Manufacturing Strategy
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Module - 7
Lecture - 35
Flexible Manufacturing System

Welcome friends. Now, we are coming to end of week 7. So far, we discussed about various concepts related to manufacturing strategy. We also discussed about the development of manufacturing strategy. And in our last few sessions, we focused on what are the specific tools which can be used for the development of your manufacturing strategy, for the implementation of manufacturing strategy.

And during that, we discussed various critical success factors for world class manufacturing. And now, continuing in the same direction, today we are going to discuss flexible manufacturing systems. Because nowadays, as we have discussed many a times, we are moving towards a situation which is more heterogeneous. And therefore, there is a continuous pressure on manufacturing to adjust with this heterogeneity.

Markets are characterized by pressing requirements of the customers. And each customer requires a different type of product. So therefore, concepts like flexible manufacturing system are becoming unavoidable for achieving success through manufacturing. And there are many things which can give you flexibility. Flexibility means, our ability to adjust with the conditions. Now, when I am talking flexibility in terms of manufacturing system, there are 2 particular aspects.

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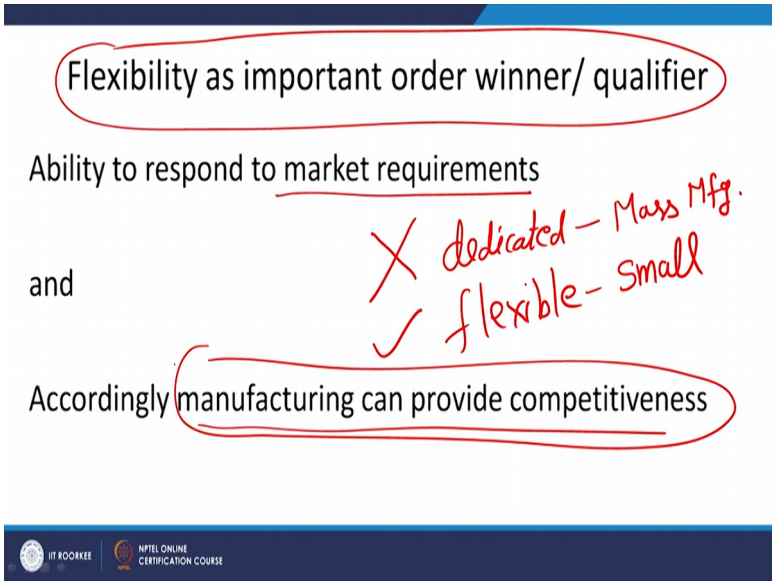

1 is ability to respond to market requirements. That how you are adjusting, how quickly you can respond to changing market requirements. So, that is 1 way of understanding the flexibility. And from the manufacturings point of view, that how manufacturing can preempt, how manufacturing can proactively understand the changing requirement. And accordingly, manufacturing can provide that competitiveness.

So therefore, if you remember our discussions of order winners and qualifiers, we can say that flexibility can be a very important order winner and qualifier. Few days back, we were discussing about quality as 1 of the center point in our world class manufacturing. But slowly and slowly, the focus is moving that quality is more or less becoming a qualifying criteria and flexibility is taking as a order winning criteria.

So now, how quickly you are able to understand the changing market requirements? And accordingly, you can adjust your marketing and manufacturing activities, so that you can quickly respond to those changing needs. So, that is the central theme in this idea of flexible manufacturing system. So, when I am talking of flexible manufacturing system, the very first thing we need to understand that you cannot have dedicated systems.

So, earlier, in our mass manufacturing era, we were having the dedicated systems. So, dedicated systems were the part of mass manufacturing. But, when I am talking of flexible manufacturing, these dedicated systems are not light. These dedicated systems are considered to be underutilized. And therefore, we want to have flexible systems, where we can produce smaller quantities.

So, volumes are becoming less and less in numbers and variety is increasing. So, to serve the purpose of more variety and less volume, we want to have flexible systems. So, that is why, nowadays, because of the heterogeneity, because of the each customer has unique requirements, we need more flexibility in our systems. And how we can design that flexible system; that is a key criteria for the manufacturing.

Now, when we specifically talk about how manufacturing can respond with flexibility to get an competitiveness, there are few terms. Because it is very difficult to define flexibility, because there can be a wide degree of flexibility. That your manufacturing system is more flexible, my manufacturing system is more flexible or some other companies manufacturing system is more flexible.

So, there can be a degree of flexibility which different manufacturing system can offer. So, it is very difficult for anybody to say that this particular manufacturing system is a flexible system and this is not. So, there can be a degree of flexibility. But whenever we talk of flexible manufacturing systems, there are few key terms which will always be there. Now, what are those key terms?

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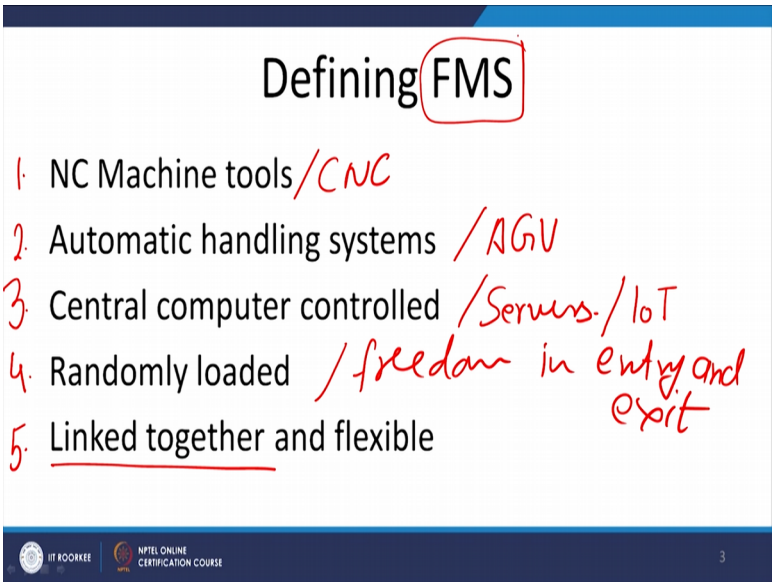

1 is numerically controlled machine tools. So, 1 important thing is that, you have those machines, those workstations which are numerically controlled. So, the worker controlled or the manual systems are being replaced by numerically controlled systems or you can say computerized numerically controlled systems. So, it is NC and CNC. So, these type of systems are 1 important element of your flexible manufacturing system.

So, whatever way you define, but CNCs and NC machines are important part of that flexible manufacturing systems. The second important thing is automated handling systems. Now, automated guided vehicles, AGVs are important things in all flexible manufacturing system. Because, different types of products may require different type of routing. And therefore, it is not possible for you to manually have that kind of routing system all the time.

So therefore, automated handling is required. And that is now quite popular in India also. You can see that, in many of the manufacturing facilities, we have automated guided vehicles, we have robots which are used for the handling purpose. Then, another important thing is centralized computer controlled. So, you have some servers in your manufacturing environment.

And these servers are used to control the entire manufacturing facility. They keep the data at a central location. And that central data can be used to control your entire system. And this is also becoming popular because of involvement of industry 4.0 or concepts like IOT with the things becoming more comfortable nowadays to implement this central control system, central command or you can say, the cloud computing is also becoming a part of flexible manufacturing system.

Then, fourth thing, randomly loaded. Earlier, in our conventional method of manufacturing, we have a particular entry point and a particular exit point. But nowadays, in this flexible manufacturing system environment, you can have random loading. Input can be provided to any of the intermediate machine. Any of the intermediate workstation can be loaded and products can be offloaded, products can take exit from any of the intermediate workstation.

So, there is no fixed entry and exit points. Rather, any of the workstation can act as entry and exit point. So, the random loading is also 1 of the key term in the flexible manufacturing system. So, freedom in entry and exit, that is the meaning of random loading. And we have the specific type of loop layout systems in which this random loading is possible. Then, another important thing is because of central computer control system.

You have networking in your manufacturing activities. All these different machines in the manufacturing environment are linked together and they have flexible scheduling systems.

So, that is how you are able to achieve the objectives set for flexible manufacturing system. So, these are some of the key terms.

In whatever way you can define it, but if I am talking of a flexible manufacturing system, you will have computer controlled machines, you have numerically controlled machines, you have some of the automated guided vehicles, you have a central data warehouse, you have electronic data interchange and machines can be loaded and off-loaded randomly from any of the intermediate points.

And all these machines are linked in a form of network. And you have flexibility in scheduling those machines. So, these are some of the key points. If you have all these things in a manufacturing environment, even if you do not say, but it is a flexible manufacturing system. So, that way, you can understand that these are the enabling things for the flexibility. That is the other way to put it in this way.

That if you have a computer, if you have more IT, you have more automation, you have sensors, you are having automated guided vehicles, it means, you are following the concepts of flexible manufacturing system. So, as we discussed that there are about 5 elements which are invariably present in any kind of flexible manufacturing environment. Or, as we discussed, that these 5 elements make my flexible manufacturing environment.

And based on this, you can summarize that any standard flexible manufacturing system has 3 important characteristics. And these 3 important characteristics are: 1 is about the work centers. So, all your work centers in a flexible manufacturing system are computerized controlled.

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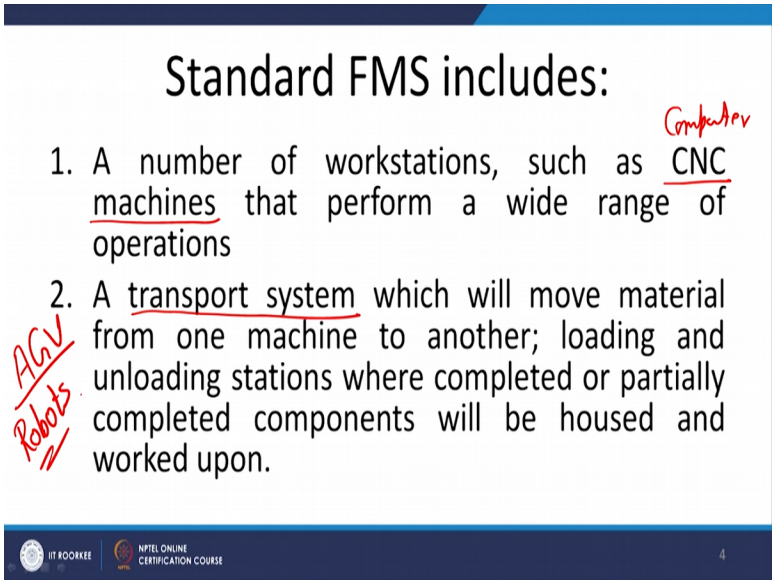

So, these are computerized numerically controlled machines which are becoming popular, now even in those environments also which are not completely flexible. So, earlier we used to have a engine lathe, turret lathe. And then, these engine lathe, turret lathes which are manually operated, gave space to numerically controlled machines. And now, because of attachment of computers to your various machine centers, we have computerized numerically controlled machine.

And you get more flexibility when computers are attached to your machining centers. Because, with the help of development in the computer added design, there are various types of softwares which are available. And these softwares give you the power to design a unique product. And a very simple example can be the 3D printing. Now, we have 3D printing. And with the help of 3D printing, you can make any individual object.

If you want to make a only 1 quantity of this pen, you can make 1 quantity of this type of pen. If you want to make 1 quantity of this type of pen, you can make 1 quantity of this pen. So, this type of power is available when computers are attached to your machining center. Earlier, we used to have numerically controlled machine, where we used to keep the profile of our product in the form of magnetic tapes.

So, whenever we want to make a second type of product of the earlier design; so, we can use the existing magnetic tape, we will feed our input in the form of that magnetic tape and you can get the desired product. But there is a limitation of keeping the magnetic tapes. They

require certain space and they require some kind of maintenance also. And wear and tear was also possible.

So, there was some limitation with respect to numerical controlled machines, because of the physical involvement. But computer controlled machines are more flexible. Because of better computing systems available day by day, you have more space, you get a more computing power and therefore you can respond in no time with new designs. So, that is 1 very important essential feature in any kind of flexible manufacturing systems.

The second important thing about flexible manufacturing system is the transport systems. Now, in a plant, we all know that our works, our product moves from 1 machine to another machine, from 1 machining center to another machining center. In the earlier periods, when we were having the mass manufacturing, assembly lines were there. And in assembly lines, many of you must have seen the conveyor belt systems, where objects used move from 1 place to another place in the conveyor belt.

And most of the organizations are having overhanging conveyor belts. So, objects are moving with the help of a overhanging conveyor belts. And workers are standing below those conveyor belts and doing the job whenever the work comes to their machining center. So, these conveyor belts were having a very fixed kind of a movement. And in the job shop type of environment, where we have a very less quantities and varieties are more; in that, we have the manual system of moment.

We used to have some kind of material handling equipments. And these worker driven material handling equipments take products from 1 machine center to another machining center. But in case of flexible manufacturing environment, these things are not going to serve our purpose. Because these things limit our flexibility. These things will not help us in providing wide amount of variety.

And therefore, AGVs and as popularly known, these AGVs are robots. Most of the time, automated guided vehicles are robots. So, these robots are involved in the manufacturing space, where they take products from 1 shop or 1 center to other shop or other center. So, like if you are going from fabrication to machining, from machining to finishing, from finishing

to printing, you have robots which is taking that product from all these shops or from all these machining centers.

So, AGVs are also another important essential feature for the flexible manufacturing systems. But you will find many organizations where CNCs are involved. But you will not find many organizations particularly in India, where AGVs are installed. Only in large organizations, AGVs are available. While CNCs are available even in small, medium type of organizations. But, it is more cost consuming when you involve AGVs.

So, you will see AGVs only in those organizations where you have a huge capital investments. So, that is a drawback in involvement of AGVs in the organizations. And the third important characteristic;

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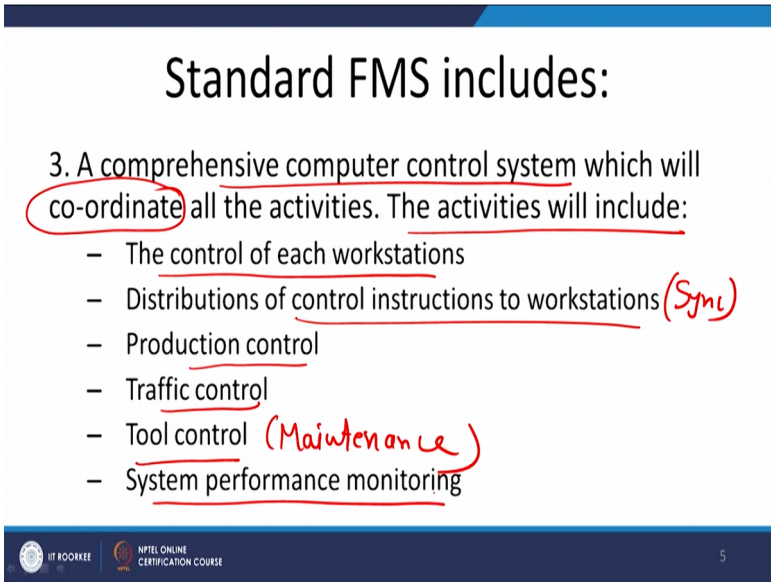

Third important element of any standard FMS is the comprehensive computer control system. Now, the meaning of comprehensive computer control system that you have a central command and that central command helps in coordinating all the manufacturing activities. If that central command is not there; so, different workstations, different machining centers may work independently.

And that may create lot of problems with respect to planning, with respect to underutilization of resources, with respect to more idle time and with respect to more queuing in front of some of the machining centers. So, there is a requirement of some kind of coordinated efforts. And that coordinated efforts is achieved with the help of a comprehensive central command

system. And nowadays, it is also possible that in a very advanced system, this comprehensive computer control system can be outsourced.

With the development of concepts like cloud computing, it is not necessary that you have this comprehensive computer control system within your own organization. Rather, you can outsource this activity. Because, this computer control system can be remotely controlled also. And it requires more technology. There are issues related to security of your systems. All those issues are there.

But there is a possibility that you can have outsourced computer control system. And things like cloud computing are helping us in doing so. And the activities which this central command system, the number of activities can be coordinated. And just few of them are listed here. That you can control different workstations which are there in your factory. So, there may be large number of workstations depending upon the investments you are doing.

And how to coordinate different workstations? How to schedule your objects on those different workstations? So, that is the first degree of coordination. So, that is possible when you have a a central command system. The second is distribution of control instructions to these workstations. So, to minimize the processing time, to increase your throughput; for this purpose, you need to have coordination between the instructions given to these different workstations.

So, you require some kind of coordination in the instructions given to these workstations. So, that is also possible with the help of; so, you can provide control instructions in sync with different workstations. So, that is also possible with a centralized system. The third important thing is, what is the rate of output you want? So, production control, the rate at which these workstations must produce output, so that you can have a very optimum level of inventory in your system.

If production control is not optimized, it will create excessive inventory in front of some workstations and some workstations may be in the situation of starvation. So, to avoid that type of imbalance, the production control rate has to be optimized. And almost all the workstations and the concepts like assembly line balancing can also be used for controlling the production output.

Then, traffic control, this is related about the movement of goods from 1 workstation to another workstation. So, if there is excessive movement, this will create more cost, this will consume more resources, this will consume more energy. So, you need to coordinate the traffic, so that there is no situation of traffic jam, there is no situation of queuing. And therefore, coordination is required between various workstations with respect to movement of goods.

And then, another important thing which is not normally taken into account. This is related to maintenance. Now, because of proper working you are expecting, because you want to have a rate of production from your workstations; so, you also need to make this point into mind that tools are available at the right time. So, availability of the tool, how you are ensuring that tools in properly maintained conditions are available to the workstation.

So, whenever a new tool is required, because 1 workstation may be doing 3, 4, 5, 6 operations; and for all these different operations, different types of tools are required. And when different types of tools are required, so you also need to ensure the availability of those tools. So, that is also an important activity which can be centrally controlled. And then, you also monitor the system performance.

So, what is the overall productivity of your system; that can also be coordinated. Because we are not interested in the productivity of individual workstations. In the traditional systems, most of the time workers were interested in the productivity of their machines. So, it was not a coordinated activity from the manufacturings point of view. But nowadays, when we are talking of flexible manufacturing system, we want to have a coordinated effort for improving the productivity of my entire organization.

So, this is the third important activity which can be coordinated. So, you can coordinate 3 important activities, working of workstations; the second is movement between the workstations and third is the tool availability of the workstation. So, these are the 3 important things which we are monitoring with the help of central command system. Now, when we have understand this type of a flexible manufacturing system, that what are the important elements of a flexible manufacturing system.

We also need to see that FMS is not suitable for all kind of conditions. There are certain prerequisites where FMS is more suitable. Now, the prerequisite is that, where variety is more and volume is low. So, that is the 1 important you can say guideline where you can understand that FMS is suitable.

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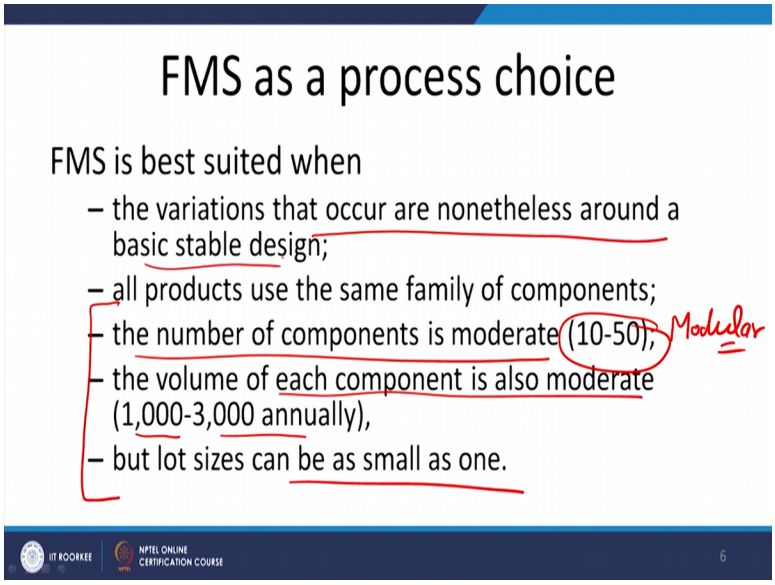

Now, when we say that 3 important things are there. And these 3 important things are there. That number of components to be made, that is 10 to 15. And between that, the components can be manufactured. And all these components can be used in different combinations to provide wide variety of output. And the volume of each component is also moderate between 1,000 to 3,000 per year.

And when you are making these components, 1 component you may require 1,000 in a year or 3,000 in a year. But at a particular time, it is not necessary that you are making all 1,000 or 3,000 in a single lot. In 1 particular lot, it can be only 1 component you are producing. So, you can produce individual component. That is the bottom line for the flexible manufacturing system.

You can provide wide variety of products by using these components and almost similar type of components. So, you can say that these are the modular kind of components. And by using these modular kind of components, you can produce wide variety of products. So, it is very important; when variations are high and you do not want any kind of standardization and volume is very low, only then FMS is a suitable thing.

If you are; so you can say that, from job shop to batch manufacturing, for those types of manufacturing environment, we can go for flexible manufacturing system. And if we are talking of assembly line, we are talking of continuous production, in that thing, FMS may not be a suitable option. Then, it is going to increase the cost without giving you any additional benefit, because variation is low in that case.

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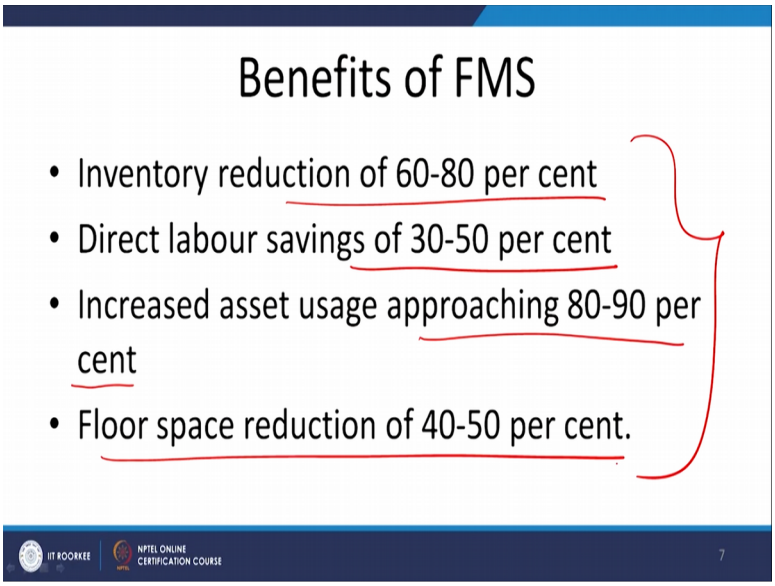

So, when some researches have happened and these researches mostly in American and European environment have identified the benefits of implementation of FMS. And as a result of that, is it was found that inventory has reduced significantly. Whether I talk of finished goods or we talk of work-in-process inventories, so there is a 60 to 80 percent reduction in the inventory.

And many a times, we have discussed that inventory is a cost to the organization. So, when we are reducing the inventory, it also means that we are able to reduce the cost. So, by reducing the inventory, you are able to reduce the cost of your final output. Then, there is a savings on direct labour cost also. Because of more automation and automation only requires capital investments; so therefore, the direct labour cost is saved up to 30 to 50 percent.

So, that is another important thing. And when you have a centralized command system which is coordinating various activities; so, with that, the asset uses, the machine uses or the transport equipment uses increased up to 80 to 90 percent. So, very high degree of asset utilization is possible by using flexible manufacturing system. So, this somehow can give you benefits related to economies of scale.

Though I should not use this economies of scale term when I am using FMS, because FMS is more towards a high degree of customization, low volumes. So, but because of computer controlled system, the asset utilization is very high. And therefore, cost of manufacturing may go down. And floor space requirement also reduces. Because of a flexible system you can produce same level of output with 40 to 50 percent of less space requirement.

So, that is another important thing. Because nowadays, space has become a very very expensive asset. And therefore, if you are able to achieve same level of output with less amount of space, it is something wonderful. So, these are the benefits. And you can see that, apart from providing the customized products, apart from achieving better customer satisfaction, you get benefit of FMS in various cost dimensions.

Whether it is higher utilization of assets, whether it is less space requirement, whether it is reduction in inventory levels, whether it is reduction in the direct labour cost. So, on 1 side, you are able to provide products which are as per the customer requirement; more suitable dimensions you can produce. And on the other side, you are saving the cost. So, you have this kind of win-win situation in FMS.

Now, when I am talking of flexibility, there are 2 types of flexibility as we discussed. That flexibility which market demands and flexibility which your manufacturing can provide. And we are more interested in flexibility which can provide competitiveness to my organization.

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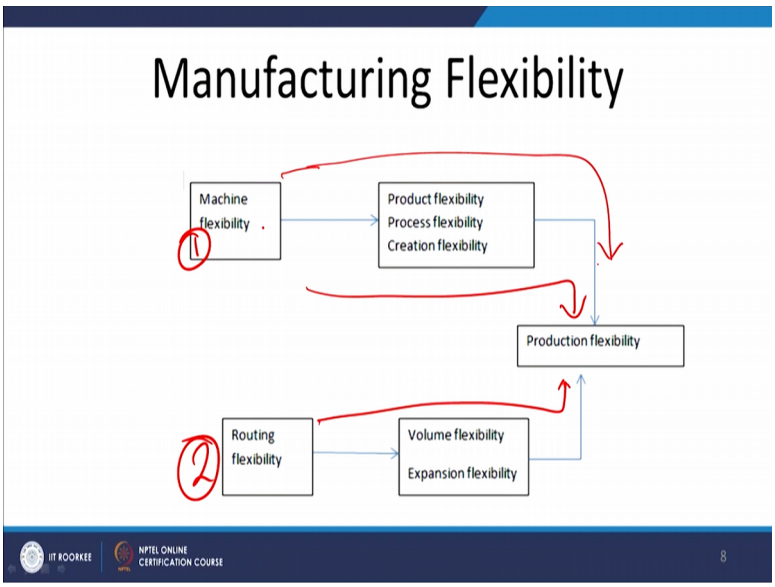

And these 2 types of flexibilities can come either from machine or from your scheduling or routing activities. And you see that, whether it is a machine flexibility, it is also reaching to the production level flexibility. And whether it is a routing flexibility, it is also reaching to the production facility. So, you have, when machine flexibility is discussed, you have product, process, creation flexibilities. And when routing flexibility is discussed, you have volume flexibility and expansion flexibility.

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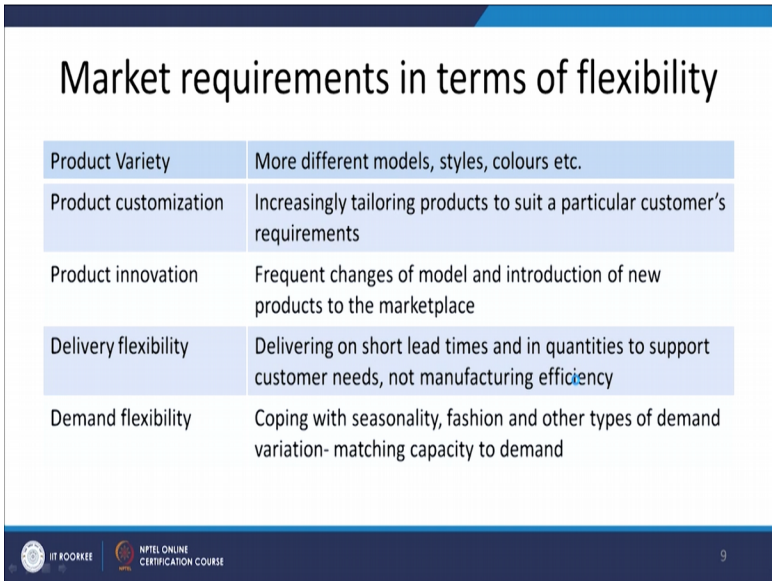

And when I am seeing this in light of market requirements; so, you see that, market require flexibility in terms of product variety, in terms of product customization which is almost similar; that more variety, more customization as per the requirement of individual customer. We require from the market's point of view, more innovative products. We require different flexibility in the delivery times also.

Customers may expect delivery at a particular moment only. And that is delivery flexibility and demand flexibility. The amount of orders which are placed to the company, that also have different quantities. So, these are the different dimensions in which you can consider the market flexibility. And when I am talking of flexible manufacturing system, we need to convert these market dimensions into our manufacturing facility.

So, some of the facilities will come flexibilities will come from the machine route and remaining may come from the, like last 2, the, how your demand flexibility, how your delivery flexibility can be achieved. So, these are possible through your routing flexibilities. So, you see that, we need to have a kind of compatibility between market flexibility and

manufacturing flexibility. And with that, we can achieve the objective if we are able to merge these 2 types of flexibilities.

Then probably, we can achieve the objectives of world class manufacturing. Then, if I see the characteristics of a successful flexible manufacturing system; so, you, as we just discussed the benefits of FMS, 1 important dimension is that machine utilization.

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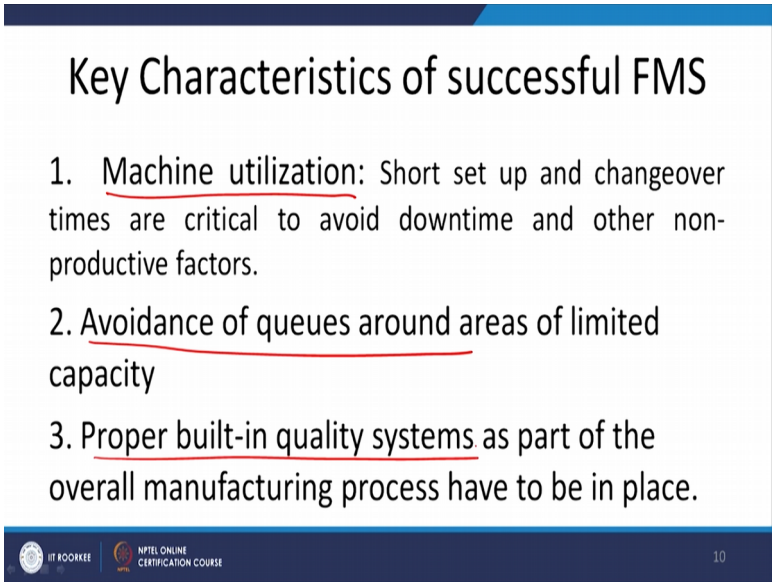

So, your machine utilization must go to a higher level. Whatever conventional level of machine utilization is there, if you are able to improve that, means you are having a successful FMS. Then, second thing is, you are able to avoid unnecessary queue in front of some machining centers. So, if you are having machine centers where you get products just in time, that is another success criteria of FMS.

And then, you have a proper built-in quality systems, where you can minimize the requirement of inspection, your process capability. Because you are doing so much for automation. The whole idea of FMS is centered around automation. So, when I am going for higher degree of automation, I expect that my process capability must improve. And I should have less (()) (32:58) requirement of inspection.

So, these are the 3 important characteristics which says that I have successfully implemented by flexible manufacturing system. So, with this, we have discussed various criteria enabling factors, what are the important requirements of flexible manufacturing system, how can you track whether the FMS is doing the justice with your organization or not and in which

particular situation FMS is suitable and where FMS is not suitable. So, with this, we come to end of this session. Thank you very much.