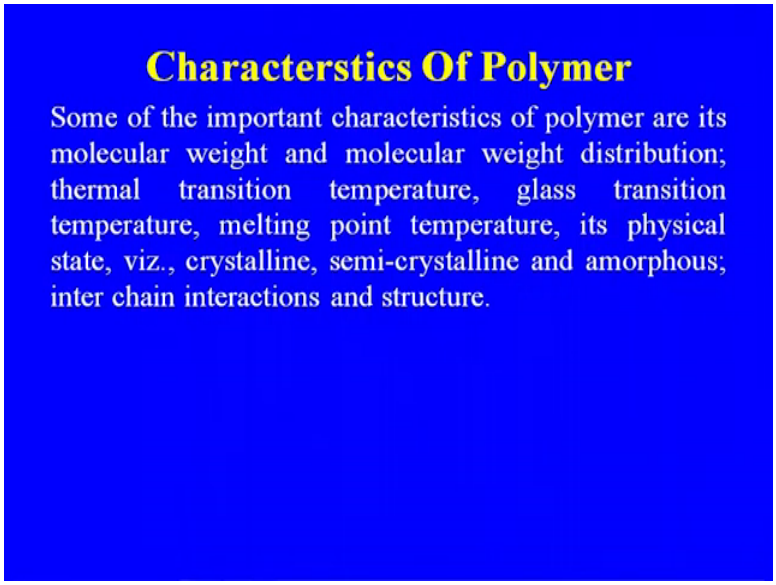
(Refer Slide Time: 18:42)



So, this is in a various types of the polymer and their application polymers plastic extruded foam synthetic fiber elastomer coating. So, these are the various types of poly ethylene poly vinyl chloride poly styrene and that is the styrene from monomer poly propylene actronyle butadiene styrene stage phenol resins melamine formaldehyde resins these are all these three are the thermo setresins. So, the various types of the your which you are using we are using as the plastic, then foam poly urethane poly styrene expandable poly styrene or the poly ethylene. So, the poly amites nylons synthetic fiber the nylon 66 nylon 67 polyester acrylic fiber poly propylene fibers cellos state viscose dam these are all coming in case of the synthetic fiber.

Elastomer we are having the various types of the elastomer styrene butadiene nitrile level poly butadiene poly isoprene. So, all these are the various type of the then the coating as I told you urethane than the unsaturated polymers poly vinyl acetate acrylic formaldehyde resins silicones. So, these are the various type of the resin that we are using characteristic of the polymer.

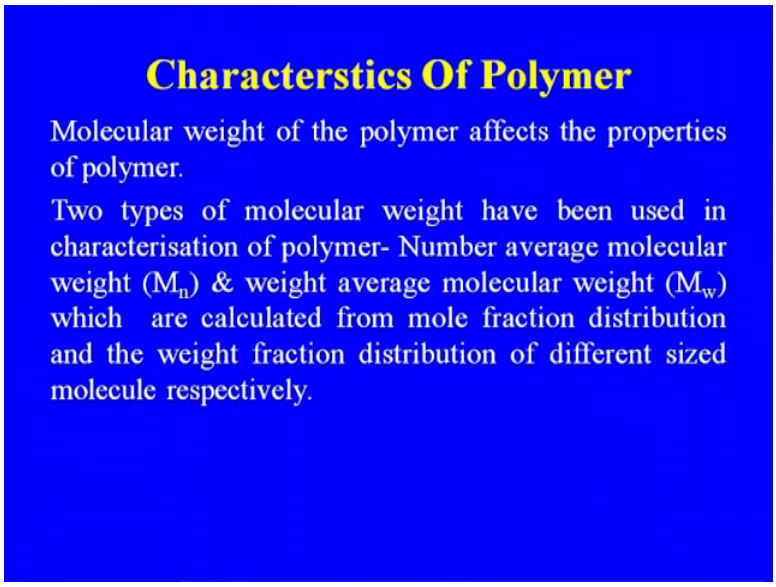
(Refer Slide Time: 20:08)



Some of the important characteristic of the polymer are its molecular because the molecular weight and molecular distribution that is very important in which will have the impact on the quality of the product. Thermal transition temp glass transition temp melting point temp its physical state via crystalline semi crystalline or the amorphous inter chain interaction and structure. These are the some of the important property of a polymer as I told you we are

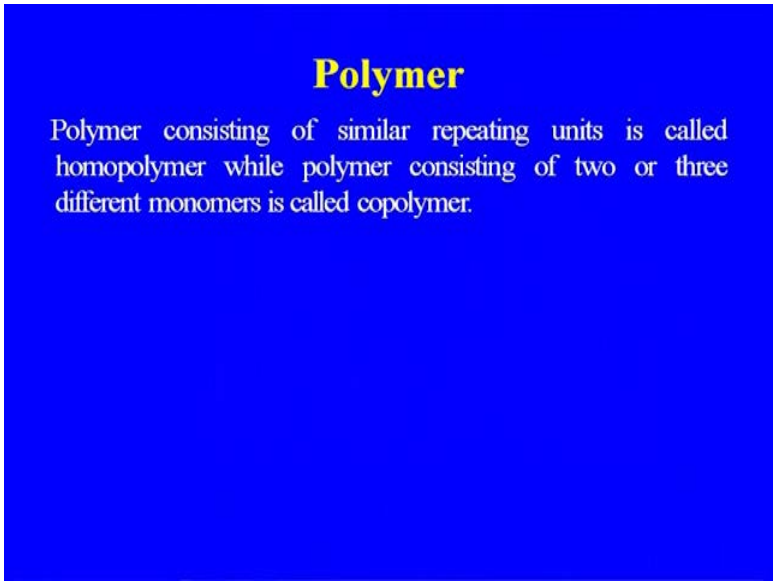
having the two types in case of the molecular weight that is very important, so we are having the two types of molecule.

(Refer Slide Time: 20:57)



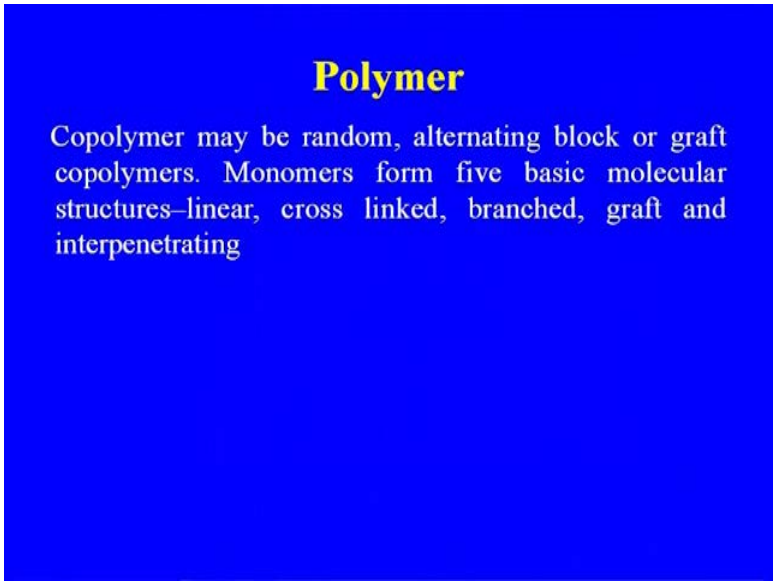
Molecular weight of the polymer affects the quality of product; two types of the molecular weight have been use in the characterization of the polymer at the number average molecular weight. The weight average molecular which are calculated from more fraction distribution and the weight fraction distribution different sized molecule respectively.

(Refer Slide Time: 21:21)



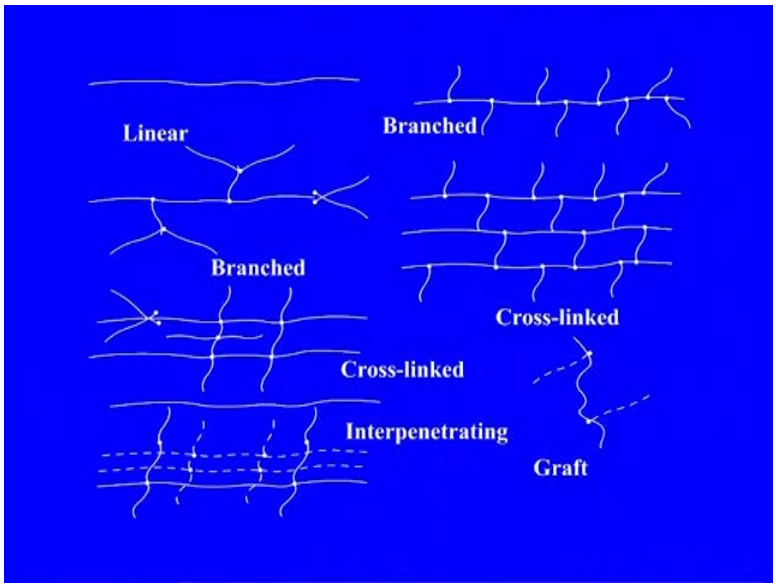
Polymer consisting of the similar repeating unit is called because you see we are having the co polymers also where we are using some co monomer. So, the just like in case of the poly ethylene we are also adding butene one, so in case of the modified acrylic fiber we are using the benzelene at the vinyl chloride also. So, that there are various combination are there, so the polymer consist of the similar repeating units is called homo polymer. The polymer consisting of two or three monomer is called the co polymer, so this is another classification you can say for the polymer.

(Refer Slide Time: 22:01)



Co polymer may be random alternating block or the graft co polymer monomer from five basic molecular structure because you see the now we are talking about the linear. So, linear cross link branch graft or the interpenetrating it is a various combination that may be the in case of the polymeric structure.

(Refer Slide Time: 22:27)



This is the linear branch actually it is not visible, but you can see the branch and the cross link interpenetrating graft. So, these are the various type of the polymers that you are getting, now let us say the production in India status of the polymer synthetic fiber and there elastomer industry in India synthetic fiber elastomer and the performance plastic. Polymer is the highest than the synthetic fiber elastomer and the performance.

(Refer Slide Time: 23:00)

Polymers, Synthetic Fibre And Elastomers Production in India During 2009-2010, '000'T

Polymers	4791
Synthetic Fibre	2601
Elastomers	106
Performance Plastics(ABS resin, Nylon66 &Nylon 66, Polymethyl methaacrylate Styrine Acrylonitrile)	172

Plastic means that the specialty plastic which are ABS where this combination of acrylonitrile butadiene styrene nylon 66, nylon 67 poly methyl methaacrylate styrene acrylonitrile various combination. So, there is the figure of the production during the 2009-10.

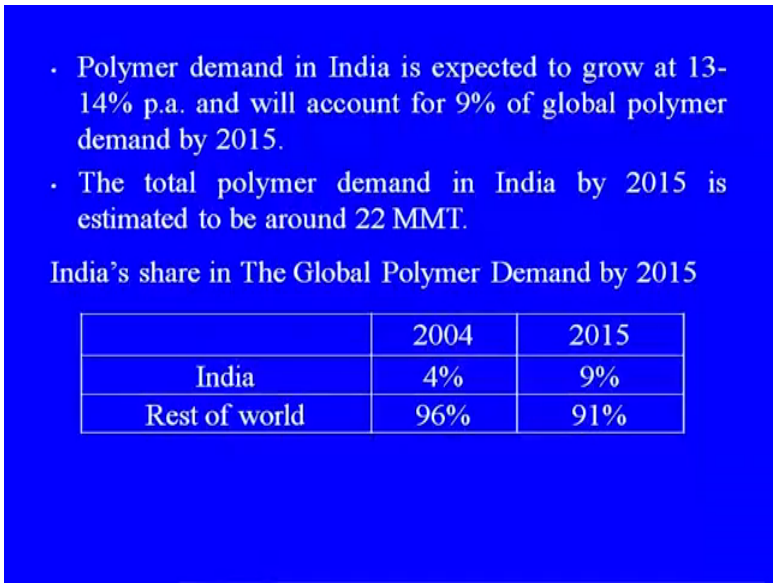
(Refer Slide Time: 23:40)

These are the some of the new polymer projects or being plant or at the they are at the election stage that is OPAL by ONGC Dahej. They are going to have a big Petrochemical complex it is just near the Gandhar unit where the Reliance they are having there petrochemical. That is also going to be the they are going to add some more units there HPCL Mittal, Panipat, RIL Jamnagar.

That is the because the they are having the refinery big refinery largest refinery in India and the now they are going to have the petrochemical complex also the cracker plant and other related products. They will be manufacturing at Jamnagar, GAIL, Assam that is in collaboration of Brahmaputra cracker plant is coming very big cracker first time that is coming in assam and where it producing large number of the polymer there.

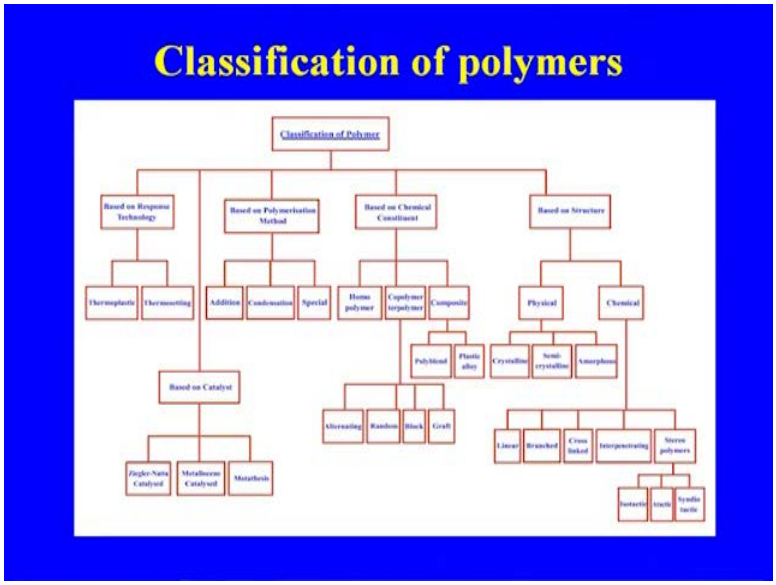
The GAIL Pata that is already set up, they are another unit is coming MRPL Mangalore, they have also gone for the cracking plant. So, the other project are just like you take case of the Panipat refinery, they are going to have the now the SBR unit styrene butadiene rubber, earlier they started the making terethalic acid which is the basic raw material for the polyester.

(Refer Slide Time: 25:22)



Polymer demand in India is expected to grow at 13 to 14 percent per annum and will account for 9 percent of the global polymer demand by 2015. The total polymers demand in India by 2015 is estimated to be around 22 million metric tons, India 4 percent, 9 percent and rest of the world 96, 91. Still, our demand is less per capita consumption figure is less than if you compare with the rest of the world are the world average figure.

(Refer Slide Time: 25:49)

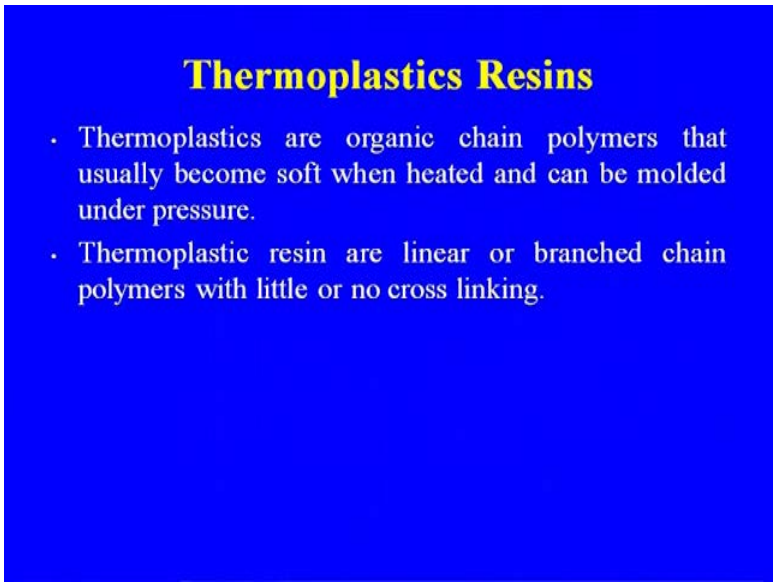


This is the broad classification of the polymer which was telling different type of the based on the technology based on the polymerization modal and then the chemical a based on the

chemical constituent based on the your structure. So, different actually the classification is there, already I discussed some of the different type of the based on the reaction based on it because you are having the different type of the polymerization based on the catalyst. Also, we are having the Jigger Natta catalyst, we are having the metrocene catalyst, so different catalyst are also as I told you that mean continuous development.

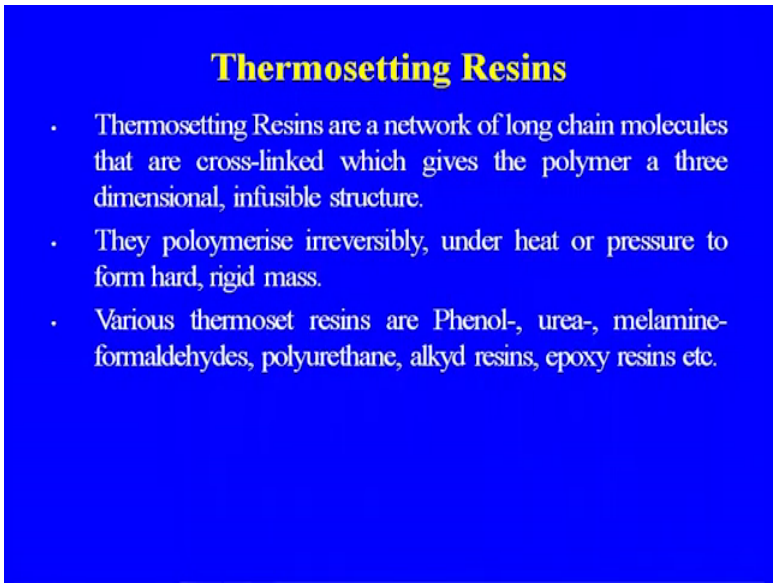
So, we called the metetrocene catalyst in case of the olefin that is the need development that has taken place. So, the so this is the alternative random the block graft structure which I discussed, so depending upon that the classification of the polymer that has been done. Now, let us come as I told you we having the two grade classification major classification in case of the plastic that is the thermo plastics and the thermo set plastic.

(Refer Slide Time: 27:13)



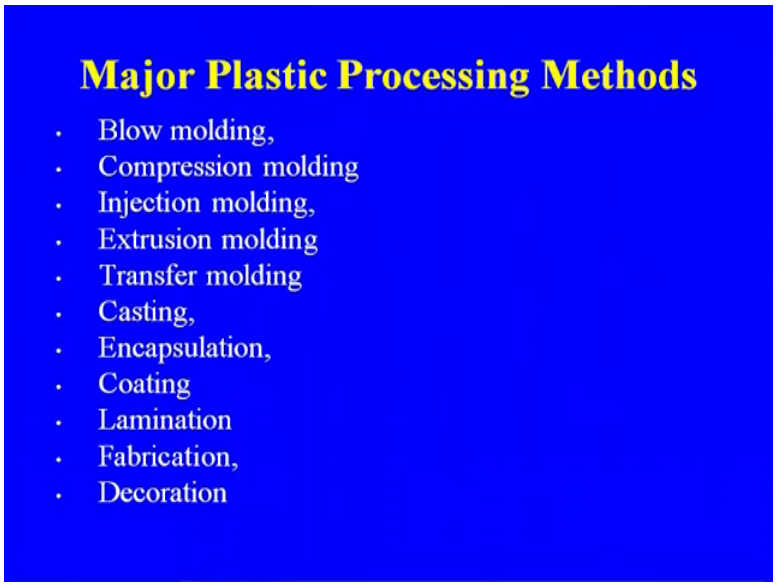
So, thermoplastics are organic chain polymers that is usually become soft when heated and can be molded under pressure thermoplastic resins are linear or branched chain polymers with little or no cross linking. So, this is the and one actually major your this plastic we are polymer which are using that is the thermoplastic whether it is poly ethylene poly propylene PVC. Some of the synthetic fiber also they are coming in the category of the thermoplastic, this I will show the list of the various thermoplastic and thermo setting resins.

(Refer Slide Time: 27:57)



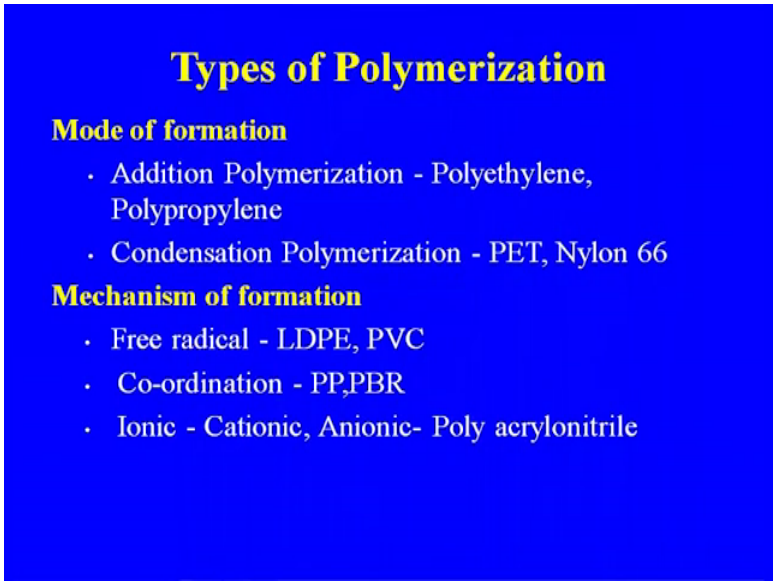
Thermo setting resins are a network of the long chain molecules that are cross linked which gives the polymer a three dimensional infusible structure. They polymerize irreversibly under heat or pressure to form hard rigid mass various thermo settng resins. So, these are the three very important thermo set resins that is the phenol urea phenol formaldehyde melamine formaldehyde polyurethane alkyd resins epoxy resins. So, these are all coming in category of the thermo set resin, this is the major plastic processing method because whatever the plastic we are getting or the polymer we are getting it has to be further processing in the different shape.

(Refer Slide Time: 28:55)



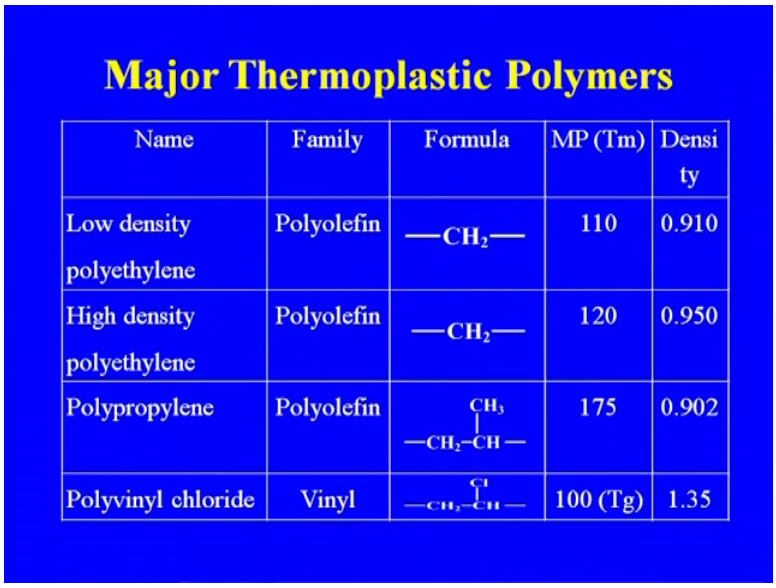
So, depending upon the process we are having either the blow molding compression molding injection molding extrusion molding transfer molding casting encapsulation coating lamination fabrication and decoration. So, these are the different type of the processes finishing processes from the polymer to the finish product that we are doing suppose if you want to meet bottle of if you want to make chair of the plastic. So, depending upon the method different type of the method we can go for the choice of the different processing schemes polymerization type.

(Refer Slide Time: 29:38)



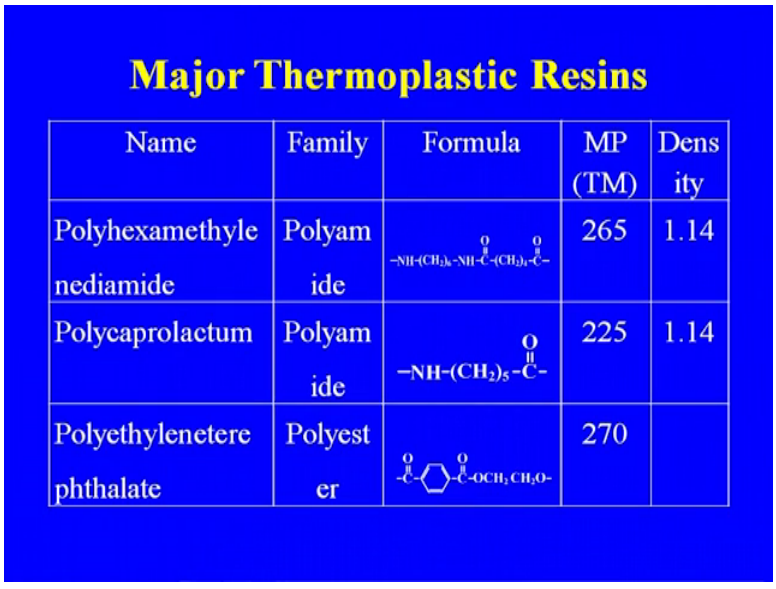
Already, I discussed that we are having the addition polymerization just like poly ethylene poly propylene. Here, we are having the addition polymerization in case of the condensation polymerization PET nylon 66 mechanism of the formation free radical. That is the LDPE PVC co ordination poly propylene PVR ionic cationic anionic poly acrylonitrile, so these are the different type of the polymerization that is taking place.

(Refer Slide Time: 30:11)



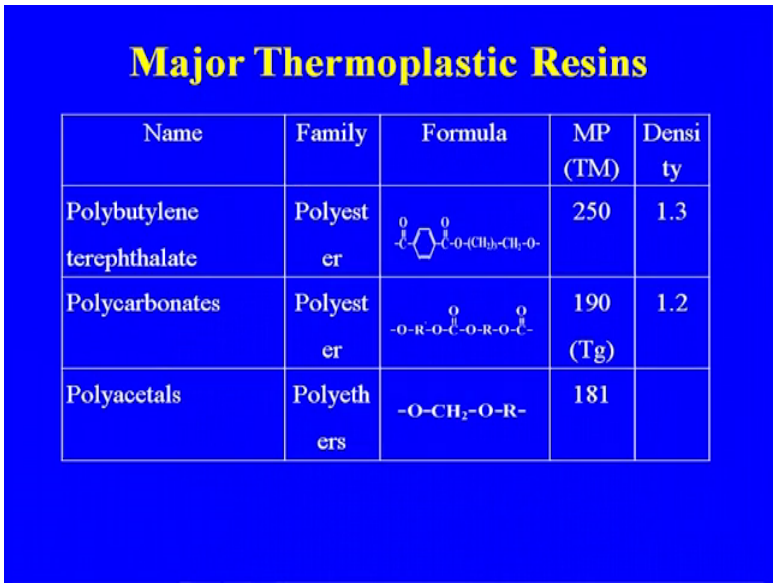
So, this is the how the major thermoplastic which I was telling a major of the plastic are into poly ethylene that may be the different forms of the poly ethylene poly propylene poly vinyl chloride. Then, the poly vinyl acetate poly styrene poly methyl acrylite these are all coming in category of the your this a thermoplastic resin. Again, poly hexa methylene diamine poly caprolactam poly ethylene terephthalate PET which i was telling that is also coming in the category.

(Refer Slide Time: 30:40)



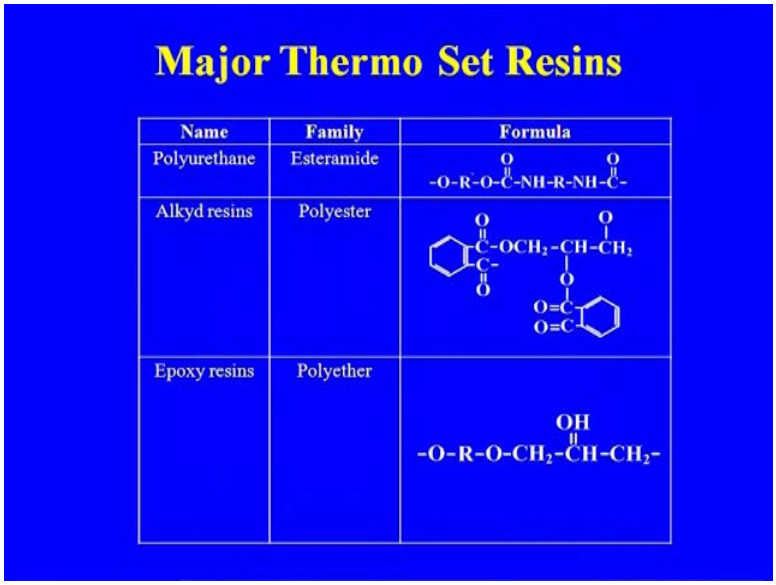
So, large number of the plastic they are poly butile terephthalic.

(Refer Slide Time: 30:52)



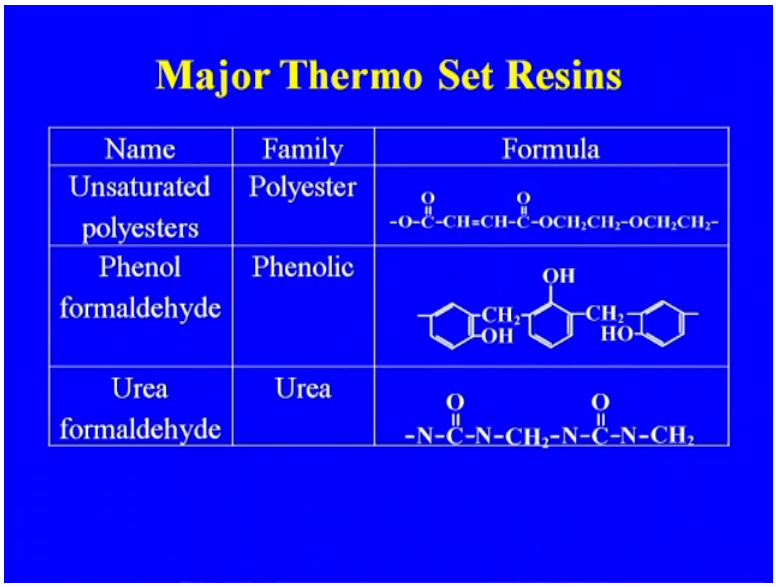
This is also another development which that has taken place because of the stronger proper major better property then the PET poly carbonates as you see the now the most of the optical glasses even in case of the CEG. Another material that you are using the poly carbonates another specialize light weight and very high strength poly carbonated even in case of the sport shoe we are using the poly carbonate poly acetyls.

(Refer Slide Time: 31:31)



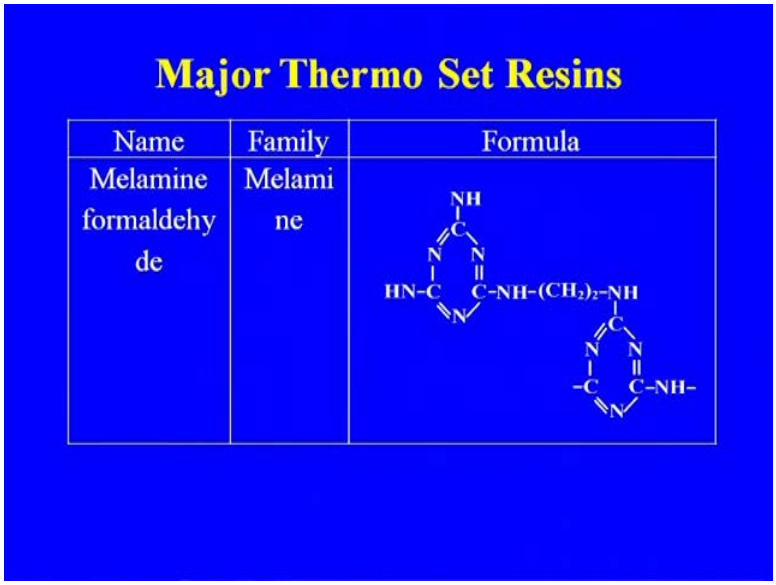
Then, the various type of the thermo set resins are poly urethane alkyl resin epoxy resins.

(Refer Slide Time: 31:41)



As I told you the phenol formaldehyde, urea formaldehyde are used.

(Refer Slide Time: 31:48)

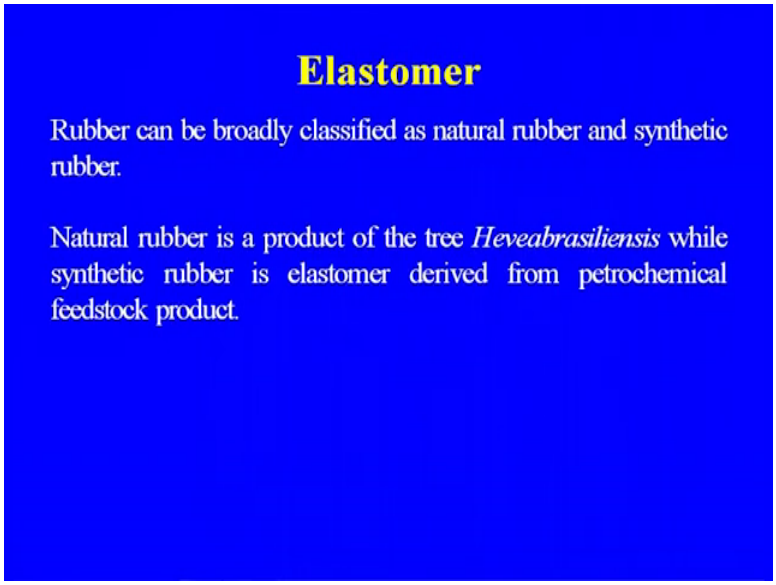


The melamine formaldehyde these are the other very important grade of the polymers which are finding application one of the phenol formaldehyde that came in the name of the back light. The major application that was the in the electrical appliances especially the switches and the material that was made that is made of the phenol formaldehyde resins. So, that was the name the starting the back light name was given, melamine formaldehyde. That is

actually the one of the very important polymer and that actually during the 1780's, lot of the revolution that take place in case of the kitchen wares.

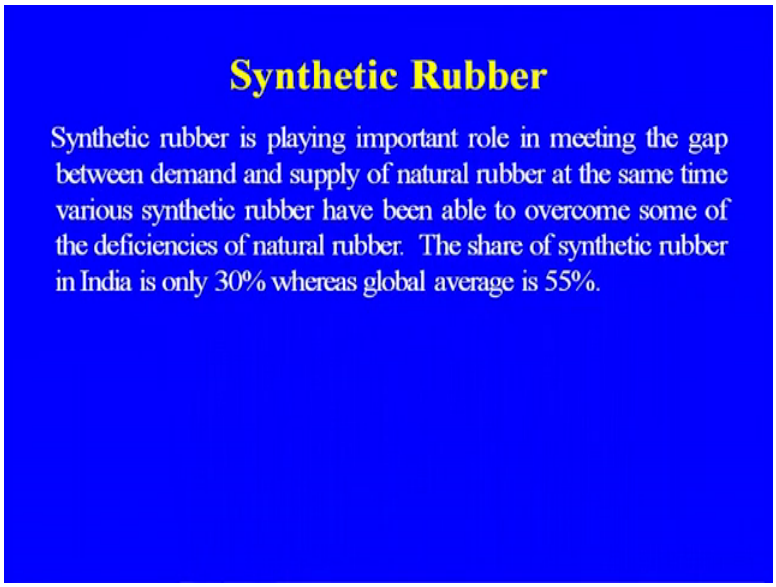
The melamine almost they completed and place the conventional stain steel utensil in the kitchen, so that was the development in case of the melamine formaldehyde. Now, let us come to the elastomer rubber can be because the when you are talking about the elastomer means the rubber even the clauses are now or the jeans.

(Refer Slide Time: 33:13)



Other thing that is there, but in case of the rubber can be broadly classified as natural rubber and synthetic rubber. Natural rubber from the natural source natural rubber is a product of tree heveabrasiliensis while synthetic rubber is elastomer derived from the petrochemical feedstock. Either we discuss earlier also while discussing the petrochemical starting from the ethylene propylene then the styrene and all those are playing very important role or isoprene or it may be the isobutylene butadiene. These are playing very important role in manufacture of the polymer elastomers as well as synthetic fiber.

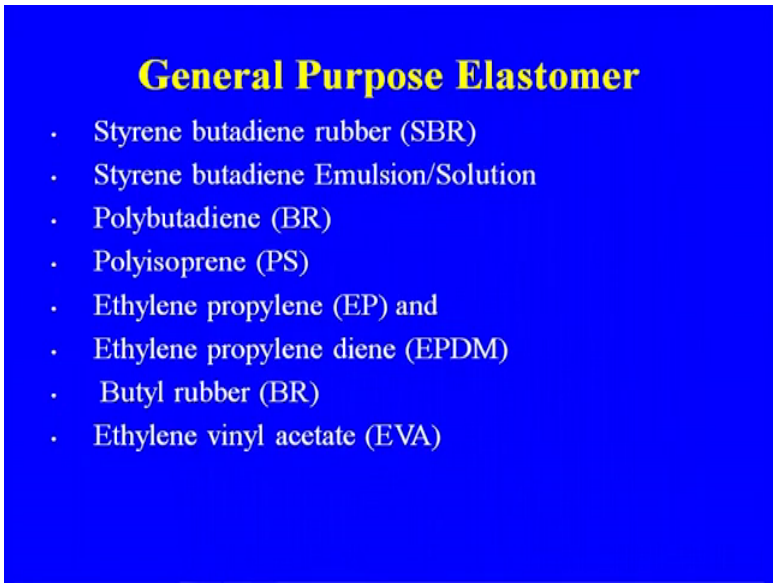
(Refer Slide Time: 33:55)



Synthetic rubber is playing an important role in meeting the gap between the demand and supply of the natural rubber because many of the countries they are not producing natural rubber. So, from here, that is what they are getting they are meeting their demand through the synthetic rubber. So, the natural rubber at the synthetic rubber is playing important role in meeting the gap between the demand and supply of natural rubber.

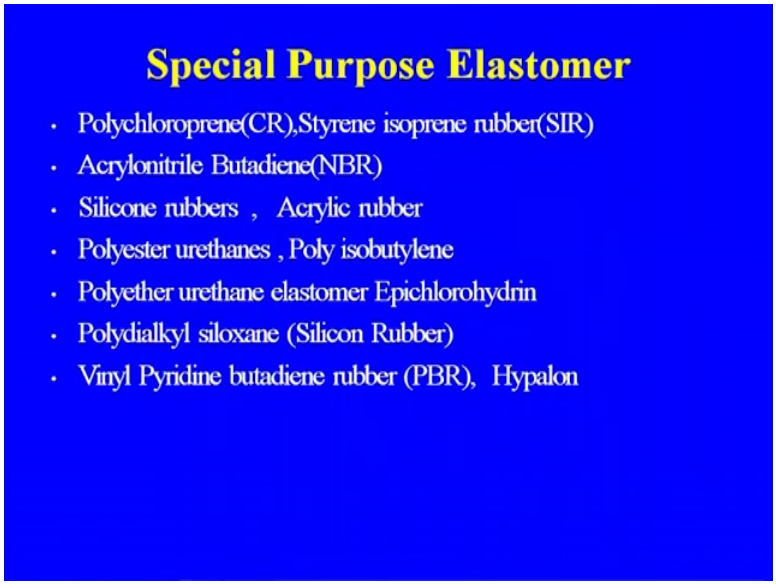
At the same time various synthetic rubber have been able to overcome some of the deficiencies of the natural rubber the share of the synthetic rubber in India is only 30 percent whereas the global average is 55 percent. India is also one of the natural rubber producing country, these are the various type of the general because we are having the general purpose general elastomer special purpose elastomer.

(Refer Slide Time: 34:57)



So, this is the styrene butadiene rubber styrene butadiene emulsion, poly butadiene ,poly isoprene, ethylene propylene, the ethylene propylene diene, butyl rubber, ethylene vinyl, ethyl vinyl acetate. Then, the special purpose elastomer because as I told you we are getting in some cases the better property then natural rubber.

(Refer Slide Time: 35:26)



So, the poly chloropine, styrene isoprene rubbe,r acrylonitrile. Butadiene rubber because NBR that was the because during the world war the development of this acrylonitrile butadiene rubber that was there because resistance to our oil. So, another type of the we are

having silicon rubber acrylic rubber then the polyester urethane poly isobutylene, poly ether, urethane elastomer, epic chlorohydrins, poly dialkyl siloxane, vinyl pyridine butadiene.

So, these are the various type of the special purpose elastomer, this is the status of the production of the synthetic rubber in India and you see the here the styrene butadiene and the poly butadiene rubber. They are the major actually the play where the because in some of the petrochemical like reliance and the Haldia petrochemical, they are having the naphtha cracker.

(Refer Slide Time: 36:21)

Capacity and Production of Synthetic rubber in 2010-11, ('000 MT)
Source:Annual Report C & P 2011-2012

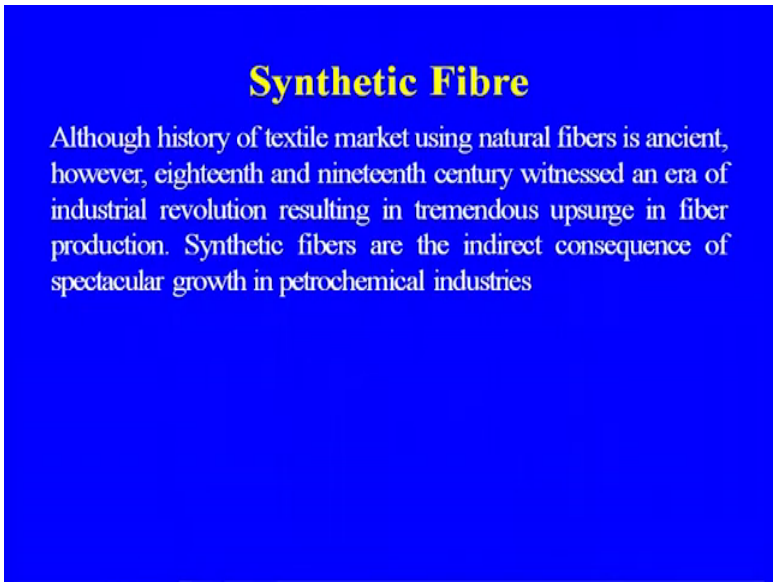
Major Group / Product	Installed Capacity 000'tonnes	Production 000's
	2010-11	2010-11
Styrene Butadiene Rubber	62	12
Poly Butadiene Rubber	74	76
Nitrile Butadiene Rubber	25	6
Ethyl Propylene Dimers	10	0
Ethyl Vinyl Acetate	13	0
Total Elastomers	184	94

So, lot of the butadiene they are getting from the naphtha cracker so that butadiene that is going that is polymerize for getting poly butadiene. Similarly, styrene butadiene rubber that was the first of all you can say synthetic rubber large volume synthetic rubber. You can say for the SBR and the new which you are going to have in India that is by the SBR plant by Panipat refinery where there will be using the ethylene from there process FCC gases.

Then, the styrene also for their aromatic complex through the ethyl benzene, so these are some types major elastomer. Then, the nitrile rubber ethyl propylene dimmers, so this is the install capacity and this is the production figure. Now, let us come to the synthetic fiber industry because the synthetic fiber industry that has been playing important role not only because it is over ran and non overran both the areas are there. Here, the synthetic fiber they are find wide application one of the major application start from the textile that was in the

tare care industry where the synthetic fiber they have played very important role in the tire lining because they are such you cannot use the elastomer.

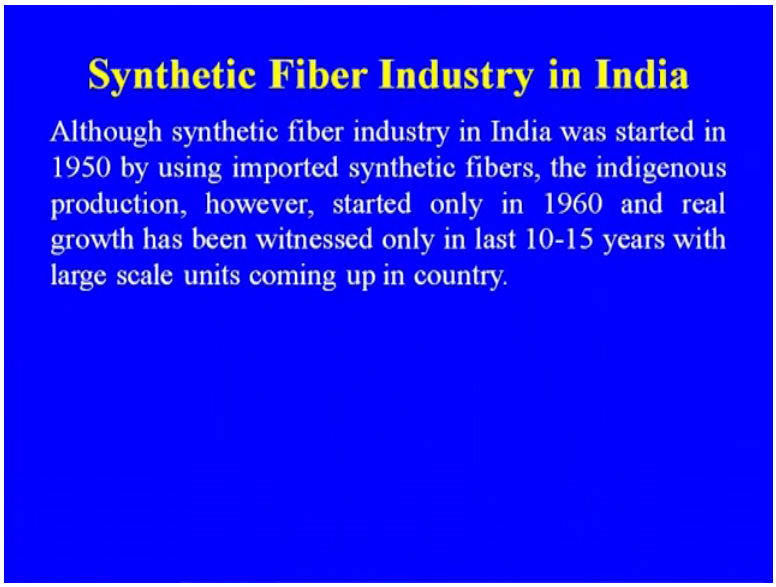
(Refer Slide Time: 38:09)



So, although the history of the textile market using natural fibers is from the ancient time however 18 and 19 century witnessed an era of industrialize industrial revolution resulting in tremendous upsurge in the fiber production. This was only possible with the coming of the larger number of the petrochemical. So, synthetic fiber are the indirect consequence of the spectacular growth in the petrochemical industry because the raw material which is available.

Here, it may be the cyclohexane and which is we are manufacturing from the benzene are the production of the nylons 66, where we are using the cyclohexane as raw material or the nylon 66 at hexa methane diamine or it may be the polyester. In all the cases, whatever the development or the revolution that we are seeing that is because of the coming of the number of the petrochemical complexes and the availability of the raw material.

(Refer Slide Time: 39:18)

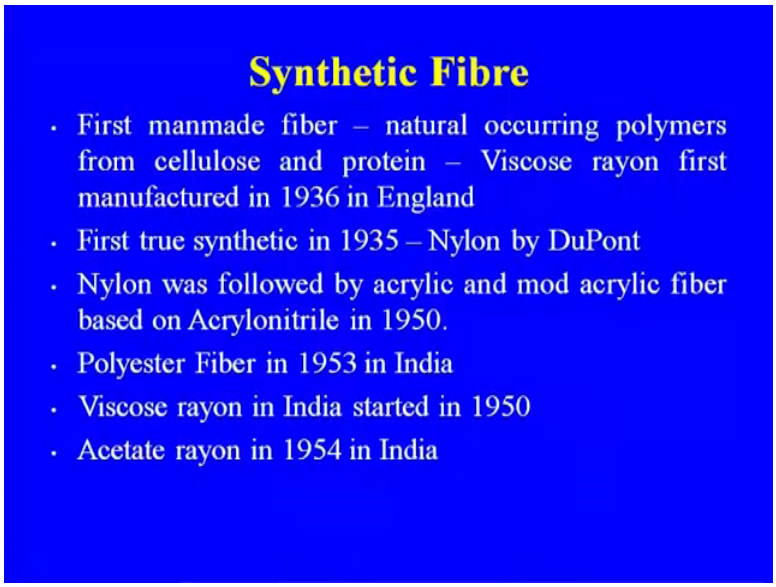


Although the synthetic fiber industry in India was started in 1950 by using the imported synthetic fiber, the indigenous production, however started only in 1960. Real growth has been witnessed only in the last 10-15 years with the large scale units coming up in the country. Reliance has been the important actually the petrochemical complex which has which is playing very important role through the making of the terephthalic acid purified terephthalic acid even. They are first patalganga that was the first unit which was started with the PTA because at their units which were started whether it was Bombay dyeing or it may be the VRPL.

They were all the based on the d m t and many of the units are that time came based on the DMT, but now all the DMT plants that has been closed. That I will be discussing while discussing the synthetic fiber in more detail, how the TP, terephthalic acid that has played important role. Now, even the synthetic fiber industry what is the role, so that we will discuss while discussing in the chapter of the polyester.

So, as I told you the real growth that has been only during the last 15 years, you can say with the coming of the number or you can say even after the 70, some of the petrochemical complex like the HPCL. Now, reliance started making DMTC over the VRPL, but real growth was during the last 80’s and 90’s.

(Refer Slide Time: 41:07)

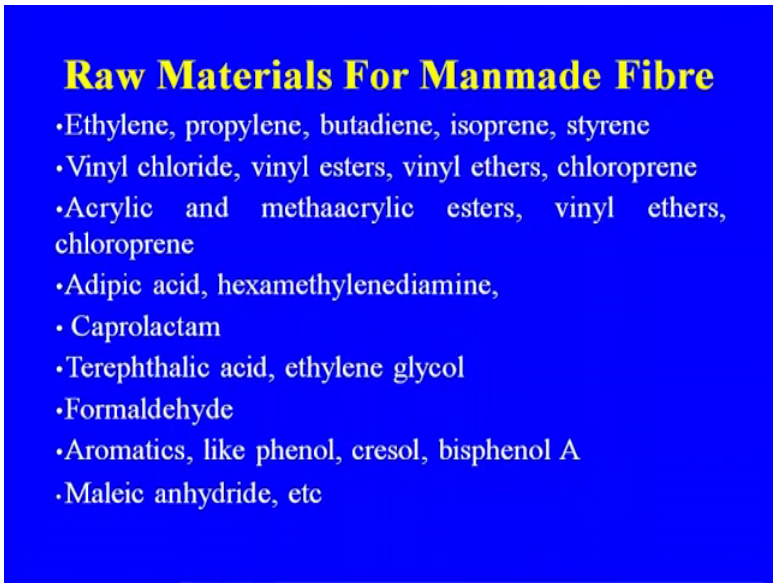


First manmade fiber was natural accruing polymers from cellulose and protein that was the viscose rayon first manufacture in 1986 in England. First true synthetic in 1935, nylon by DuPont, nylon was followed by acrylic and mod acrylic fiber based on the acrylonitrile in 1950. Polyester fiber in India 1953, three viscose rayon in India, started in 1950 because in case of the viscose rayon, we are using the cellulose pulp cellulosic material. This means the pulp which you are getting a good quality of pulp which has cellulose contain that we are using in case of the viscose rayon are the acetate rayon in nineteen fifty because acetate rayon is just like this silk.

So, one of the unit, now it is closed that was the Silkpur, Kagaj Nagar where making the and the number of the viscose rayon are in India and Grassim industry. They are the one of the major player major manufacture of the viscose rayon raw materials for manmade fiber. As I told you, the various raw material which is available from the petrochemical they have played very important role in the growth of the synthetic fiber industry.

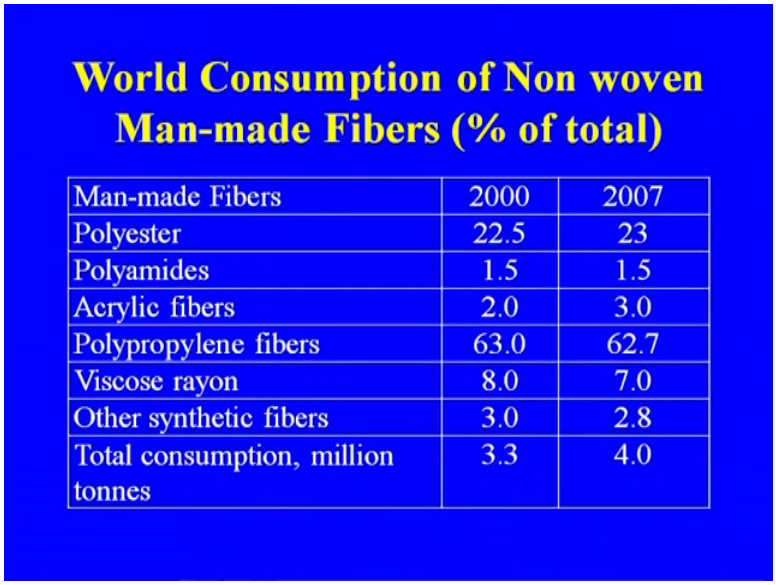
Not only synthetic fiber industry, it is all the polymers if you poly ethylene or the poly propylene or it may be the elastomer. In all the cases, the synthetic the petrochemical industry they have very important, so these are the some of the broad actually the raw material for the petrochemical Industry. That means where we are making the final product ethylene propylene that is in case of the only manmade fiber, but also in case of the other polymer compound.

(Refer Slide Time: 43:05)



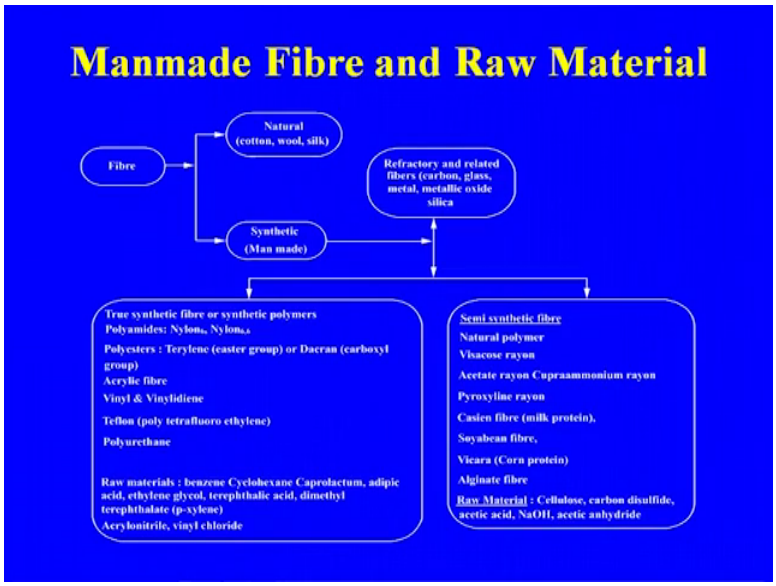
So, they are ethylene, propylene, butadiene, isoprene, styrene, vinyl chloride, vinyl esters, vinyl ethers, chloroprene acrylic and methaacrylic esters, vinyl ethers, chloroprene. Adipic acid, hexa methylene diamine, caprolactam, terephthalic acid ethylene glycol because one of the major this terephthalic polyester making is one of the major consumer of the ethylene glycol which you are making. This is the reason most of the petrochemical complexes, they are having both the ethylene oxide and ethylene glycol the MEG mono ethylene glycol plant, the formaldehyde.

(Refer Slide Time: 44:02)



So, this is the status of the consumption of the non woven because as I told you the oven and non oven, both we are using. So, this is fibers, so manmade fibers polyester polyamides acrylic fibers poly propylene fibers viscose rayon other synthetic fiber. So, this is the figure if you compare from 2006 to 2007, these are the some of the non oven industry where you see the polyester now it is being used in huge amount another the propylene fiber also.

(Refer Slide Time: 44:52)



This is the actually the broad classification as we discuss in case of the plastic of the polymer. So, the fiber that may be based on the natural fiber that was the earlier cotton wool or the silk this were the natural fiber and the in the ancient we have been using the natural fiber. Synthetic fiber are the manmade fiber which you called that may be the two types that may be the based on the natural raw material or based on the petrochemical other type of the manmade means the refractory. The related fiber fiber glass carbon glass that will find application of the fiber glass making some, I saw one figure photograph that was a lady at least she was wearing a cloth made of the fiber glass.

So, this is the how the metal fibers warriors earlier used to have the coverage with the metal oven fibers. So, metallic oxide these are the also coming in the category of the synthetic fiber. So, another classification the two synthetic fiber or synthetic polymers where you are having the polyamides, polyester acrylic fiber, vinyl and venylidiene fibers teflon. That is also because high resistance and you can use as a high temp because here in case of the other

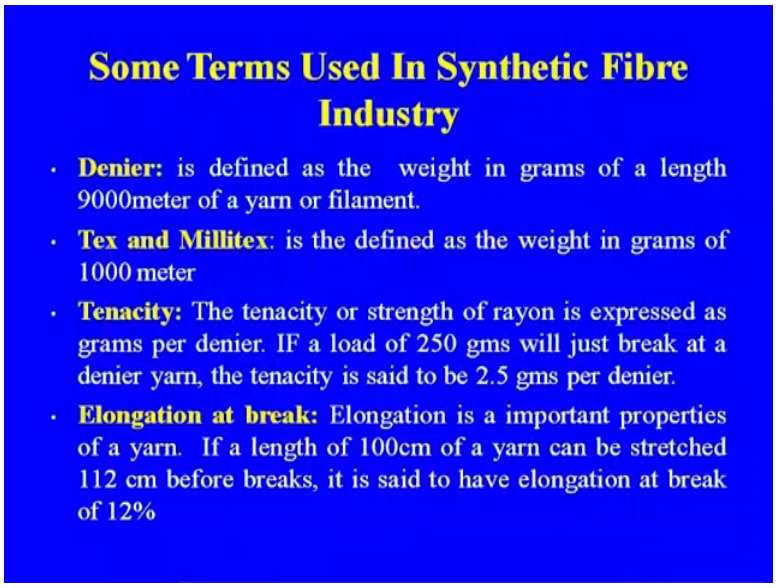
synthetic fiber melting point that is around 240, 230, but in case of the teflon you can go for a high temp at resistance corrosion is there.

So, teflon fiber for this specialized application that are also being used polyethane also that is coming and that we are using raw materials various raw materials which are there. The benzene cyclohexane from the benzene we are using for caprolactam, adepic acid, ethylene, glycol for the terephthalic acid and DMT. We are using para xylene also for these then the acrylonitrile vinyl chloride in case of the acrylic fiber, semi synthetic fiber. There is again a number of the semi synthetic fiber which is made from the cellulosic material.

So, the viscose rayon that is one of the major industries because now in the textile along with the polyester viscose being playing a very important role as a substitute of the cotton because the viscose is more comfortable especially for the high temp region. Just like India, we are having because they are having the better moisture absorbency, then the polyester. So, now the blend is to give the more comfort we are having a blend of polyester and the viscose, so normally 70- 30 percent of the combination you see the any cloth you are that is having the polyester and the viscose combination, pyro oxylene rayon.

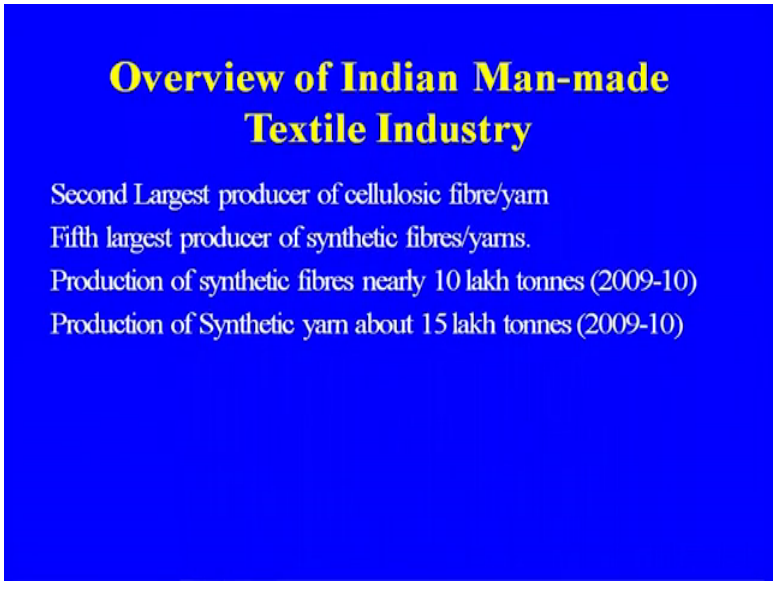
Then, the other casing fibers then the soyabean fibers, these are all the small fiber, these are the small amount of the portion, but the major portion is the viscose and the acetate rayon and acetate rayon. Also, you are having these, where we are using the high cellulose first cellulose contain cellulosic material and so that the process again we will be discussing in detail about the semi synthetic fiber. Especially, the viscose rayon and turn by discussing the viscose rayon that will be the last lecture of this module where will be discussing about the manufacture. They also will be discussing separately the manufacture of this synthetic fiber, two synthetic fiber polyamides acrylic fiber or the polyester.

(Refer Slide Time: 49:25)



These are the some of the terms normally we are using in case of the synthetic fiber industry. Denier is defined as the weight in grams of the length of 9,000 meter, Tex and Mili tex tenacity elongation at break. So, these are the term normally we are using in case of just like in case of the paper means the economic. So, similarly we are using these term, again I will be discussing these point in detail while going to synthetic fiber. In case of this, properties are very important, one is the twisting you are in case of synthetic fiber that is very important to give the more and more strength overview of the Indian manmade industry.

(Refer Slide Time: 50:06)



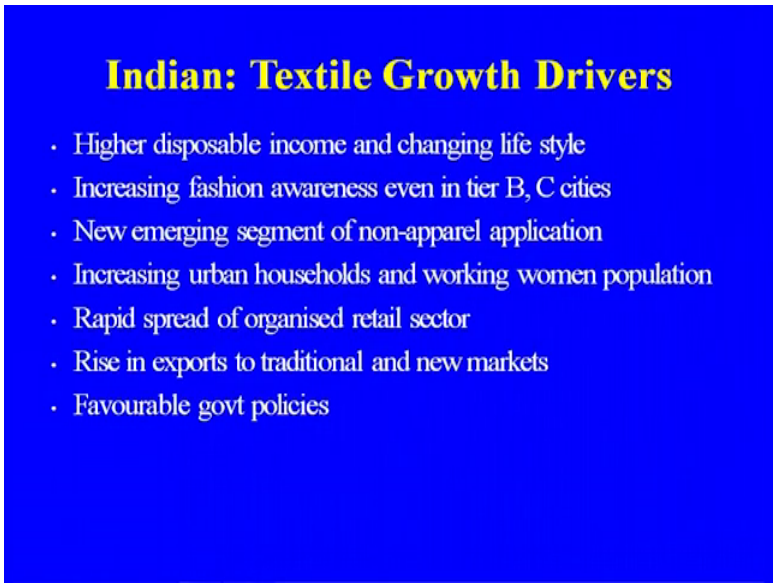
It is second largest producer of the cellulosic fiber and as I told you the 1950 and the Birlas, they have been an important player in the manufacture of the cellulosic fiber. Fifth largest producer of the synthetic fiber yarns, production of the synthetic fiber nearly 10 lakh metric ton production of synthetic yarn about 15 lakh because we are having this there.

If you see the whole petrochemical industry, we are having one large integrated, then where we are making the intermediate and then intermediate that is going to the other down steam processing of the petrochemical industry. Here, you can process either the because in the poly ethylene chips that may be available fiber in case of the it may be stable fiber or yarn that may be available and the final finishing of this staples and fiber that is being done on other units.

(Refer Slide Time: 51:15)

So, current all fiber demand is around 80 lakh tones cotton, 43 lakh and polyester around 30 lakh all fiber demand to grow nearly 130 lakh metric ton by 2020. Polyester fiber has grown at around 10 percent CAGR in the last decade is likely to sustain similar growth.

(Refer Slide Time: 51:42)



Indian textile growth drivers are higher disposable income and changing life style, increasing fashion awareness, new emerging segment of non apparel application increasing urban households, working women population. Also, rapid spread of the organized retail, sector rise in exports to traditional and new markets favorable government policy. So, these are the major growth diverse and you see the textile industry that has played a very important role in development of this polyester synthetic fiber. They have played very important role in the development of the textile industry and now you will find the all the places most of the textile which were totally depended upon the cotton.

Now, they are making the polyester fiber, they are making the polyester yarn, they are making the polyester glass also. One of the problem you see the why the nylons and the polyester although they are cheaper than the cotton still they are not being used. Viscose combination is there, it is not the polyester nylon because the polyesters they are not comfortable as we compare to the viscose or the cotton. So, the combination is always even acrylic fiber, you see the woolen or the hazira industry, this is all coming of the nylons. Earlier, even the nylons a sweater another thing that was actually the they replace the conventional woolen fiber, but after coming of the acrylic fiber the real growth in case of the your woolen industry.

That was because now we are using the blanket in the market you are finding these all the made of the acrylic fiber even in case of the carpet industry in case of this curtain industry. Lot of the development and at the cost that has been reduces earlier the people used to have

the woolen fiber for the carpet, but now it has been replaced with the acrylic fiber. So, this is this was in general about the overview of the polymer industry the various polymers and their details.

In the next lectures, we will be discussing in detail about the individual polymer, so first the second lecture that will be on the poly olefins and the poly styrene because these are the three major polymers which are manufacturing. The next lecture will be third lecture that will cover PVC and some other plastic. So, this was all about the general polymer industry.