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

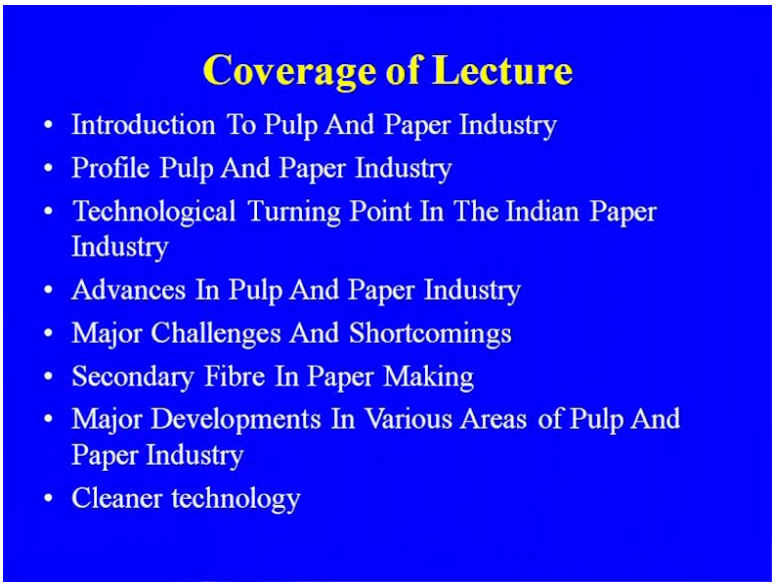
Module - 3
Pulp and Papers
Lecture - 1
Pulp and Paper

We are discussing organic chemical technology course. Already we have discussed module 1 and module 2. Today I will be discussing module 3 that will contain the, about the pulp and paper that will have the 4 lectures; one on the interactive part, second will be on the pulping and bleaching, third will be the on the recovery of chemicals and fourth will be on the paper making. So, we will, will be asking one question, you may ask that why the four lecture on pulp and paper, because you see the pulp and paper that is one of the very important commodity that we are using in our daily life. And if I say the life starts with the paper.

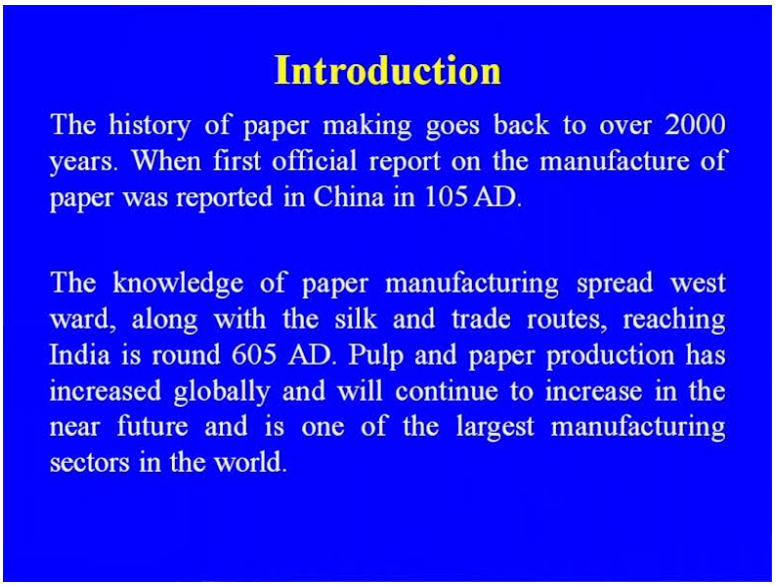
And hence with the paper, you see the why I am telling the life starts with the paper, you see the just I will show the, this is this is horoscope that is when a child is born the, your horoscope that is written. And even the invitation there may be doctor's prescription, tissue paper all those thing that is the beginning of the life that we are starting and end of the life also we are using in some or other form the paper. So, the lecture 1, the coverage of the lecture 1 that will be introduction to pulp and paper industry, raw material for paper industry and technological development that has taken in pulp and paper industry.

This is about the in more detail introduction to pulp and paper industry profile of pulp and paper industry, technological turning point in the Indian paper industry advances in the pulp and paper industry, major challenges and shortcoming, secondary fibre in making of the paper. Because you see the secondary fibre that has become very secondary fibre is a waste paper major developments in the various areas of the pulp and paper industry and the cleaner technology in the paper industry. Let us go in the history of the paper making.

(Refer Slide Time: 02:04)



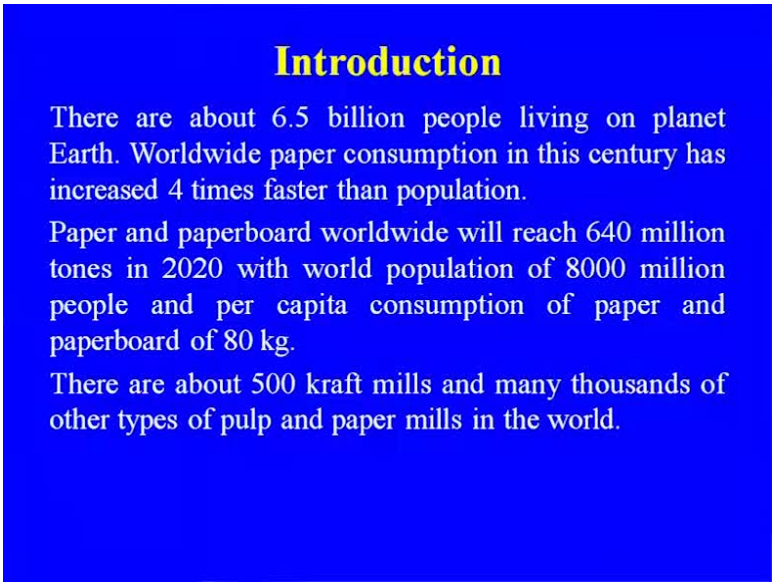
(Refer Slide Time: 02:42)



The history of the paper making goes back to over 2000 years and when first official report on the manufacture of paper was reported in China in 105 AD. Now, you are seeing the, all the old manuscript are available on the paper and so this is only because of the development in the handmade paper that was the earlier. And China was the many of the development you are seeing that started with the China and India. The knowledge of the paper manufacturing spread west ward, along with the silk and the trade routes, reaching in India is around 6 605 AD. Pulp and paper production has increased globally and will continue to increase in the near future.

And it is one of the largest manufacturing sectors in the world, because you see the earlier the people were expecting with the coming of the electronic media. Use of the paper that will decrease will decline. But it is not happening, because the use of the paper in some or other form that has increased although the writing paper that may be less quantity, but other type of the paper which we are using that has increased.

(Refer Slide Time: 03:53)

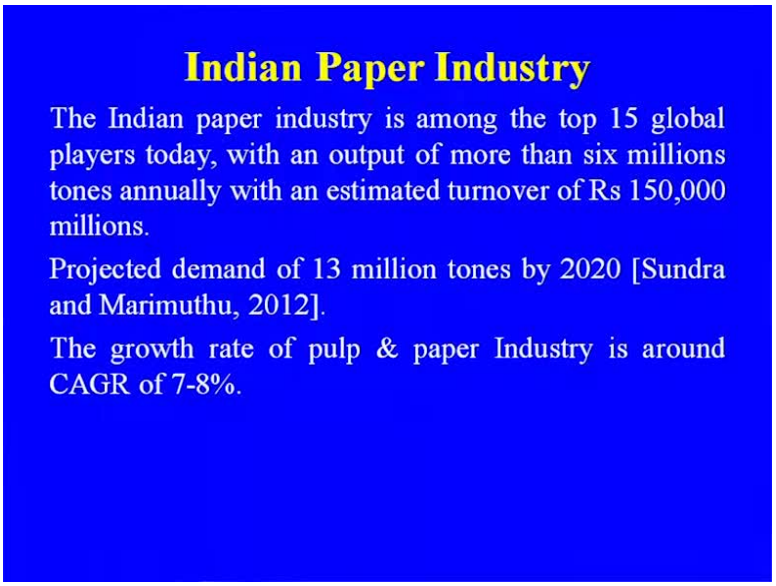


There are about 6.5 billion people living in planet earth. Worldwide paper consumption in this century has increased 4 times faster than population. Paper and paper product worldwide will reach 640 million tons in 2020 with world production of 8000 world population of 8000 millions. It means 8 billion and per capita consumption of paper board that is going to be 80 kg's. Although the per capita consumption in India that is less that is around 8 to 9 kg today, but the even the per capita consumption that is going to increase.

And the per capita consumption that is always a very confusing part, because our population is more. And in many of the development countries population is more wherever the population there, the per capita consumption definitely that will be less. There are about 500 kraft mills and many thousands of other types of pulp and paper mills, because we are using the agro base mill, agro base raw material, we are using the waste paper, number of the plants that has come in China also which is where they are using agro based raw material waste paper that has come in a big way. Because the huge

amount of the waste paper that is generated in the form of the packaging material, in the form of the news print, in the form of the office waste. So, all those waste paper they are playing very important role in meeting the raw material requirement and the sustainable development of pulp and paper industry.

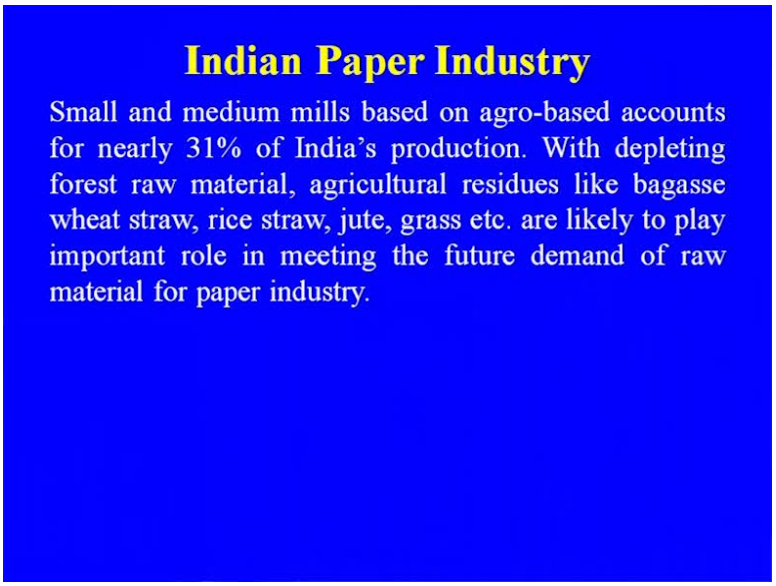
(Refer Slide Time: 05:30)



So far Indian paper industry is concerned the Indian paper industry is among the top 15 global players today, with an output of more than 6 million tons, annually with an estimated turnover of 150000 millions that is the, 150000 millions projected demand of 30 million tons by 2020. The growth of the rate of the pulp and paper industry is 7 to 8 percent that is the, because we are going to use that with the increasing population more and more a requirement of the paper will be there. There are about 500 already I have discussed this point at about the status of the paper industry.

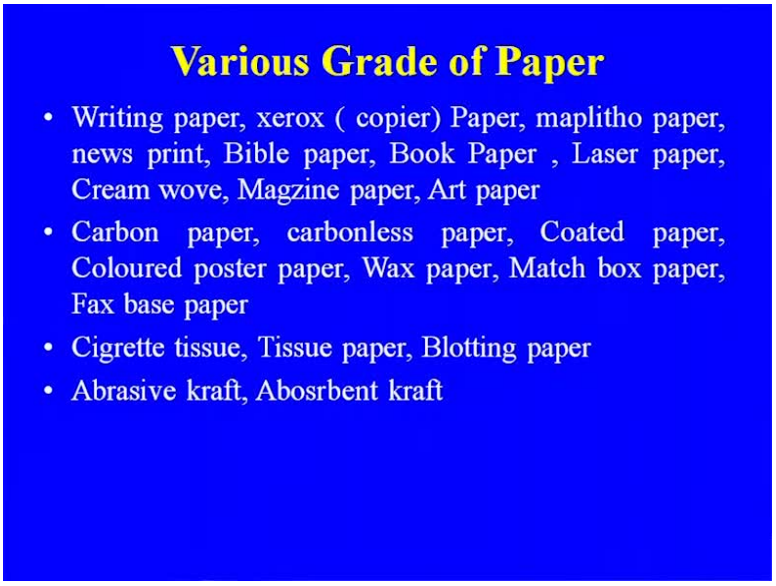
And Indian paper industry we are having the small and medium based on the agro based which accounts for nearly 31 percent of the Indian paper production with depleting forest raw material, agriculture residues like bagasse wheat straw, rice straw, jute grass etcetera, are likely to play important role in meeting the future demand of the raw material for paper industry. You see the in case of the go the Haryana, Punjab and other part of the country western U.P, we are finding large number of the paper mill which are based on either the agro based raw material it may be the bagasse also, because we are a sugar producing country.

(Refer Slide Time: 06:23)



So, bagasse based paper mill or wheat straw based paper mills are there. And the another important development that has been the utilization of the waste paper that is the even the we are getting the imported waste paper used, amount of the imported waste paper we are using in the Indian paper industry.

(Refer Slide Time: 07:31)

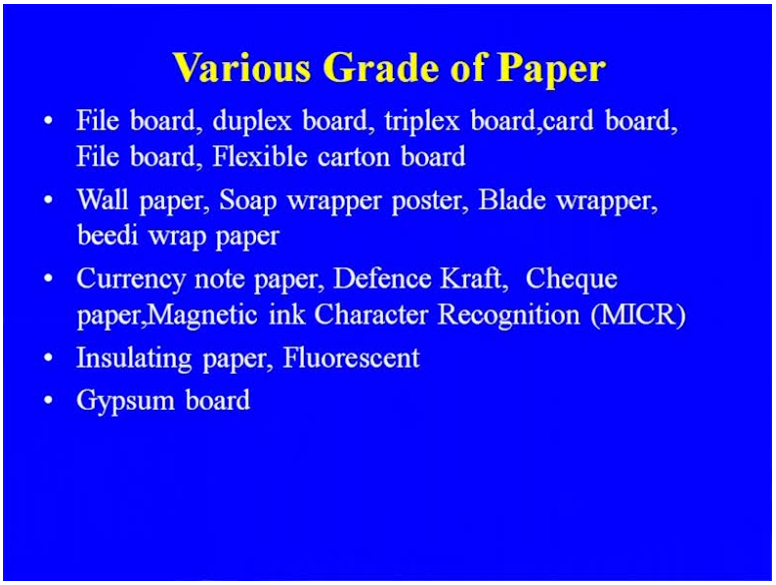


Various grade of the paper you see the, we are producing a large quality of the paper that may be writing paper, Xerox, copy of paper. And you see the maplitho paper, news print, Bible paper, book paper, laser paper, cream wove, magazine paper, art paper. These are

all the paper that we are using in some or other form in your daily life, even the bond paper what we call equity bond paper or it may be the Xerox paper, Xeroxing that has come use of the paper in the Xerox machine that has come in a big way in neutralization of the paper and increasing the per capita consumption of the paper.

Another specialty papers we are also making the carbon paper, carbonless paper, coated paper, coloured poster paper, wax paper, match box paper, match box that is also still we are using huge amount of the matchbox what is coming of the new fuel, the lighter still the matchbox that is being used in the rural area. Fax base paper, cigarette, tissue, tissue paper blotting paper these are the all the non size paper, tissue paper and various type of the tissue paper even the you are the paper napkins, we are using, we are using the tissue for toilet tissue paper we are using the blotting paper earlier when the ink feathering were or the ball pen was not there we are using the ink. And so at that time the importance of the blotting paper was there, abrasive paper, absorbent Kraft, paper that we are making.

(Refer Slide Time: 09:05)



File board, duplex board, triplex board, card board, file board, flexible carbon board. All these type of the different type of the board were paper board we are using it may be duplex means one side will be the bleach paper that will bleach pulp that will be using white. And the another side that will be the your normal paper and the triplex board, both the side will be the white paper.

And the inside that will be the so normally the gram weight, because the paper that is holding the terms of the gram weight normally the writing paper they are 60 GSM means the 1 square meter of the paper that will be 60. Normally, the copier paper they are 70 GSM like that the in the board that may be around 300 to 400 GSM that may be there, even file board we do not have the normally the GSM is high. But it is the single layer of the, your paper is there, but in case of the duplex and triplex the three layers are there.

So, this is the different type of the, and packaging the, because this has come in they are being used in the packaging of the medicine packaging of the soap packaging of the tea. And now everywhere seeing the, with the coming of the electronic media also we are using huge amount of the, this packaging material, wall paper, soap wrapper paper, blade wrapper, paper beedi wrap paper. So, these are all the actually various quality of the paper that we are making another important that has been the currency note paper. And the defence kraft, currency note paper, you see the still or the cheque paper, magnetic ink, character recognition MICR paper. These are all the specialty papers and that is needed, and because of the, you see the, now the, we are also thinking to go for the polymeric currency note. But I do not know what will happen, but still that is in the consideration.

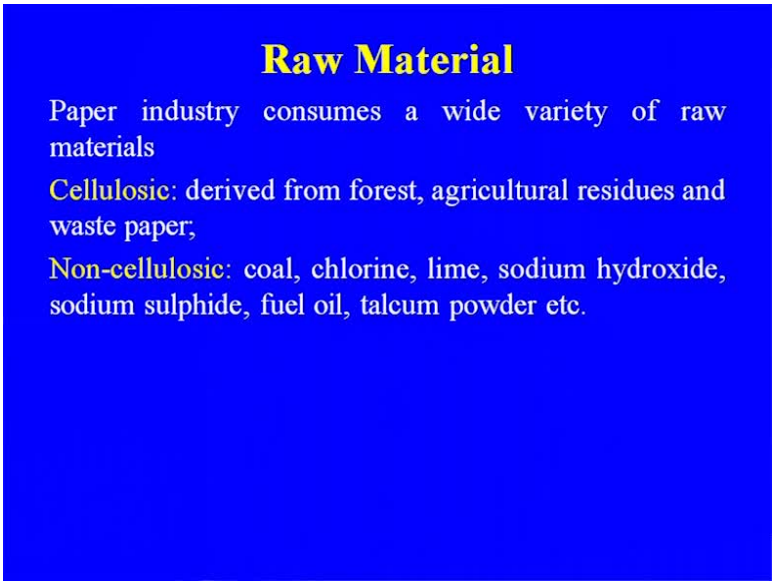
Another type of the paper which we are making the insulated insulating paper, fluorescent paper, gypsum board that we are seeing that has come again in report big way, because of the coming of the air condition chambers. And so the, we are having the fall selling sometime the gypsum board that we are using. And if you see that I can say the, I told you that the writing paper, news print, all that we are having the using in our daily life. Sometimes the, this is the wrapper for the soap; this is the greeting card we are making on the paper; this is the, your cheque paper that we are using in our daily life.

Similarly, different type I was telling about the board, this is the thick board that we are using. And this is the well coated paper also we are making and calendars. And all those table calendars, all those things that we are using the paper. Magazines; if you see the in case of the magazines, lot of the changes that has come in the magazines also, because you see the coated magazine, very good quality of the paper long durability that we are preparing in case of the and even the all the magazines.

Now, we need earlier, earlier it used to be the slightly inferior quality, but most of the cases. Now, you will find the good quality of the paper, coated paper which may last for longer time that we are using. Another type of the paper just I will show that the coated paper. This is the coated paper that we are one side, it is coated, another side is not coated that is the for the film purposes also we are using. Another type of the paper for making the, your this greeting card envelope and the equity bond, because slightly this is the equity bond paper that we are using slightly better quality than the normal Xerox paper and the cost is also and the weight of the paper GSM that is also very high. So, this is all about the some of the papers which we are using in our daily life.

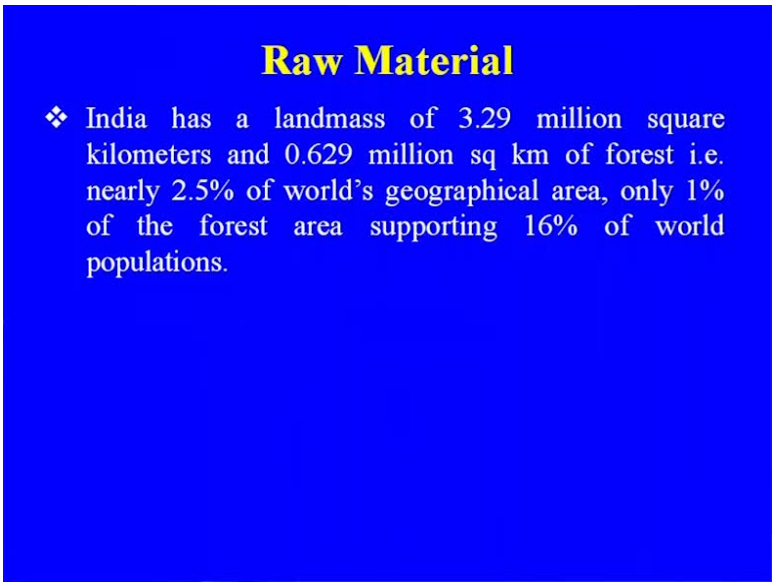
Let us come to the raw material for the paper industry what are the raw material that we are consuming, because you see the consumption of the paper is very large. And the even if you see the you take the case of the only news paper, huge amount of the paper news, print news, print paper that we are using daily and throwing just after reading in. So, the average life it is not more than one day, if we are keeping for one day and then it is waste. So, the huge amount of the news, print and even its number of pages in the news print, because of coming of the advertisements and other thing. So the number of the pages that has increased now and so the consumption of the raw material that has and so the various type of the raw materials that we are using in the paper industry.

(Refer Slide Time: 14:28)



That is the cellulosic material derived from the forest, agriculture residue and the waste paper. Non cellulosic; these are the raw material which are non cellulosic, raw material. And the production of the paper that you are using the huge amount of the coal, chlorine, lime, sodium hydroxide, sodium sulphide, fuel oil, talcum powder. Apart from the in the cellulosic material some of the cotton fibre also, we are using just like hessian cloths or the, your white cloth, waste that we are using for this board paper where the your of your bending stinter or the just, because you are after folding it there should not be crack in the board. So, for that the, we are using also 1 to 2 percent of the cotton linter or the some of the other hosiery waste in the paper. So that is also we are using in the making of the paper or for the specialty paper. Especially so far the availability of the raw material is concerned.

(Refer Slide Time: 15:36)

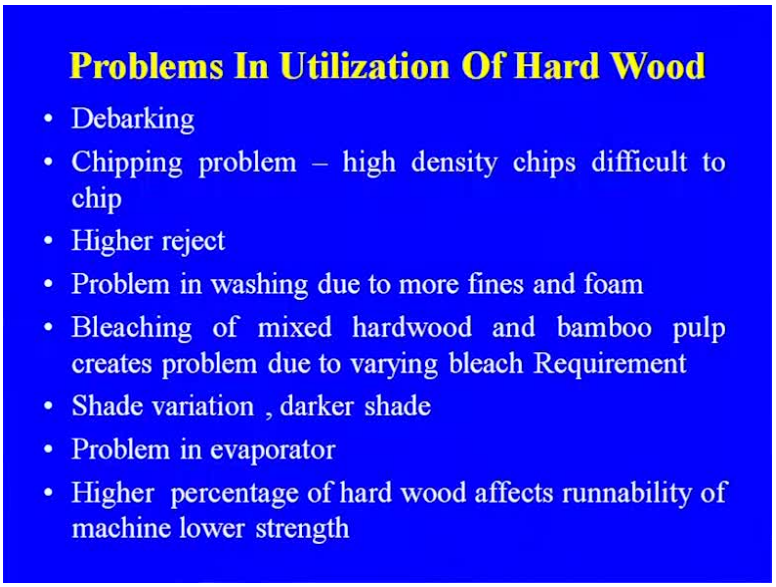


India is a land mass of 3.2 million square kilometre and the 6.29 million square meter of the forest, nearly 2.5 percent of the world geographical area. And only 1 percent of the total forest area and supporting more than 60 percent of the world population. Now, our population is the 1.3 billion and so the out of the 7, you can see the how much the contribution of the population is there. And so the, our forest cover area against the, whatever the standard figures are there that is much less, because we are losing our greenery. Similarly, in the case of the deforestation has been done, our social forestry is although we have invested lot of money on the social forestry, but the still the forest cover area is against the standard figure that is much less.

We are using actually the some of the raw material in the hard wood that came earlier we used to have the soft wood and the bamboo. Because so far India is concerned, normally we are using the bamboo as a raw material, bamboo and the some eucalyptus, because lot of the eucalyptus plantation was there 3 decades back. And so the huge amount of now the popular wood that is also being found some part of our country specially in the hilly area so that we are using, but in case of the hard wood, because this is the mix spacy from the forest we are using.

The quality of the hard wood that is the paper which we are making from the hard wood that is not so good as we compared to the soft wood fibre length is less. And in case of the soft wood the fibre length is high, quality of the strength in the paper that is very important whether you are making the kraft paper or you are making the mapalitho or you are making the cheque paper. In all the cases the strength that is very important, but just to meet the requirement of the raw material of the paper industry, hard wood utilization was more and more and so the some of the problem

(Refer Slide Time: 17:50)



That is we are facing in case of utilization of the hard wood that is the debarking problem, chipping problem; high density chip difficult to chip in comparison to soft wood. Higher reject problem in washing due to more fines and foam, bleaching of mixed hardwood and bamboo pulp. Because normally in case of the furnace which we are using as a raw material mixed hardwood and bamboo in Indian condition that we are using,

because of lot of the bamboo plantation is there. So, we are using the bamboo along with the hardwood. So, the requirement of the bleaching that is different for hardwood than the bamboo or it may be for the softwood.

So, there is a problem in bleaching of the mixed hardwood and bamboo pulp which creates problem due to the varying bleach requirement. Shade variation, because normally the softwood is the lighter shade and the your hardwood is in the darker shade so the shade variation also, because you are having the mix raw material that we are using problem in the evaporator that may be there in case of the, because more fines that will be generated, because as I told you in case of the your softwood more higher fibre length is there. Higher percentage of hardwood affects the runnability of the machine, because of the lower strength. So, we cannot go we have tried 100 percent hardwood also and the paper mill. But the problem was there in the proper smooth running of the machine, even the quality of the pulp which we are getting that was inferior. And so the normally 100 percent hardwood we are not using.

(Refer Slide Time: 19:32)

Raw Material Consumption Pattern in India

Year	% share		
	Wood	Agro residue	Waste paper
1970	84	9	7
2000	39	31	30
2011	31(57%)	22(39%)	47(4%)

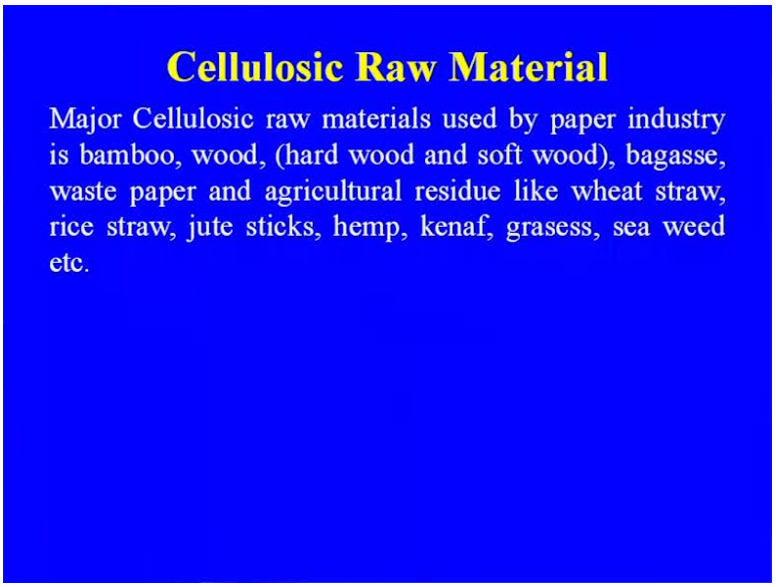
Percentage figure in bracket for global raw material)

This is the raw material consumption that we are you see the lot of the changes that has taken place from 1979 to 2011 and the wood 84, 39, 31. And then the global is the 57 agro residue 9, 31, 22, because there was problem initial stages number of the small paper mill came. And they were utilizing the agro base paper mill and the problem was in the recovery of chemical from the agro base.

Because earlier you see the concept of the small paper mill, small units or fertilizer plant, small mini cement plant, mini plant concept came during the 70 just to promote the industrialization. The same thing happen in case of the paper industry also, agro base residue that was being used in huge quantity, because they were having the recovery chemicals. And the black liquor which was produced that they are throwing.

And so after some time the pollution what you see the if you compare the mills large integrated mills which were using the wood, bamboo or the eucalyptus. There the pollution 3 times pollution load is higher in case of the agro base, because they were, but now it has been a mandatory for the all the agro base paper mill either you go for the recovery of the chemicals or close it and so the people are shifted towards the more and more waste paper so the waste paper consumption that has increased. Now, it is around 47 percent, many of the big paper mill, earlier the concept was the around 100 to 200 ton capacity that was considered. But now you will see the mills having the 400 500 t p d capacity they are based on the waste paper.

(Refer Slide Time: 21:21)



Cellulosic raw materials; the, what are the major challenges used by the major challenges raw, raw material regarding raw materials used by paper industry? These are the sorry that is the major cellulosic raw materials used by paper industry, bamboo wood, hardwood, bagasse, waste paper, agriculture residue like wheat straw, rice straw, jute sticks, hemp, kenaf, grasses, sea weed. These are the some of the cellulosic raw material,

but major challenge which I told you that we are facing in the utilization of although we are having lot of the hardwood, but the softwood availability is less.

So, mixed spaces of the hardwood were facing lot of the problem still. And so that was the reason the bagasse you see the, because bagasse that is the waste from the sugar mill. And so the that can be utilized for making of the paper that will be discussing about the, how we can integrate a paper mill with the sugar mill or the chemical plant paper mill and the sugar plant or alcohol plant while discussing the sugar and the fermentation industry.

So, this is the how the bagasse that can be made available, quality of the paper that is being made from the bagasse that is very good. But problem is in case of the wheat straw, rice straw, where the silica even in case of the bamboo, silica is higher than the wood. And so this was the problem faced in the Indian paper mills from very beginning they are facing when they are going for the higher bamboo in comparison. And so this is the, how the black liquor quality, that is varying very widely, because of the utilization of these raw material. Even in case of the, if you take the case of the wheat straw and rice straw there it is around 4 percent in case of the wheat straw, rice, rice straw as is as high as 14 percent. So, the, all the ash in the form of the silica, that is going to the black liquor after the making of the pulp. So, the recovery of the chemicals that become jute stick also huge amount of the especially some part of our country west Bengal and Assam that is available that can be used for making of the paper and to some extent we are using.

Then the secondary fibre in paper making, because you see the raw material requirement, that is increasing and just it is very difficult to meet all the requirement of paper industry from the forest raw material and similarly, the deforestation whatever, the. Now, the problem we are seeing the climatic change in other problem that is because of the deforestation, if our social forestry or if the plant action is not proper. So, definitely we are losing huge amount of the wood spaces, the various spaces in the forest. And so the recycling of this secondary fibre means the waste paper that is very important and the so far the recycling is concerned we are facing lot of the problem and the poor recycling is there.

(Refer Slide Time: 24:26)

So, the increase of the use of the recycled paper is the current trend in the paper industry globally as it is one of the survival routes for the paper industry against the dwindling fibre resources and environmental related issue, because especially in case of the agro base raw material rice we are facing lot of problem in the. So, from the environmental point of view also, this is very important. Collection of the domestic secondary fibre, an initiative as corporate and social responsibility shift in the raw material consumption pattern in India. Now, the, as I so that table where the consumption of this waste paper, that is increasing now. And the waste paper we are using the and now the whole mill about the 400 ton 500 capacity they are based on only the waste paper.

This is about the raw material consumption in small and large integrated paper mill, cellulosic raw material or the cooking chemicals even the cooking chemicals for small and integrated paper mill where we are having the using the wood that is slightly higher cooking chemicals. Sulphidity; We are using the normal the kraft pulping process in case of the integrated pulp and paper, in case of the small paper mills we are using the soda pulping.

(Refer Slide Time: 25:21)

Raw Material Consumption in Small and Large Integrated Pulp and Paper Mills

S. No.	Raw Materials	Requirement per tonne of paper	
		Small Paper Mills	Integrated Pulp and Paper Mills
1	Cellulosic raw material, Kg(Hardwood, soft wood, agricultural residues etc)	2500-3000	2200 – 2500
2	Cooking chemicals, Kg as Na_2O	70 – 90	310 – 360
3	Caustic for bleaching	20 – 35	20 – 35

So, this is the requirement costing also we are using in case of the bleaching of the bleaching stage after the chlorination we are adding the caustic. So, caustic, caustic extraction stage that we are using the caustic apart from the cooking. Other raw materials are that also we are using, because now the more and more bleach paper requirement of the bleach paper that has I mean is the white paper that has increased and.

(Refer Slide Time: 26:22)

Raw Material Consumption in Small and Large Integrated Pulp and Paper Mills

S. No.	Raw Materials	Requirement per tonne of paper	
		Small Paper Mills	Integrated Pulp and Paper Mills
4	Chlorine, Kg	100 – 160	130 – 160
5	Salt cake, Kg	-	60 – 70
6	Lime (available CaO 60%) Kg for bleaching	70 – 100	70 – 100
7	Lime (available CaO 60%) for causticising section, Kg	-	350 – 450

So, the, for bleaching it may be chlorine earlier it was the chlorine. Now, it is the chlorine dioxide, but as we are talking about the chlorofine chlorine free and the, and the

some of the mills the oxygen requirement. And we will have to produce the oxygen salt cake that we are using as a maker of salt in the case of the, you can see the, this is only we are using in case of the integrated paper mill.

And where we are the, we are adding salt cake as the makeup chemical, because the sodium sulphate that is reduced to sodium sulphide and which is the, because sodium sulphide that we are along with the N O H. We are using as the cooking chemical in case of the kraft pulping, part kraft for that came you see the kraft form is the Swedish name that is the in the call it the more strength.

So, normally the all the integrated mills using the, your hardwood, bamboo or the softwood they are using the kraft pulping process, because of the better. Some of the environmental concerns are also there when you are using this kraft pulp. So, lime that is also we are using huge amount about 0.7 ton per ton of the, that is we are using for the causticises action for recovering the white liquor from the, your green liquor so lime that is the requirement in. So, earlier actually the lime that was not being caust your calshine or it was not going to the lime. So, I will be discussing all those while discussing the, your recovery part of the chemicals.

(Refer Slide Time: 28:04)

Raw Material Consumption in Small and Large Integrated Pulp and Paper Mills

		Requirement per tonne of paper	
S. No.	Raw Materials	Small Paper Mills	Integrated Pulp and Paper Mills
8	Coal;,Tonne	1.0 – 1.35	1.5 – 3.0
9	Sulphuric acid, Kg	-	6 – 7
10	Alum, Kg	50 – 60	50 – 60
11	Rosin and Wax Emulsion, Kg	10 – 12	10 – 12
12	Starch, Kg	-	11
13	Hydrochloric acid, Kg	-	2

This is all the other raw materials that we are using apart from the coal, sulphuric acid, alum, rosin, these all material that we are using during the paper making starch for the, in the sizing of the material hydrochloric acid, that also we are using.

(Refer Slide Time: 28:22)

Raw Material Consumption in Small and Large Integrated Pulp and Paper Mills

		Requirement per tonne of paper	
S. No.	Raw Materials	Small Paper Mills	Integrated Pulp and Paper Mills
14	Furnace oil, Kg	-	75
15	Water, m^3	150 – 300	150 – 300
16	Power, kWh	1200 – 1300	1300 – 1800
17	Steam, Tonne	6.0 – 7.0	11 – 16
18	Soda ash as % of Rosin	7 – 8	7 – 8
19	Talcum, Kg	120 – 150	150 - 180

Furnace oil in the recovery furnace, because you are using the huge amount of the steam also, during the cooking; during the paper drying. So, their requirement of the power requirement of the steam that is. So, all the units they are having their own power generation, steam generation in some of the mills they do not have the power generation, but atleast they are having the boiler for generating the steam. So, we are using huge amount of the coal and the furnace oil and the steam soda ash and then the talcum powder for loading purposes paper.

(Refer Slide Time: 29:34)

Profile of Indian paper Mills & Global Competitiveness

Unit	World	India
	6.2 Billion	1.1 Billion
Mills (No.)	9000	>600
Capacity (mtons)	370	9.5
Kg/A/Capita	55	8.3
Energy Consumption GJ/T of Paper	32.0-40.9	51.6-80.0
Water Consumption m^3/t of paper	30-50	80-150

Source: Eloranta, J. 'Indian pulp & paper industry- challenges and opportunities" In paper

Because normally see the in case of the writing paper, writing grade paper they are having, because just to reduce the cost. So, that the more profitability is there so writing more actually loading is done. So, that it is around 12 to 14 percent loading that may be as I 14 percent so that is the in the form of the some of the fillers that we are using. This is about the other if you compare the various actually the parameters.

The profile of the Indian papers and global competitiveness, your population that is 6.21 point is more than 1.2 now and is around 7 billions you can say mills 9000 less than 600 number of mills. Here is the 600 that is very confusing figure, because we are using number of the handmade paper or the small units a lower capacity mills, these are all come in the total number. But actual number that may be around 300 to 400, but if you do not count the smaller mill, handmade papers capacity 370 9.5 kg annual per capita, that is the world figure 55. Now, it is around 80 and India 8.3 that is going to be 10 to 12, 11 to 12 in the near future, energy consumption; if you see the figure our energy consumption figure is much higher.

But now the some of the new mills they have already taken the care for reducing their energy consumption. And they have been able to reduce the energy consumption of course, because you see the water consumptions earlier used to be in case of the paper mill 250 300 400 cubic meter. Nobody was bothering about the water consumption, but after coming of the water sys.

(Refer Slide Time: 31:39)

Profile of Indian paper Mills & Global Competitiveness

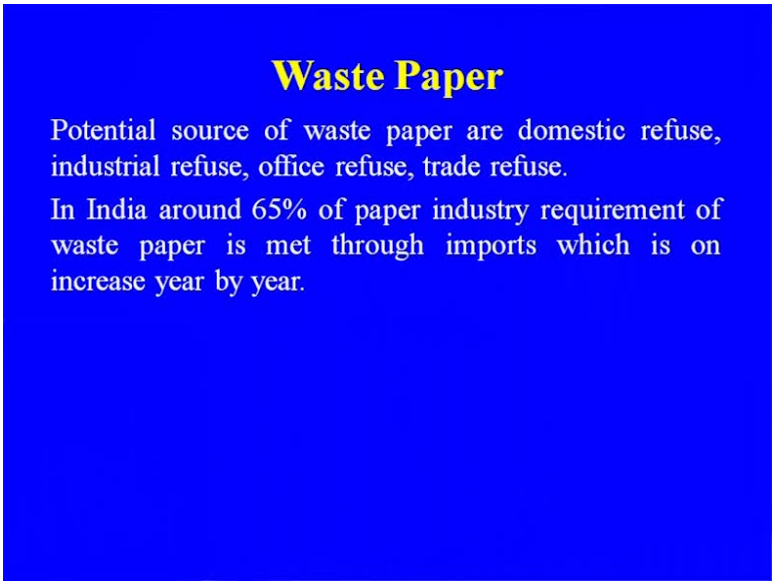
Unit	World	India
	6.2 Billion	1.1 Billion
Mills (No.)	9000	>600
Capacity (mtons)	370	9.5
Kg/A/Capita	55	8.3
Energy Consumption GJ/T of Paper	32.0-40.9	51.6-80.0
Water Consumption m^3/t of paper	30-50	80-150

Source: Eloranta, J. 'Indian pulp & paper industry- challenges and opportunities" In paper

Now, the consumption that has been reduced, but still our, per ton of the paper the consumption of the water that is high in comparison to other developed country. And lot of scope is there for the, your recycling of the water also in this system. But some of the inherent problems are there, because especially the, our raw material and their raw material in the development till where they are using more softwood less and less hardwood. So, that is slightly different actually situation is there.

But still you see the figure water consumption still it is high. Now, the, we have come atleast to 80 to 140 cubic meter per ton, but in case of the waste paper base mill definitely the figure is around 80, but in large integrated mill the figure is around 150. So, this is the, how the water consumption and scope is there for the recycling of the more water, but one of the problem that we are facing in recycling of the water that is the foaming, because of the more and more foam is developed if you are recycling in the system.

(Refer Slide Time: 32:15)



A waste paper the potential source of the waste paper are domestic refuse, industrial refuse, office refuse, trade refuse. The packaging material that will come in the industrial refuse and in India around 60 percent of the paper industry requirement of the waste paper is made through the imports which is on the increase here by. You are getting huge amount of the waste paper imported, waste paper from the developing country,

developed country in the especially the south east Asia, we are getting huge amount of the, because there electronic industry that is increased.

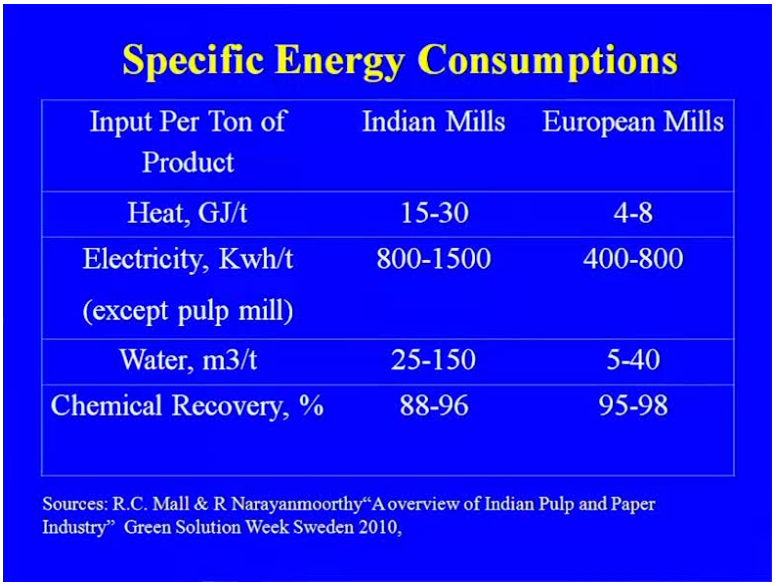
And so, the packaging they are using and their quality; one of the, another advantage of the using the waste paper from the other country. Because the waste paper which are generated from the softwood base, they are stronger than the, what you are even some time the kraft paper, the kraft paper made from the softwood, because even the waste paper that is at par with the hardwood paper which we are making here. So, this is the reason why the more and more waste paper from the import of the waste paper is there.

(Refer Slide Time: 33:28)

This is the paper recycling and if you see the around 20, now it is you can say the 20 to 25 percent. So, still there is a scope for the more and more recycling or the, because the only one thing is there our collection system is not good in India. And so this is the creating problem even in recycling of the plastic also, we do not segregate the waste just you put all the waste at one place and then we are trying to say. So, quality of the road sweeping waste paper if you are getting that is much inferior. Then the what the people are because in case of the paper industry, especially specially for the board, we are talking about the duplex board and triplex board; the liner part and the filler part both the things are the. So, the top cover page are the in case of the duplex that is used to be virgin part and the liner part that is from the waste paper.

So, the quality of the waste paper if the bad, then definitely, it is going to affect the whole paper making as the quality of the paper. So, that is the one of the problem in recycling and the proper recycling that has to be done in case of the. And for that the proper collection system be there, and all the paper waste that has to be segregated at the generations stage itself, not it is going to the municipal waste and then again we are segregating. So, that is not going to solve the problem, so that will that is a problem that has to be looked by the government, just to increase how to better collection system that can be incorporated in the various towns and the cities and so that the more and more recycling is there.

(Refer Slide Time: 35:13)



This is about the parameter electricity, the chemical recovery and that the European mills is high, in Indian mills also in some of the mills they are having the new recovery boiler so their efficiency of the recovery but in some of the old mills the recovery of the chemical is still less. And so, there is lot of scope for the going for the new recovery system, because daily we are losing. And if you take the total cost of the replacement then I think that will be more economical to go for a new recovery furnace than the operating at the where lower recovery of the chemicals means below 80 percent or around 80 to 85 percent recovery. So, this is the one of the bigger challenge for the Indian paper mills to increase their recovery part and so definitely that is going to add in the overall economy of the paper industry.

Now, let us discuss slightly in brief very brief, because again I will be discussing in detail, all these point and the what are the various stage involve in case of the making of the pulp and paper. First thing is the raw material preparation that may be the de debarking chipping that may the part in case of the forest raw material bamboo or hardwood or the in case of the bamboo. For lot of the waste that is the biomass waste that we are getting in the forest or the, from the debarking of the wood, so that can be, because that is the reason why we are working. Now, the lot of the work that is going on to biomass strength, cutting that is the, what we are using not the chipping, chipping. Normally, we are using for the hardwood cut are the bamboo and chip cutting, we are using for the straws means wheat straw, rice straw or the it may be the bamboo also. Then the, finally, screening of the, so that is the fine dust which is generated during the chipping or the cutting that is eliminated or the even some of the raw material preparation. And that is the washing of the raw material that is also being done especially in case of the bamboo and the hardwood.

(Refer Slide Time: 38:12)

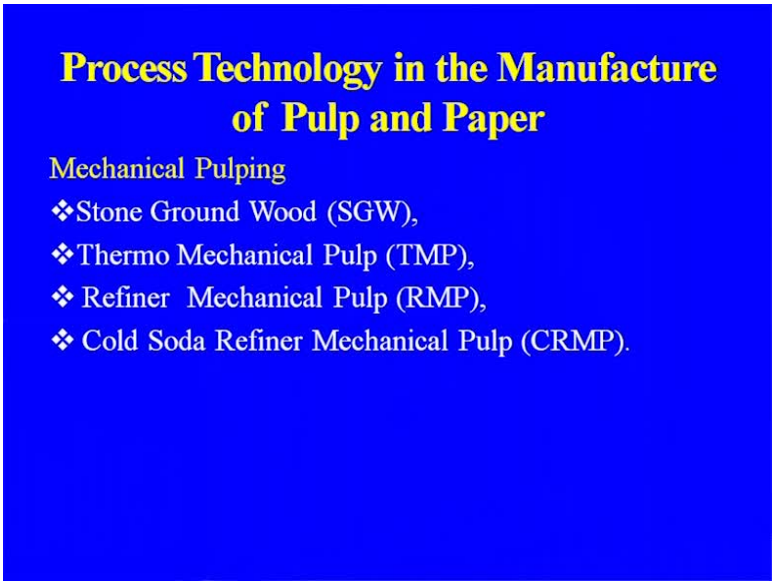
So, that is the silica which is adhering to the hardwood or the that is not going to the, just to avoid that if you are having the better wash having the proper washing of the raw material before it is being. So, definitely it is going to improve the quality of the product, pulping means we are having again using the different types of the pulping process, depending upon the requirement. Because you see the normally the chemical pulping always the yield is much lower than the what you are having in the case of the

mechanical pulping, chemical pulping yield may be 40 to 45 percent. So, we are in case of the chemical pulping normally we are using the sulphate.

That is the we call it, the kraft pulping process where sodium sulphide, sulphate also that from a we are using the sulphate process means this sodium sulphate that we are using as a makeup chemical in that sodium sulphate in presence of the carbon that is due to sodium, suphide. Soda pulping means NOH that we are using in case of the, your agro base mill. And another is the sulphate pulping, not it is sulphate, but it is sulphate pulping and then the semi chemical; neutral semi sulphide, sulphide, chemical pulping. So, NSSC, NSSC that we are using in case of the, because here yield is in between the mechanical and the chemical pulp. And so normally for the packaging material corrugated part we are using the semi chemical process.

Sulphate pulping normally we are now, not using in most of the mills whether a in India or other mills. In India we are not having any sulphide base, because 1 unit was there and that has been also closed and so the mostly, because here we are requirement of the free S O 2 and the sulphur. Because of the sulphur, sulphur is important at the k at the same time generation of the S O 2 lot of the environmental problem is also there.

(Refer Slide Time: 40:20)



So, normally and one another, but one very important waste that we are generating Lingo sulphate here, but still that is the use of the sulphate pulping is much less. As I told you the mechanical pulp they are having the higher strength, higher yield, lower strength than

the chemical pulp. In case of the mechanical pulp the yield of the, that may be as high as 95, because most of the material which is present in the cellulosic raw material that is retained in case of the chemical pulping we are delignifying, we are removing the lignin. So, that is loss in the total amount of the material which we are feeding, but in case of the mechanical pulping everything that is retained.

So, stone ground wood pulping, thermo mechanical pulping, refiner mechanical pulping, cold soda refining, because thermo mechanical means the TMP that has come specially in case of the, and news print that we are using. Because in case of the news print, we are using around 70 per line share of the paper is from the mechanical pulping and the rest is from the your chemical. So, 70 is mechanical pulp there and so that mechanical pulp earlier, the stone ground pulp that was being used. But now, the stone ground pulping that has been replaced, that has been replaced with the thermo mechanical pulping. What are the various requirement in, in case of the news print?

All those things that will be discussed separately, then the next stage in case of the pulp and paper making is the washing and the screening that is very important for the recovery of the, because we are using the cooking liquor for cooking of the raw material after the chipping. And so the black liquor is generated in the white, the liquor which we are using for the cooking that we called the white liquor. And the after the cooking it is black liquor and that black liquor that has to be separated from the, your pulp and it will go for the recovery of the chemicals from the black liquor. So, that is very important, because the lignin that is having the dark brownish colour.

So, that removal of the black liquor that is being very important, otherwise the whole effluent which you are getting during the screening or the centri cleaning where the huge amount of the water that we are using, because normally it is 1 percent in case of the screening. In case of the centri cleaner is less than 1 percent of the pulp and rest 99 percent of the water. One reason I can say the in case of the, what is happening in case of the pulp and paper making? We are adding water at 10 percent removing the water.

So, huge amount of the water that we are using in case of the, so if the proper if you want to have the proper recycling of the waste water, proper washing of the pulp that is very important. Again this will, will go in more detail, what are the various type of the washes that we are using. Next step in case of the after depending upon the requirement where

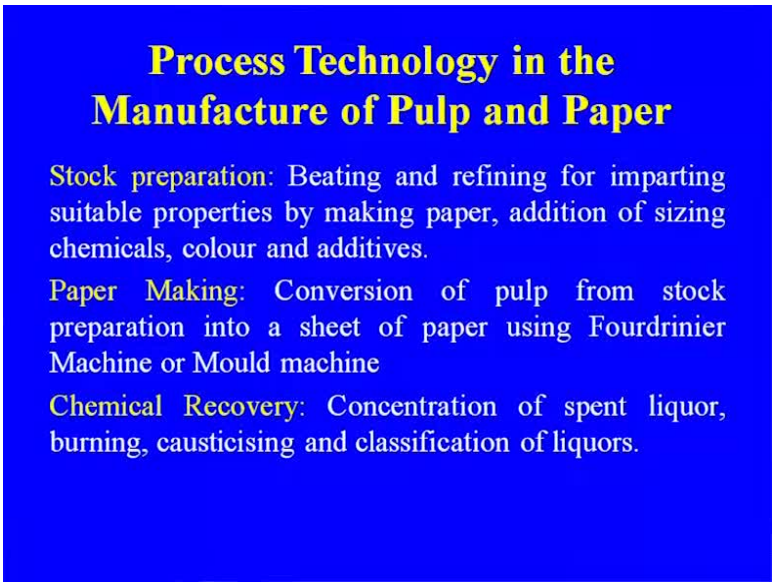
our need is for the kraft paper or the, if you see the kraft paper means the brownish paper. This file board if you see this is the kraft paper no bleaching that has been only the colouring matter that has been added.

So like that the, if you want to make the kraft paper. Normally the packaging in some of the packaging material that the kraft paper that we are using. So, the if the bleached paper means the white paper just like the writing paper or the cream paper mapelitho equities and all these the white and the so bleaching that is the C h means the chlorination extraction hypochloride 1, hypochloride 2 then because these were the earlier sequence there has been lot of the changes in this sequence also and stage of the chlorine. Now, we are talking about the chlorine dioxide bleaching, so chlorine dioxide that has been added in the place of the chlorine, or in addition of the chlorine, both and at the same time.

Now, the in case of the pulping also it has been the, now the, we call it the deligning oxygen deligning, because what is happening in case of the oxygen deligning? We are removing the some of the lignin before it is going to the bleach liquor, because bleaching plant means the, in case of the pulp bleaching the effluent, which is generated highly toxic just to reduce the toxicity and the colour. So, priorities going the delignin bleaching section if you are having the oxygen delignification. So, the requirement of the bleaching chemical that will be less at the same time, the quality of the pulp that will be better that will have the higher strength, because the lot of the detoriation, the quality of the paper is there when you are using the hypochloride.

Other bleaching agent which you are using for bleaching hydrogen paraoxide, sodium proxide, hydrosulphide for mechanical pulp these are the some of the actually the bleaching chemicals we are using for in case of the mechanical pulping. Because you see the, now the requirement in case of the paper that has also changed that is also changing even in case of the paper. If you are seeing the lot of the printing is involved and even some of the some pages are more actually the glitch paper type, the material that we are getting. And so the coated paper that we are also using in the, and the lot of the advertisement paper which we are getting in the paper they are also the glitch paper or the coated paper.

(Refer Slide Time: 45:20)

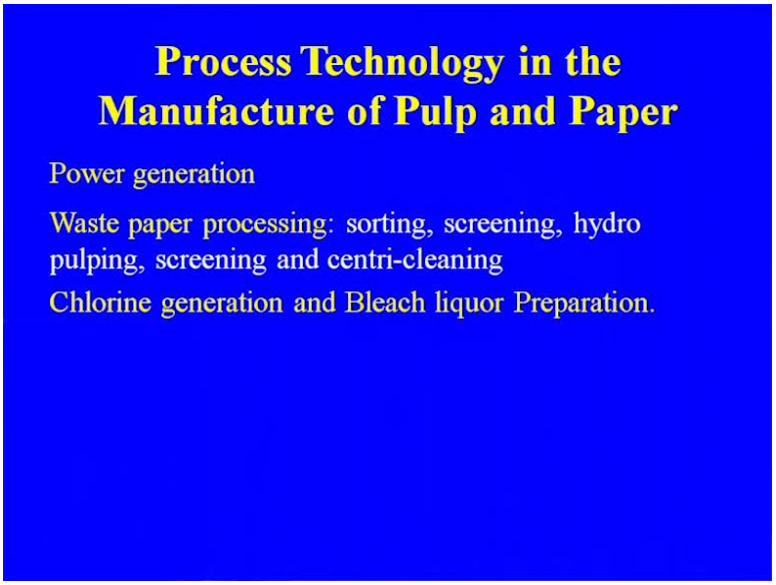


So, process technology in the manufacture of the pulp and paper next step after the pulping bleaching washing and or the stock preparation where the beating and refining for imparting suitable properties by making the paper, addition of the sizing chemicals colour and additives. If you want to interested for the colour for some of the actually, the poster papers all those thing or even in case of the match box you see the typical, actually that is the we are using the violet colour for colouring that paper and so the lot of the dyes also involved. So, the chemicals sizing chemicals if you want to have the tissue paper then we do not need the sizing what in other cases we need the sizing we need to coating, all those thing additive better retentionates that we are having using. So all these thing that is mixed during the stock preparation and finally, after the stock preparation pulp that is going to the.

For paper making that is the conversion of the pulp from the stock preparation into sheet of paper using fourdrinier machine or the mould machine. Because we are having the 2 3 type of machine that may be fourdrinier alone or it may be combination of the fourdrinier machine, or the mould machine, or it may be the mould machine. Only as in case of the some of the mills they are having the only mould machine where they are making the duplex or the triplex board or it may be the combination of the both fourdrinier or the mould. Then the, another important section in case of the pulp and papermaking is the concentration of the spent liquor burning causticising and classification and the causticisation of the liquor. Power generation waste paper processing, because that is

also that has become very important part in case of the most paper making a well, but they are using the waste paper as such total or they are using for their in the making the duplex or the triplex board.

(Refer Slide Time: 47:26)



So, sorting screening hydro pulping and centri cleaning, these are the some of the steps involved in case of the screening. And the centri cleaning means centri cleaning means you are using the smaller diameter cyclone which we call it the centri cleaners there in case of the paper industry. So, for the removal of the specially, the silica and other material or the uncooked material, that is taken place during centri cleaning.

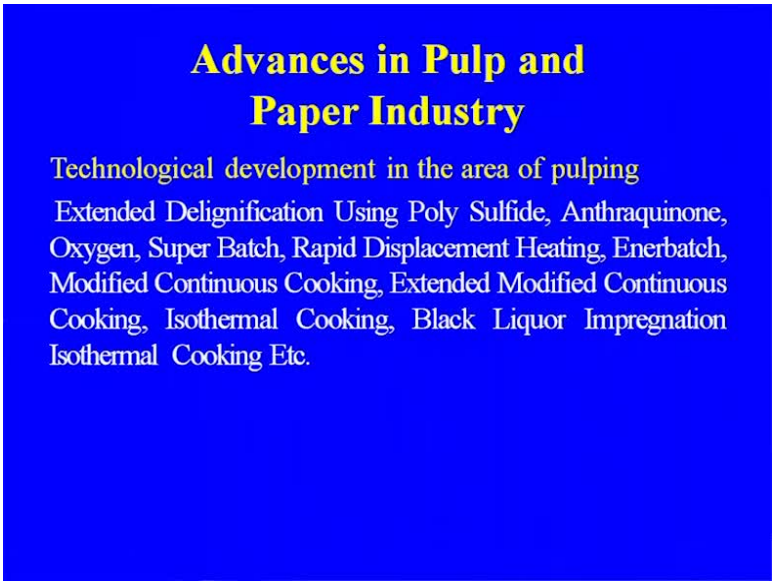
So, what are pulp, which is going to the final paper making the free from any type of the material, spects dirt and silica that is not there? One thing that is also as I told you the, for bleaching purposes, still the chlorine bleaching that has been practiced. And although the some of the mills they have gone for the chlorine dioxide, but chlorine still that is being used in case of the paper mill, the chlorine in the chlorine bleaching is there or it may be for preparation of the hypochloride calcium that we are forming in case of the bleach liquor.

So, this is the another unit normal integral part of the that paper mill or that may be sister concern as in some of the paper mills they are having the. So chlorine that in some of the mills they are getting from the in the cylinder form or in some of the mills directly through pipe line. Because just side of the mills they are having the chlorine and the

chlorine dichlorine gas that is being supplied in the pipeline. Some of the technological development that has taken place in case of the pulping, because there has been continuous development. In case of the paper industry the, to meet the environmental standards which is becoming more and more stringent in case of the all the industry.

So, even just to increase the productivity just to increase the yield of the paper. Just improve the quality of the paper lot of the changes that has taken place in case of the pulping also, extended delignification, what we call it, why we going for the extended? Because as much as lignin, you can remove at the initial stages less and less bleaching chemical that would be required, because loss of the pulp is more in case of the bleaching than the pulping stage. So, normally it is avoided chlorine bleaching or the hypochloride bleaching. So, it is now the people are going for the oxygen delignification.

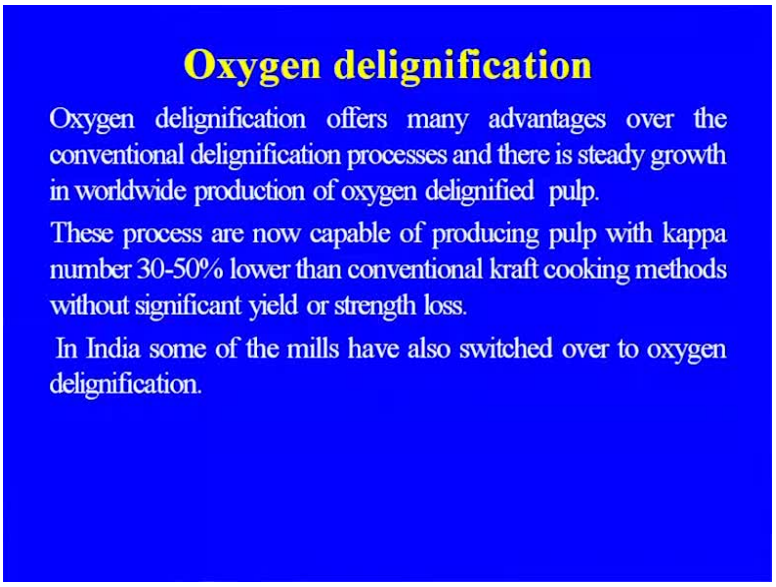
(Refer Slide Time: 50:04)



Polysulphides, anthraquinone, oxygen, super batch, rapid displacement heating, enerbatch, modified continuous cooking, extended modified continuous cooking, isothermal cooking, black liquor, impregnation isothermal. These are the some of the development that has taken even in case of the actually if you when I was talking about the pulping. You see the pulping that can be the batched diester or the continuous diester or in case of the if you are having the agro base material then you are normally you are having the spherical and digestor, because the it is more bulky in, in. If you compare the bulk density of the hardwood or the bamboo it is high and so in case of the normally the

spherical some continuous and your puplers are also there. But spherical digestor that is preferred in case of the pulping of the agro base raw material.

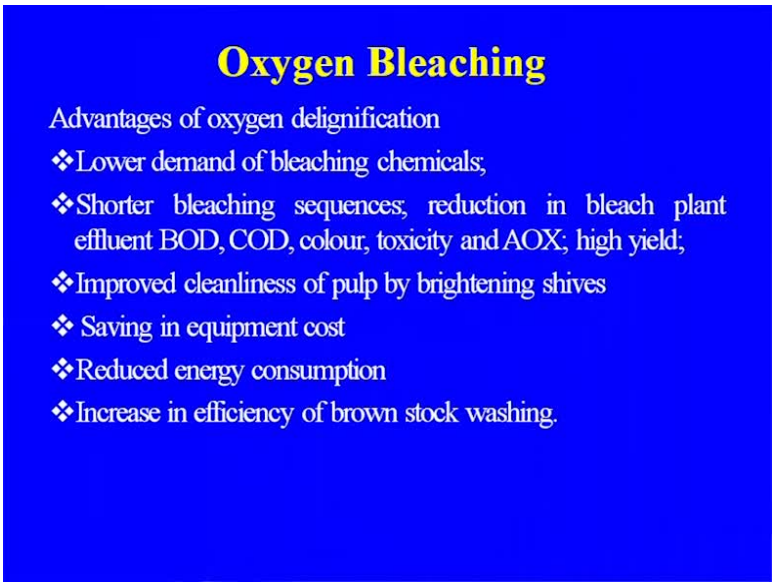
(Refer Slide Time: 51:06)



So, as I told you the oxygen delignification that offers advantage over the conventional process and there is a steady growth in the worldwide production of the oxygen delignified pulp. In India also, we have started using and many of the mills, but still in many of the mills they are not using the oxygen bleaching or sometimes bleaching and the delignification both the things are same.

Because the bleaching also we are removing the lignin here delignification, oxygen delignification or the oxygen bleaching. Both the words that we are using these process are now capable of producing pulp, kappa number of 35 30y to 50 percent lower than the conventional Kraft cooking method without significant yield or strength loss. Because normally in case of the oxygen delignification if you are doing. So, final pulp and the paper which we are getting that will have the higher strength than what we are getting with the conventional pulping and the bleaching process. These are the some of the advantage lower demand of the bleaching chemicals, because the major portion of the lignin we are removing before it is going to the bleaching of the pulp.

(Refer Slide Time: 52:23)



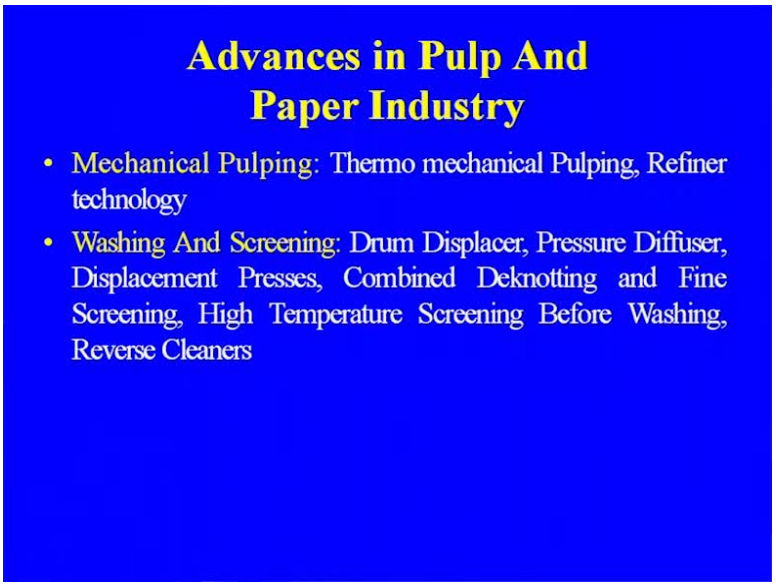
Shorter bleaching sequences that may be required and the effluent route is also lower than the lower BOD, COD, colour, toxicity, AOX, high yield is also there. Improved cleanness of the pulp by brightening, because the one more thing that has been there in paper industry requirement of the brightness that has changed earlier it used to be 70 percent.

Now, we are having the 90 percent brightness, even if you go for the writing paper which is best if you are having the dull paper low brightness paper we will not prefer. So, this is happening our requirement that has changed from 70 to 90 percent or high brightness and so the requirement of the, your bleaching chemical that increased. So, the quality that will also actually affect the quality, but with the oxygen bleaching of the delignification the qualities high much better.

So, improved cleanliness of the pulp by brightening (( )), saving in the equipment cost, reduced energy consumption, increase in the efficiency of the brown stock washing. Actually washing of the pulp which was that is called we also call it the brown stock washing. Mechanical pulping, thermo mechanical pulping, refiner technology that may be, because the disc refiner all those thing that has come in case of the mechanical pulping. And they have replaced the conventional stone ground pulping and so the thermo mechanical even become, because thermo mechanical means softening of the chips before it is going to the refiner or the refiner with the some of the chemical that we

are heating, washing means cleaning. Again in case of the washing you see the lot of the development that has taken place, because the washing, proper washing that is very important with the minimum use of the water so that the black liquor of the higher concentration that we are getting.

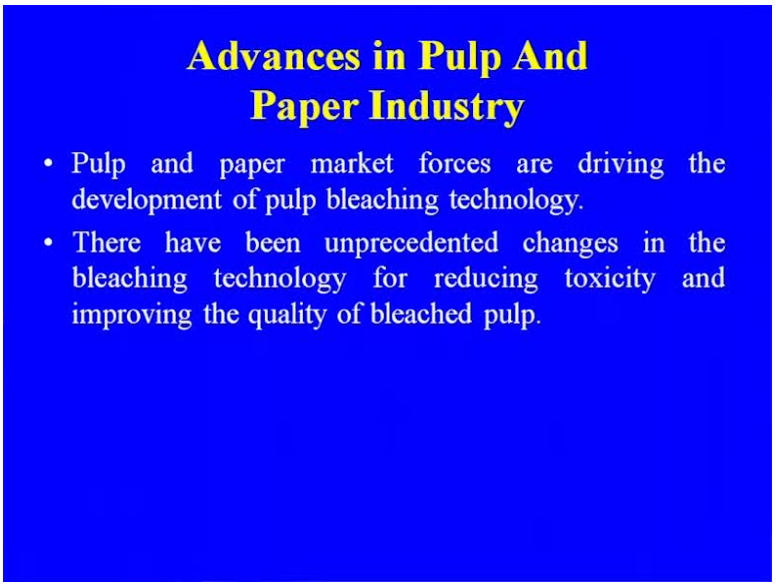
(Refer Slide Time: 54:20)



So, these are the drum displacer, pressure diffuser, displacement presses, combined decknotting, and the fine screening, high temperature screening before washing, so reverse clean these are all the actually development that has taken place in case of the washing and screening. So, advances another advance actually as I told the in case of the mechanical pulping.

Now, this also we are adding the chemical, bio technology application that has come in big way in case of the paper industry also and the form of the bio pulping, bio bleaching enzymatic, deinking enzymatic, refining during the refining stage also that we are using. And already we have discussed about the washing and screening, because the wash screening part that is also very important in case of the making of the pulping.

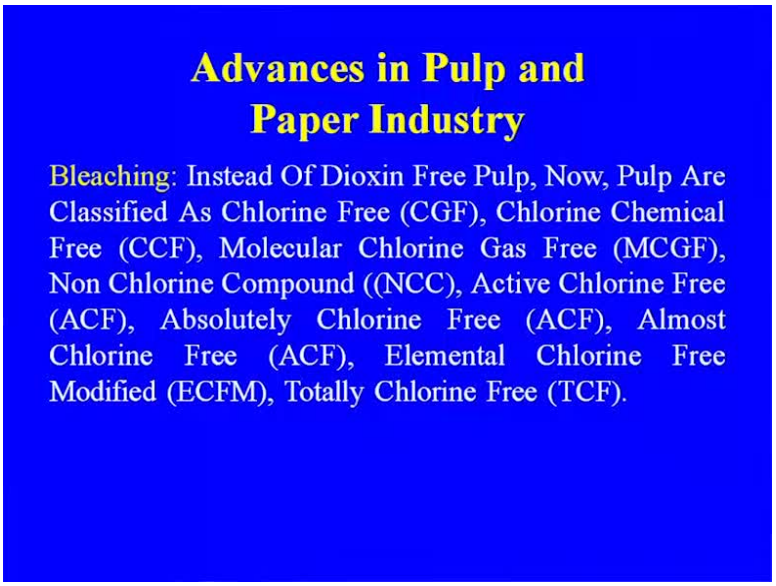
(Refer Slide Time: 55:18)



So, pulp and paper market forces are driving the development of the pulp and bleaching technology, because most of the development now you are finding that is from the environmental point of view. From now we are talking about the chlorine free paper in the market environment eco friendly paper. So, if you want to go for the international market definitely it used to be the more we are talking the greener paper where the less and less even the chlorine why the, which is the while discussing pulping and bleaching. We will be discussing why the, how the various actually the sequences of the bleaching that has been changed?

So, there have been unprecedented change in the bleaching technology for reducing the toxicity and at the same time improving the quality of the bleach part. So, these are the some of the actually the advances, because dioxine that is produced during the, in case of the pulp and paper making and lot of concern that has been shown, because of the presence of the dioxine in the effluent of the pulp and paper.

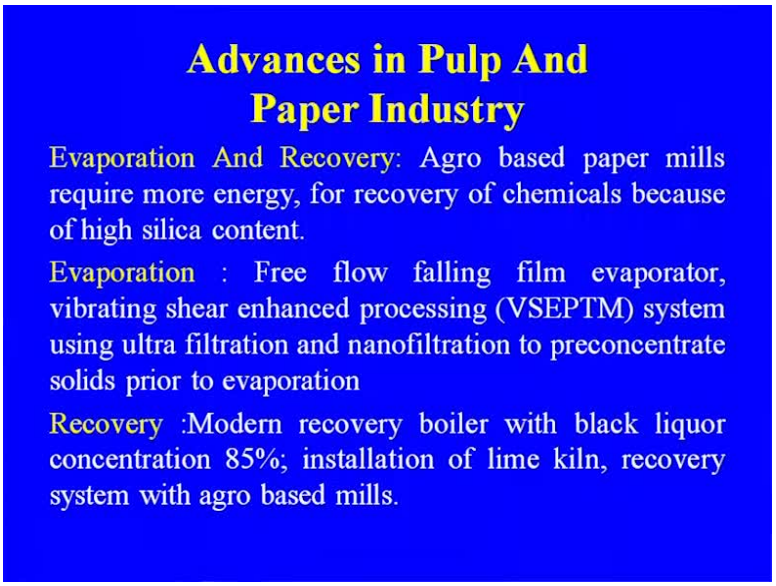
(Refer Slide Time: 56:33)



Now, the Pulp are classified as the it may be chlorine, free chlorine, chemical free, molecular chlorine free, non chlorine compound, active chlorine free, absolutely chlorine free, almost chlorine free, elemental chlorine free, modified totally chlorine free. So, these are the some of the various sequences various type of bleaching that has been incorporated in. Fibre modification that is also the some of the advancement enhancing the obesity of the fibre through pigment particles better fibre loading pressurised instive adhesive alkyline sizes. Now, the people are talking about the sizing I will be discussing while discussing the paper making the acid sizing to alkyline sizing why the people accepting? Now, we are going for the alkyline sizing also paper machine, paper making, because. Now, what we are doing? We are making on the machine that paper, so the speed of the machine with the sophisticated instrumentation.

Now, we are having, we are having earlier it used to be 200 capacity that was considered 200 405. We are having the machine 1000 meter per minute that is running, the high speed machine that we are using with the much more sophisticated instrumentation control. Because you see the continuous running of the paper there should not be breakage transfer of the paper from wire part to or the mould part to the press part and to the dying part close road and insulation of the dry cylinderine. Because we are using the steam for final drying of the paper installation of the tuning press these are all the some of the development that has taken place in case of the paper industry.

(Refer Slide Time: 58:21)



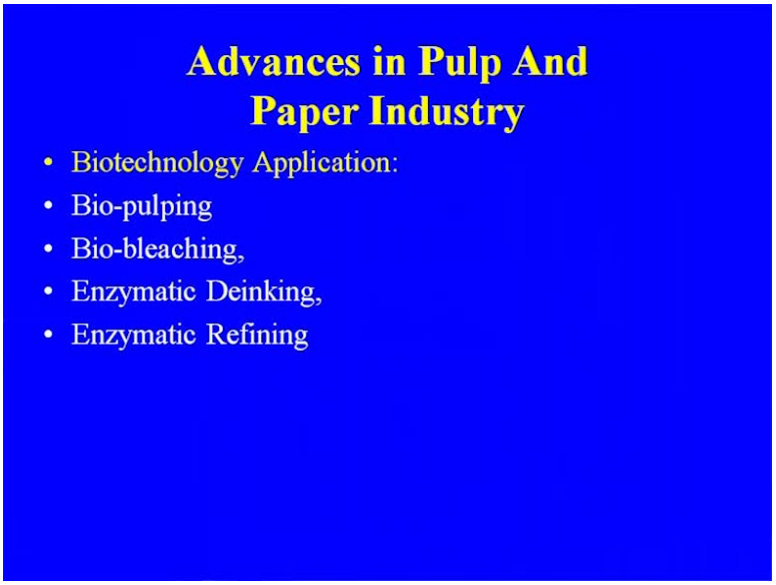
Evaporation and recovery also the advancement that has taken place agro base require more energy, for recovery of the chemicals, because of the high silica content. In case of the, you cannot go in the conventional evaporation beyond 30 35 percent, black liquor where in case of the agro bamboo base and the hardwood base you can go to around 45 percent of the concentration of the black liquor. Even in case of the other part of the, for where they are using only hard softwood and there black liquor concentration is slightly higher than what we are, because in case of the bamboo also which is the major raw material in Indian paper industry the silica content is high. So, that silica created problem if you going for higher concentration.

So, for the recovery the higher silica content that is the especially in case of the agro base evaporation. Now, the most of the mills they have added in along with the 5 to 6 effect long tube is operated, they have gone for the filling evaporator for further. Actually the concentrating the black liquor, because the concentrated black liquor that is being fired in the recovery furnace. And so, the amount of the additional fuel which will be required that will be higher, first it will be drying part and then the other reaction which will take place in case of recovery. So, these are the some of the actually the ultra filtration also nano filtration, this is the people are.

Now, talking about the membrane process for concentrating the black liquor and so that the concentrated black liquor it is flowing. People are also talking about the recovery

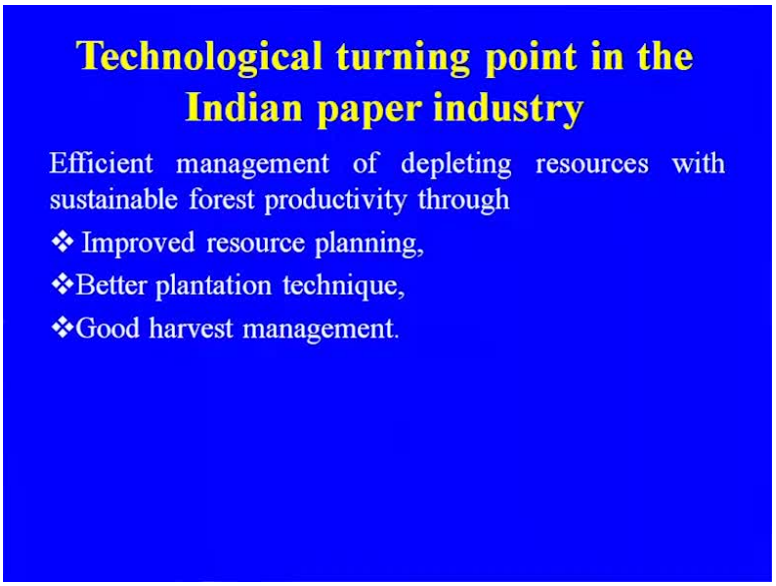
part, because you see the modern recovery boiler they are having the higher actually the concentration around 85 percent normally we are feeting around 60 65 percent, but modern recovery boiler they can go for the 85 percent of the much more water removal at the initial stage. So, this is the how the development that is recovery system with the agro base, because there has been changes in the. Because that has been made mandatory in case of the agro base mill to go for the recovery, earlier it was again problem because the silica content. Now, they have gone for the recovery of the chemicals from the agro base mill also.

(Refer Slide Time: 00: 01:01)



These are the some of the biotechnology application already I discussed earlier bio pulping, bio bleaching, enzymatic deinking, enzymatic refining. So, all these actually the, that has been tested, but still so for the, if you go for the industrial scale. So, how much improvement is there? There are so many varying parameters are there, but it has been actually found very suitable, if you are going for the bio pulping or bio bleaching. So, that the chlorine if you want go for chlorine this is the one of the solution that you can go for the bio delignification or bio bleaching and the enzymatic deinking why it is very important especially for the your recycling of the waste paper.

(Refer Slide Time: 00:01:55)



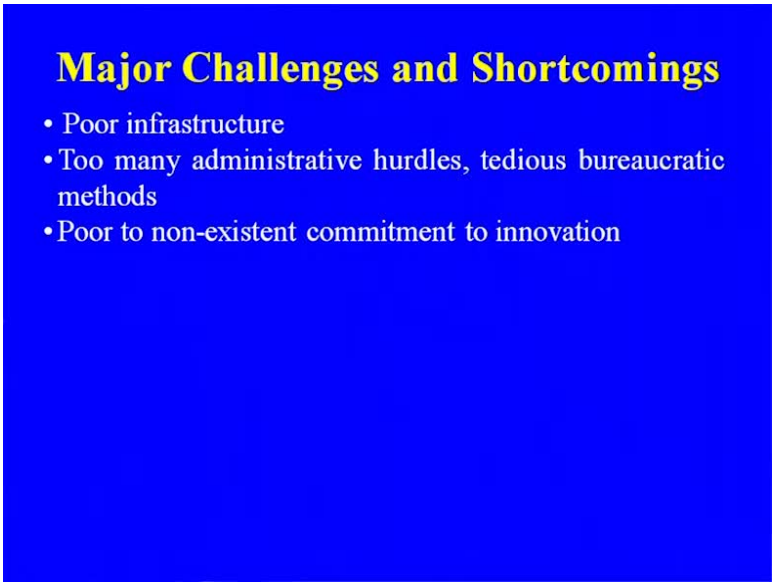
These are the some of the technological turning point in the Indian paper industry that is the improved resource planning, better plantation technique, because the our social forest is poor wood harvest management.

(Refer Slide Time: 00:02:04)

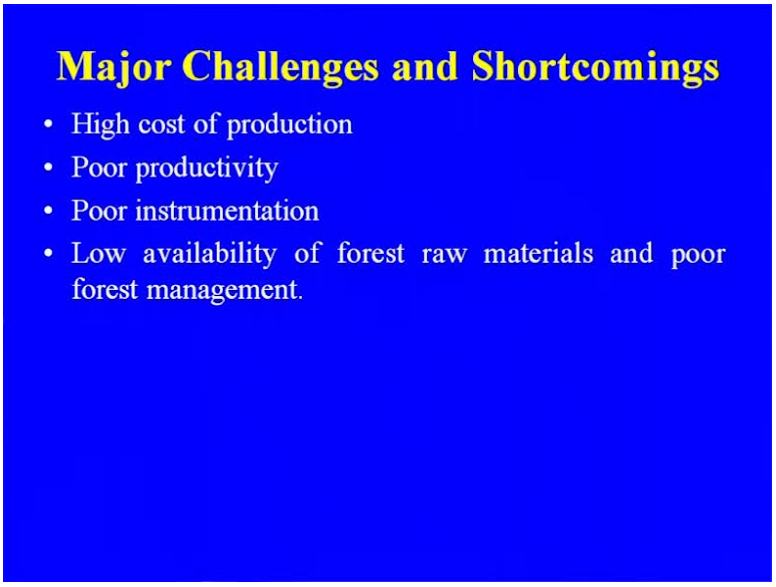
So, in the technological turning point in the Indian paper industry, some of the things we have already discussed the conservation of the natural resources, effective waste utilization, recycle, improved cleaning efficiency, better environmental condition eliminating. The toxicity improved product yield odourless mill better fibre properties

and improved unability. So, some of the challenges in the paper industry, because as I told you earlier also, there has been lot of the consumption of the paper, that is increasing. So, how to meet that requirement that is one of the big challenges that you can go through the slight the consumption which was there in 2004 and the future requirement.

(Refer Slide Time: 00:02:46)



(Refer Slide Time: 00:03:06)



So, these are the some of the shortcomings which we are having that is the poor infrastructure, too many administrative hurdles, poor to nonexistent commitment, high

cross of the normal method of financing. These are the problems rising cost of the inputs on chromic size an absolute technology many old methods still they are using.

So, these are of the some of the high cost of the production, poor productivity, poor instrumentation, low availability of the forest raw materials. So, these are the major challenges in case of the pulp and paper industry. In the next lecture will be discussing about the in more detail about the pulping and bleaching, what are the various methods, some of the, that might be just I have given the summary. But process steps involved in case of the pulping and bleaching for the, and conventional pulp for the news print, for the, your other papers that we will be discussing in detail.