Innovation, Business Models and Enterpreneurship

Dr. Rajat Agarwal
Department of Management Studies
Indian Institute of Technology, Roorkee

Lecture – 25
Technology Forecasting

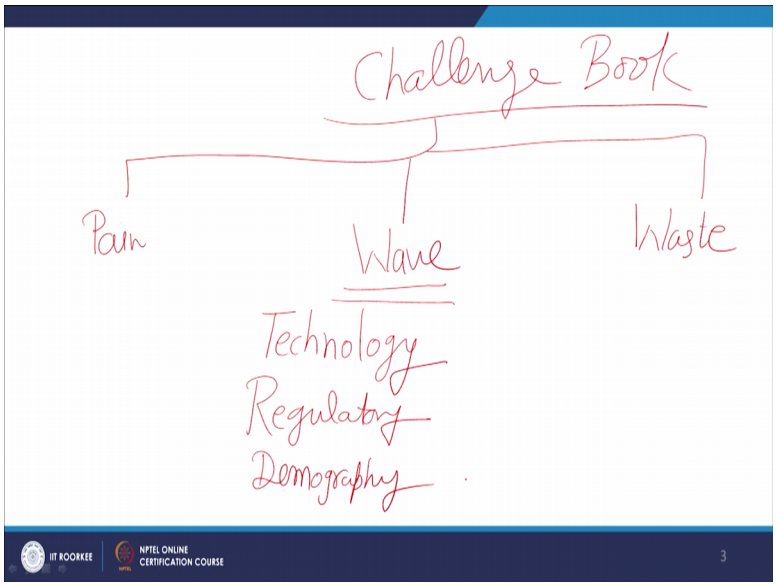
Welcome friends. So, in our last session we discussed various strategies which we can adopt for technology management.

Now, we saw that there are leaders in the technology innovations and then there are followers and then there are people who develop applications around that technology. And then there are people who not only use it for the commercial purpose, but also try to exploit the innovation or technology of other people by taking the license by going for the technology transfer or by following some other rule to exploit those innovations in their local markets. So, that is all up to us that what type of technology strategy we want to adopt.

But if we recall our very first or second session of this course, we discussed one particular issue related to idea management system. And in that idea management system we discussed that we need to see the wave see the wave was one important area of innovation, that is one important way to get ideas, that is one important way to get entries into your challenge book. We discussed about challenge book if you recall and I requested all of you to make challenge books.

Now, I expect that by this time you must have sufficient entries in your challenge book. And I request that you divide the entries in your challenge book if you have this challenge book or simply the diary if you are maintaining.

(Refer Slide Time: 02:25)



In that diary you classify your ideas whatever entries you are making into three categories. This we discuss in that session but just a quick recap of that, there are ideas which are coming because of pain, because of problems. You see problem surround you and those problems are important source of entries into your challenge book.

Then another important source of entries into your challenge book is the wave. You observe some patterns, you observe certain trends and those trends those futuristic thing that you feel that this thing will happen after 1 year, this thing will happen after 2 years, this thing will happen after 2 years. So, how you become capable how you develop your competency to exploit the benefit of those trends that is the wave.

And third is you see the waste. There are different types of waste around us waste of human resource, waste of energy, waste of natural resources; so, how to optimally used all those things that is another important source of entries in your diary in your challenge book.

So, in this particular session we are going to discuss this particular issue that is wave and in wave also we are particularly going to discuss the wave related to technology. You may have different types of waves, you may have waves related to regulatory systems, you may have waves related to demography, you may have waves related to other socio economic aspects political aspects consumer behavior aspects. But in this session we will limit our self to wave related to technology.

And as a start of has entrepreneurs, as future entrepreneurs, potential entrepreneurs we need to see that how to exploit the technology wave how to see how to visualize that what type of technology will be there. And then in our last session we have already discuss about the various a strategies related to technology innovation management, so how we will adjust our self, how we will develop the competence with respect to those future technologies.

Just to give you an example, that is why this technology fore casting for entrepreneurs is important. Like if I know that after 1 or 2 years there will be more and more use of electrical vehicles there will be more and more use of solar energy even in my day today house hold activities because there is lot of research which is going on in area of solar energy.

So, I understand or I forecast that we will have much better solutions for solar energy in your future. May be we may have materials building materials where they are directly giving you the benefit of solar energy. You need not to install a separate solar panel for that purpose your wall of the building can act as solar panel itself. So, these things are quiet possible.

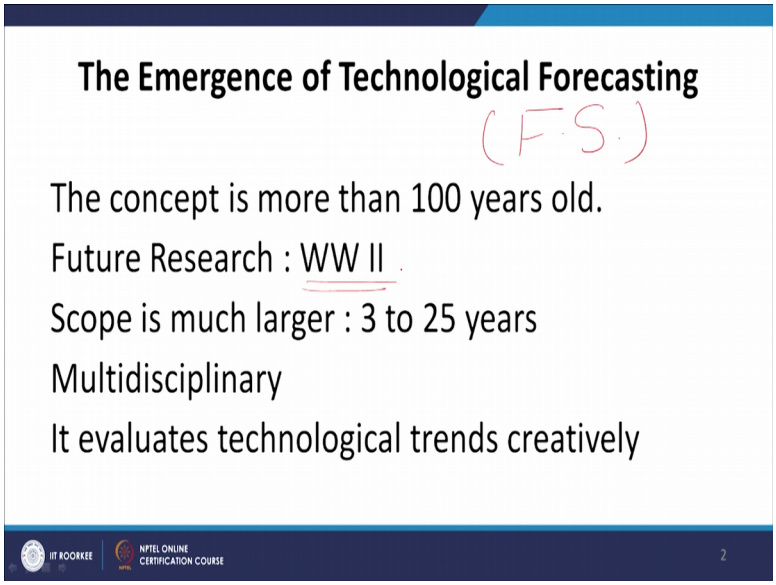
Now, if I am a thermal power company and in India we all know that the contribution of thermal power is very high in our overall energy requirement so obviously, my contribution is going to decrease. And the contribution of renewal energy in the fulfillment of the requirement will going to increase. And in that case what will happen to my heavy investments in plants machineries in developing those with thermal power plants.

Obviously, my plant note factor will going to decrease and you can check the data of companies like NTPC in India, where plant note factor used to be more than 90 percent and now, it is continuously decreasing. And it is touching somewhere around 60 percent at the present time.

So, it becomes a matter of deep concern for such companies which are technology intensive companies because of shift in technology and if you are not keeping space with that shift in technology you will be in trouble. Therefore, technology forecasting becomes very important for all those who are in technology saving companies, who are

in technology oriented company. And this session we will discuss some of the techniques popular methods for doing technology forecasting.

(Refer Slide Time: 08:57)



So, let us see what are the important methods of technology forecasting. So, now, if I talk of this concept of technology forecasting this concept is very old the concept of technology forecasting which is also known as future a studies this concept is also known as future studies. And in this future study concept because a literature you will find this future study word also interchangeably used for technology forecasting.

So, concept is very very old as I mentioned that it is more than 100 years old and the word future research became popular around second world war, and there were people who is started thinking that lot of development took place with various technology during the world wars and particularly in the second world war; So, after the war people a started extrapolating that these technologies can be applied in the business organization as well.

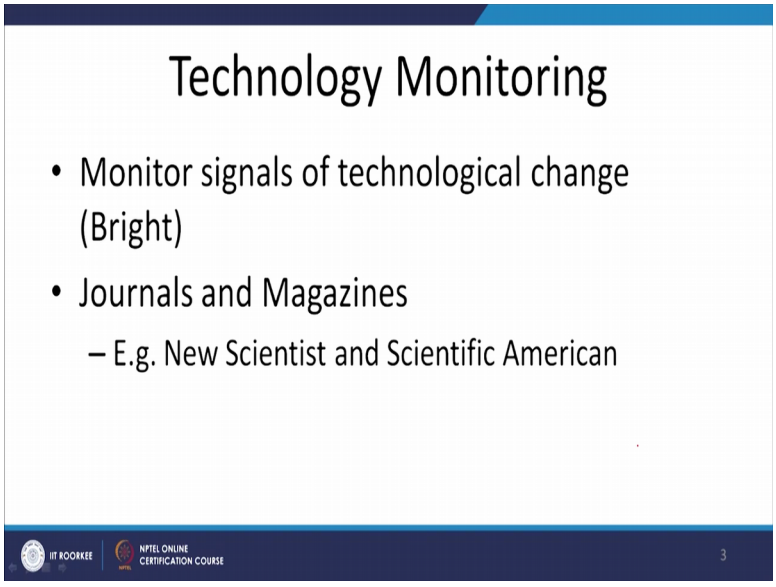
So, the concept became more popular after the second world war. And in this technology forecasting it is slightly different than the normal forecasting it demand forecasting which we are used to. If we go to our economics class, if we go to our operations management class we are used to have demand forecasting. And demand forecasting we do for 1 year, 2 year period, 1 month, 2 month, 3 month, 6 month, 10 months period or

even weeks also. But here the a scope is much larger it is from 3 to 25 years or even more.

So, the a scope of technology forecasting with respect to time horizon is really very very huge. And the demand forecasting where you have some kind of historical data and you just extrapolate that historical data and the assumption in that is all other factors are remaining constant as it is. So, therefore, you only extrapolate the previous data historical data to get the future demand, but in case of technology forecasting we are not depending on the historical data like that rather we consider technological environment, social like environment, political environment, economic environment. So, it is much multi disciplinary approach which we follow in technology forecasting.

So, you have socio, economy, technology, political inputs while we do the technological forecasting; and since it is not depending on one single factor so that type of extrapolation which we do in demand forecasting may not be applicable for technology forecasting. And therefore, we need to apply some kind of creativity. It require some creativity for technology forecasting it is not a mathematical activity it is mathematics and some creativity some qualitative factor. So, it is a combination of both the approaches where you use quantitative as well as your creative inputs for getting the forecast related to technology.

(Refer Slide Time: 12:54)



In the process of technology forecasting we also have one term which is close to technology forecasting that is technology monitoring. In our one of the previous sessions we discussed at a stages of technology innovation management given by Bright and in Bright's literature we also find the mention of this term technology monetary, where it is mentioned that you need to monitor signals of technological change. But, some signals you need to as we mentioned in our very first class that innovation a starts with curiosity.

So, you need to keep your ears eyes open so that you can observe those signals. The environment gives you single, but sometime we keep our eyes and ears closed. So, we are not able to sense those signals and we need to see what type of changes are happening. If the whole world is moving into the direction of green energy, if whole world is committing towards reduction in carbon emission. So, when we are seeing that the word is trying to reduce the carbon emission. So, we cannot think of a factory, we cannot think of a new enterprise which is using fossil fuel at this time.

If I install a new factory based on fossil fuel it is like complete ignorance. I am not leaving in the present word I do not know what is happening around me. So, I need to see the I need to very very careful about the technological changes and that is what technological monitoring all about.

And what are the sources for that purpose? How do I know what are the new signals coming? I need to have some sources only then nobody is going to come to me that Mister x these types of changes going to happen. I need to go to different places to monitor those signals and the best way the best way to monitor those signals is to go through various journals and magazines.

Journals and magazines are giving you the possibilities of future. The papers presented or papers authored by good academicians these papers give you signals about the future technologies. So, you need to have a collection of you need to have a data base of some of the selected journals of your field magazines of your field.

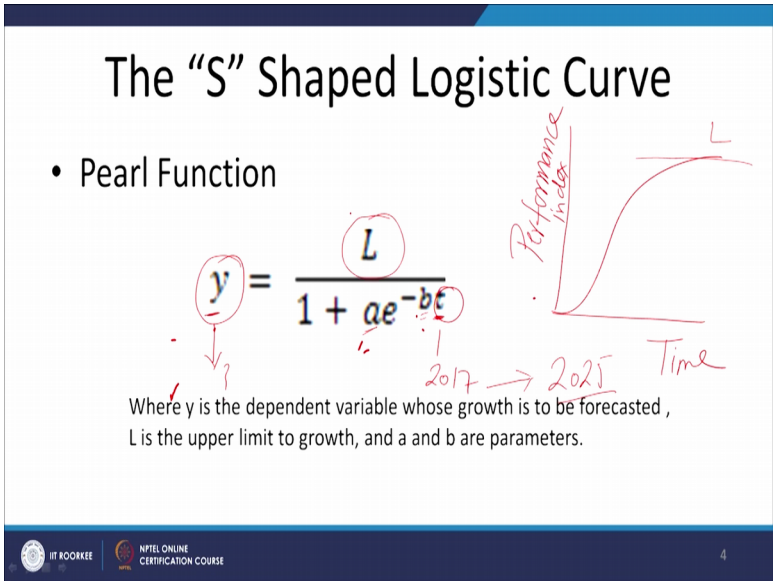
For an example, if I am into one North American company country, if I paper or if I article is first published in a popular science magazines known as new scientist and then it is published in scientific American. And if I can have a track of that if I can monitor this thing that this paper or this type of technology is published earlier a new scientist

and now, it is published in scientific American. So, I have this kind of sense that yes this is a future technology.

So, we need to continuously update we need to continuously, read, we need to read more and more to keep our self updated with the latest signals which are in the market. So, that is technology monitoring.

Now, let us talk some of the a specific forecasting tools which are there with respect to technology forecasting. We have already discussed about the S curve in our previous sessions and with respect to S curve we have this pearl function which can help us to some extend the on this x axis we have time and on this y axis we have performance index.

(Refer Slide Time: 17:21)



And now, with the help of this pearl function you have this y which is the dependent variable. And we need to forecast the growth of this dependent variable and this dependent variable is; obviously, the performance index and we are using a generic word performance index. But performance index can be anything performance index can be the efficiency of your lighting equipment that can be one performance index and that is the dependent variable.

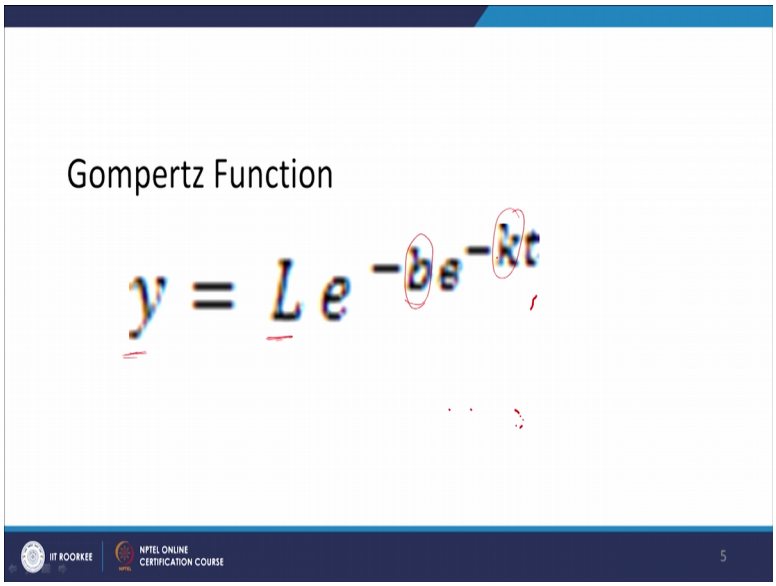
L is the upper limit of growth; Like this is L which we expect that this technology will go to that level. So, selecting an appropriate L value is also very very critical for forecasting

using this pearl function that what is the expected label of this. Because this pearl function is giving the value between y and t because t is the time, at what time what will be the performance index. And a and b are the parameters which you come to know with historical data.

And by doing the logistics arrangement if you both the logarithmic of function of this pearl function then it becomes a simple linear function also, but if you see. So, you need you can calculate the value of y at a particular time t. So, like for a particular product or category of product you know the present value in 2017 what is the value of this performance index. And when you know the values of a and b with the help of your historical data and if you substitute in place of 2017, 2025, then you can correspondingly calculate that what will be the performance index by 2025.

So, that is the simple way of calculating the performance index over a period of time that is, but the success of this pearl function depends on carefully selecting the value of upper limit of this performance index that is L. So, this is the L.

(Refer Slide Time: 20:30)

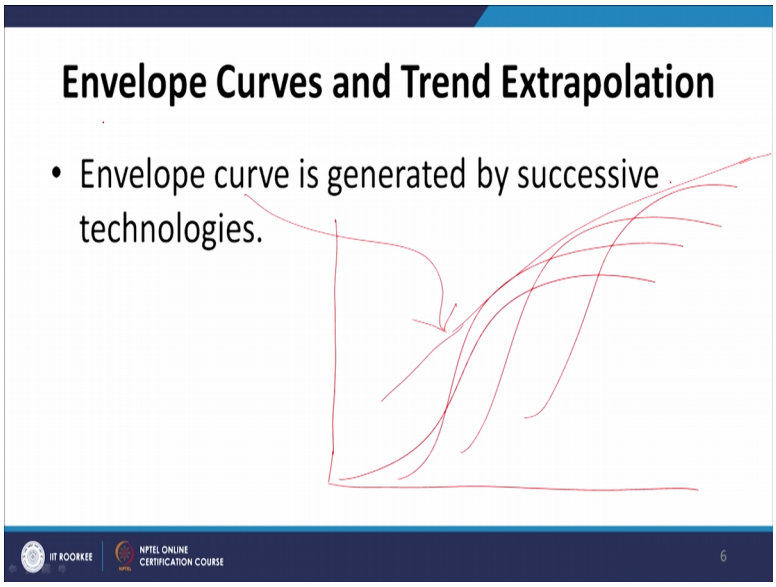


Similarly, there is one more function which is given by Gompertz. This is also based on the S curve, and in this also if you see you have y which is the dependent variable, L that is the upper limit as we discussed in the previous function pearl function. And in this case again you need to determine only to dependent two variable that is b and k and this also gives you value with respect to t.

So, this is another function where you if have values of fast performance at different times. With the help of those fast performance at different times you can evaluate the value of b and k and then with the help of the value of b and k you can determine the value of y for any future time.

So, these are two methods one is pearl function another is Gompertz function which can help us in determining the performance index at a particular given time.

(Refer Slide Time: 21:46)



Then we have another technology another method for determining the future technology or the a status of future technology that is the envelop curve and trend extrapolation. Now, the envelop curve is generated by successive technologies. This is also based on the concept of S curve. Now, as we discussed that S curve is like this and after some time your present technology is starts maturing and that it will decline.

So, what we do we keep on introducing new technologies successively and these type of curves keep coming; And as we discussed in one of the previous session that the successive technologies are superior technology. So, what we can do? You see that you can have a straight line which is like this and this is the envelope curve this is a straight line is the envelop curve.

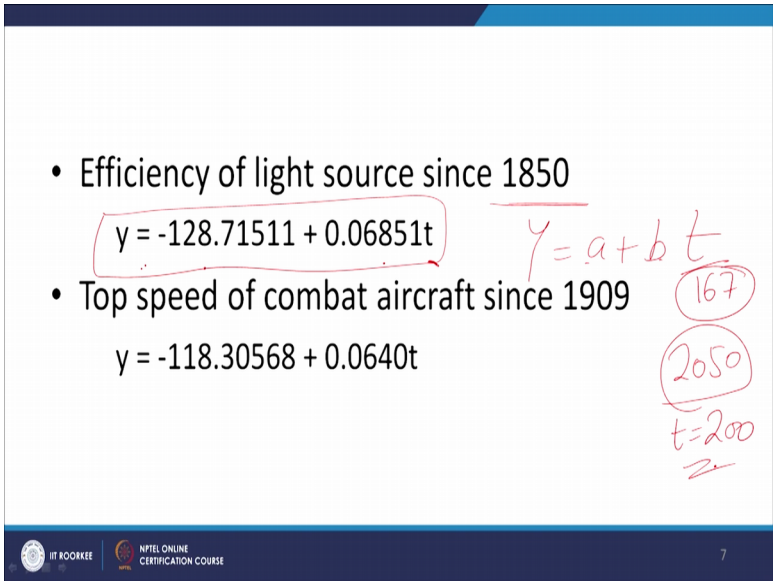
So, where you have different types of S curves and their peaks from where they are a started moving to maturity side. If you see that from where they are a started moving the

maturity site the that particular point if you are joining for different S curves that gives you the envelope curve,. And then if you extrapolate this envelop curve you will know what will be the performance index for a new technology at a given particular time.

So, this becomes a kind of regression line and if you extend this regression line then you will come to know that what will be the performance index of this particular technology or the set of technology. Or because these different S curves represent these different S curves represent micro radical innovations. These represents the generational improvements. So, if I go with very good trend analysis trend extrapolation we will come to know that what will be the performance index of this technology at a particular time.

Then there are certain equations which are given by some of the scientist for different types of important technologies; like we discussed in our earlier discussion about the pearl function which is given by this.

(Refer Slide Time: 24:52)



Now, people have given a specific functions for a specific technologies. Like for efficiency of light source after 1850 you have this type of equation where these you can say minus 128071511 and 0.06851 these are considered to be values of a and b.

So, if I say simply it is y equals to a plus bt. So, where t is the time so time you are calculating from 1850. So, if I am today in 2017. So, it is 100, say 167 years and the value of t is 167 here and a and b are here. So, I can calculate that what should be the

efficiency of light source in 2017 and if I want to calculate it in 2050 then the value of t is equals to 200. So, in 2050 what should be the efficiency of light source I can determine that.

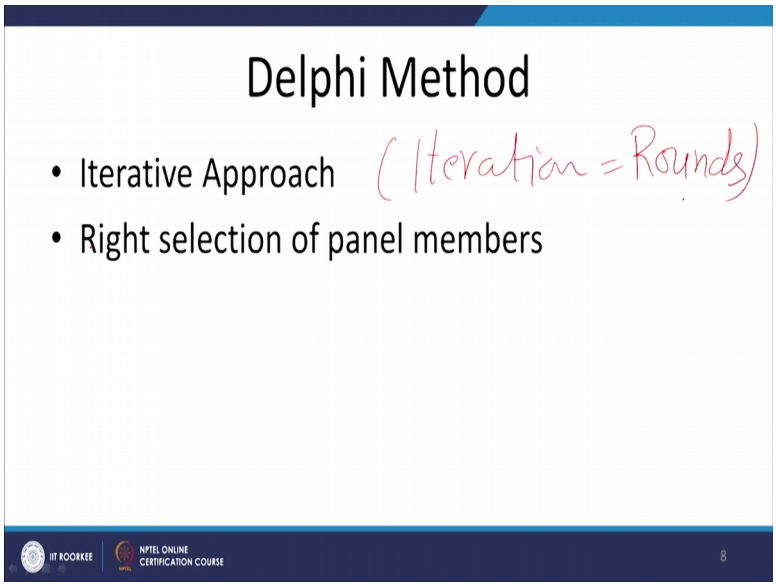
And why it is important? Because if I am doing some innovation and if I am not able to reach if figure closure to this value which I will get by putting 200 here in 2050. So, I should check my innovation, I should check my technology that where is the flow, why I am not reaching that label of forecasting which is expected at that time.

Similarly, the equation for top is speed of combat aircraft since 1909 is given by this equation y equals to minus 118.30568 plus 0.0640t. So, this is for the a military aircrafts bombing aircrafts this type of equation was suggested. And you will see that lot of development in real life has taken place based on these forecasting equation.

So, you can have this type of equation for a particular product, but it requires huge amount of data and only one the basis of that huge data you can develop this type of equations. As we discussed in the beginning of the session that it is very difficult for us to exactly quantify the technology forecasting.

So, qualitative methods are equally important in technology forecasting. And one of the important qualitative method which we can use and which is very popular and very simple also that is Delphi method.

(Refer Slide Time: 27:55)



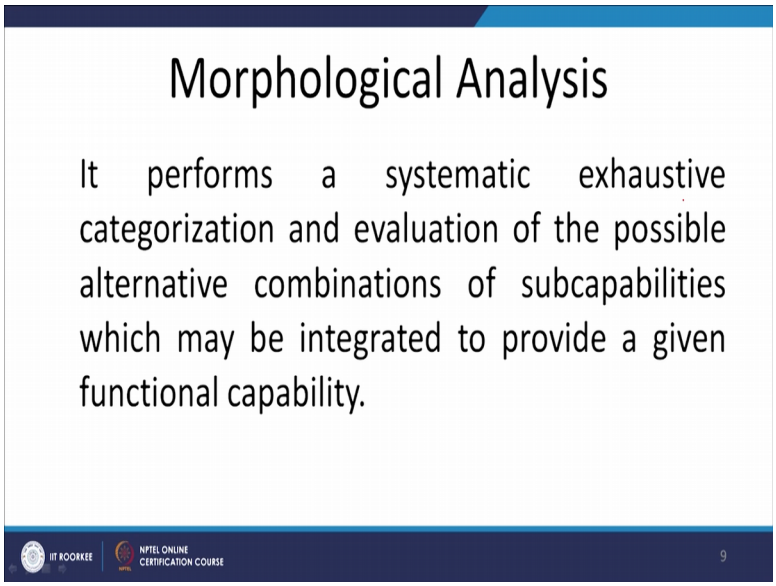
In Delphi method what we do, we invite some experts 4 5 6 7 experts we invite and these experts are the subject area experts, experts of that technology. And there is one moderator of that group and the moderator gives some very a specific questions to those experts. These experts give their opinion on the basis of questions ask to them.

Opinion means they give their forecast, then the moderator of the group combines the information provided by each expert and then ask again those experts to revise their original estimate in light of assumptions made by other experts of the group. So, they revise their original estimate and this process these rounds are repeated three or four times. Therefore, Delphi method is an iterative approach. Iterative means each iteration means each round iteration is equal to round here.

How many rounds moderator take to reach a concesses value where all members of the group, all experts of the group they agree almost on one particular value, they converge on a single phenomena single value that is the final of Delphi method. So, Delphi method is a very popular method of doing the forecasting because it requires long term assessment, and long term assessment may not be possible because all our earlier methods where we discuss equations and extrapolation. In that we are not able to take care of various different types of factors.

Here in Delphi because of the qualitative nature it is easy to take care of not only technological factor, but other socio economic factors also. So, therefore Delphi is a very popular method of technology forecasting.

(Refer Slide Time: 30:25)

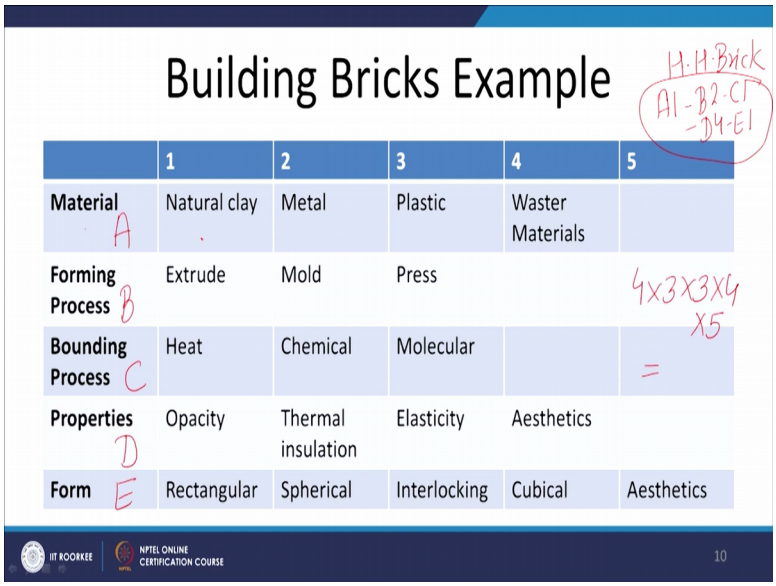


Then another pearl possible method of technology forecasting is morphological analysis. It is also very popular morphological analysis. And now, what we do in morphological analysis we perform a systematic exhaustive categorization and evaluation of the possible alternatives, alternative combinations of sub capabilities which may be integrated to provide a given functional capability.

So, each functional capability is divided into various sub capabilities, and for various sub capabilities we find that what are the possible technological alternatives. And then you can have different combinations of those alternatives for sub capabilities. So, that there will be large number of combinations there will be large number of combinations for our final solution for final output.

So, to have the understanding of this morphological analysis let us do one example. And this is a very popular example you will find this example in various bricks also that is the building bricks example.

(Refer Slide Time: 31:46)



Now, in this building bricks example the brick which we use for the construction purpose; Now, the capability of a brick we have divided into 5 different (Refer Time: 31:56), and these are material, the forming process, the bounding process, the properties, and the shape form of the brick.

Now, let us see what are the alternatives for these sub capabilities. If you see that this is sub capability A, this is sub capability B, this is sub capability C, this is D, and this is E.

Now, material can be natural clay, it can be metal, it can be plastic or it can be waste materials. The forming process can be exudation, it can be molding or it can be pressing. The bounding process can be through heating the chemical bounding can also be done or molecular bounding can also be done. Properties are related to capacity, thermal insulation, elasticity and aesthetics, these are the different types of properties which are possible. And the shape we need to we can have rectangular, a spherical, interlocking, cubical and aesthetics. All these are the different types of alternatives with respect to different sub capabilities.

Now, our normal house hold brick, the normal house hold brick which we use. So, if we see the normal house hold brick house hold brick. So, the combination which we are using material is natural clay A 1, the forming process is molding B 2 the bounding process is through heating C 1. Then the property is it is thermally insulated or elasticity or aesthetics let say it is thermally insulated not thermally insulated it is aesthetics. So,

property is D 4 and form is rectangular E 1. So, this becomes my house hold brick combination.

If I go for a furnace, so it again can be the same, but in case of D 4 it will be D 2. In case of a furnace I want use to bricks to develop a furnace. So, the alternative in D will not be D 4 rather it will be D 2. So, you can think of that how many different combinations we can have. You have 4 alternatives here, you have 3 alternatives here, you have 3 alternatives here, you have 4 alternatives here, and you have 5 alternatives for E.

So, these many alternatives are there, 4 into 3 into 3 into 4 into 5. Out of these many alternatives we have only tried 2 or 2 alternatives so far and there are possibilities that you can try many more alternatives. It is possible that we may move from natural clay to waste materials over a period of time.

So, even in our house hold bricks. So, in some cases it is happening you are using fly ash for developing the bricks. So, that is moving from A 1 to A 4, so that type of combinations are possible. So, morphological analysis which we have taken from the field of biology, but it is very much useful in technology forecasting also.

So, with this we come to end of this session and we saw the use of technology forecasting, some of the techniques of technology forecasting, and the important thing is that we need to understand that technology forecasting is much complex activity then the demand forecasting. It is multi disciplinary, it involves not only technological inputs, but it also involves socio economic inputs and therefore, techniques like Delphi or morphological analysis are more suitable then purely quantitative techniques of technology forecasting.

Thank you very much.