Sustainability Through Green Manufacturing System: An Applied Approach

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Lecture – 03
Sustainability and Manufacturing

Good afternoon everyone, welcome to the third lecture on sustainable manufacturing, we actually had a long lecture which is broken down into 2 earlier, today we will be doing third lecture which is basically on sustainability and manufacturing and I am Doctor Deepu Philip, I am from IIT, Kanpur.

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So, today's agenda; we are going to talk about is understand the concepts of sustainability and what are the factors or the drivers that drive sustainability in an organization and the major aims that are used in manufacturing and; obviously, the viewpoints how does the hierarchical view point is typically used in doing sustainability analysis.

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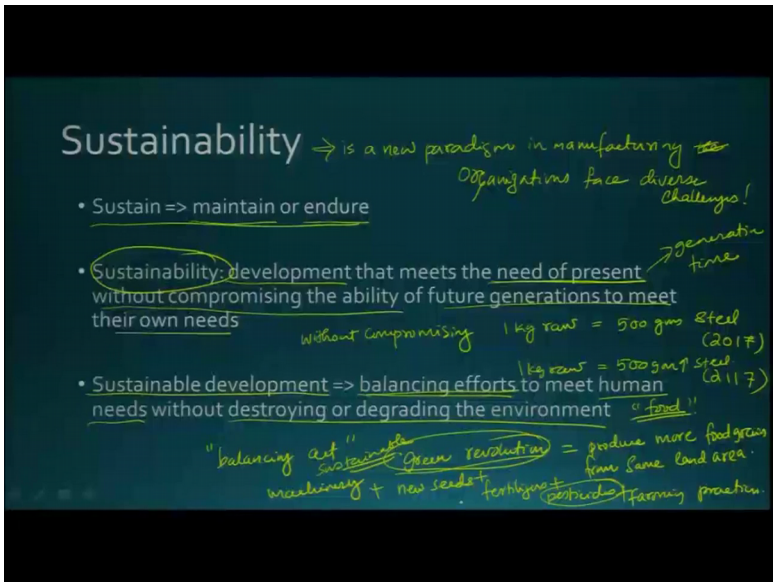

These concepts; this term sustainability is an important time for us because you want to understand how this time has come in and these are the drivers or in other ways what are the factors that drives sustainability in an organizations and we will see some of the factors are like positively influencing or what we call as rewarding kind of a factors and other once are actually what we call as punitive or regulatory factors in another way to think about it. So, will see the details of this then we also talk about what are the major aims and that is important to understand that and the view point how do we hierarchically analyze a system.

Sustainability; obviously, everybody heard about this word sustainability and the major aspect of sustainability is that the first most important thing is sustain means it is to maintain or endure. So, sustainability for that matter is a new paradigm in manufacturing the concept of sustainability has been there for a long time, but a new paradigm in manufacturing. This concept are been therefore, some time and the reason the reason why this is a new paradigm is purely because of the fact that organizations face diverse challenges and one of the challenge is sustain their operations, sustain that business or maintain the business or end let the business be endurable.

When we talk about sustainability is a development that meets the need of the present, when we say the need of the present means it can be the present generation or it can be the present time; however, you look at it the need of the present without compromising

the ability of future generation to meet their own needs. So, you are allowed to meet the need of the present the present generation or present time without compromising this is the most important phrase without compromising the ability of the future generations to meet their needs.

So, in a way that if you are able to make let say we will take about this you have 1 kilogram of raw material from which you can make 500 grams of steel today present, in the future generation let say this happens in 2017, in 2117, 100 years from down air. Now they should still be able to make this 1 kilogram of raw material they should be able to make 500 or more or more of steel, they should be able to do that. So, that is an important thing the future generation should also be able to meet their needs that is what the design or the word sustainability is defined.

If you talk about sustainability in manufacturing then we talk about it is the ability of the present you can change the definition ability of the present to produce whatever it they want to meet the demand without compromising the capability of the future generation to produce whatever they want to meet the demands. When people talk about sustainable development lot of the time sustainability has been more people use to say, it as a sustainability is like an environmental initiative it is nothing to do with manufacturing, but when we talk about sustainable development it is actually balancing effort or people call it as a balancing act or a balancing effort to meet human needs without destroying your degrading the environment.

A classic example of this is when we talked about green revolution green revolution to a large extent was a developmental initiative where your aim was to produce more food grains from same land area. So, for green revolution the major inputs where new seeds, fertilizers, pesticides, new farming practices, machinery, etcetera these were all the big things. Machinery, new seeds, fertilizers, pesticides, farming practices everything put together resolved in something called as a green revolution, but later down the road people realized yes you are able to produce more food grains, but in the same process you are also degrading the environment.

You are started using pesticides that are organophosphates, organosulfides which had long lasting adversarial effects on not just human beings or other life forms the extensive use of ddt everybody has studied that how it has reduced the as in adversely impact the

population of certain birds and stuff like that. That type of a revolution which actually produced more food grains, but at the same time harming the environment was not really a sustainable development; it was a development, but not a sustainable development.

Now people talk about something called as sustainable green revolution which means you are basically doing the you know you are trying you are having efforts to meet the human needs. The human need in a green revolution is food having food, that need you are trying to meet, but at the same time you are not trying to destroy your degrade the quality of the environment, that is any sustainable development. If you say I am doing sustainable manufacturing then you are manufacturing the things to meet the needs of a human beings without hampering or without harming the environment.

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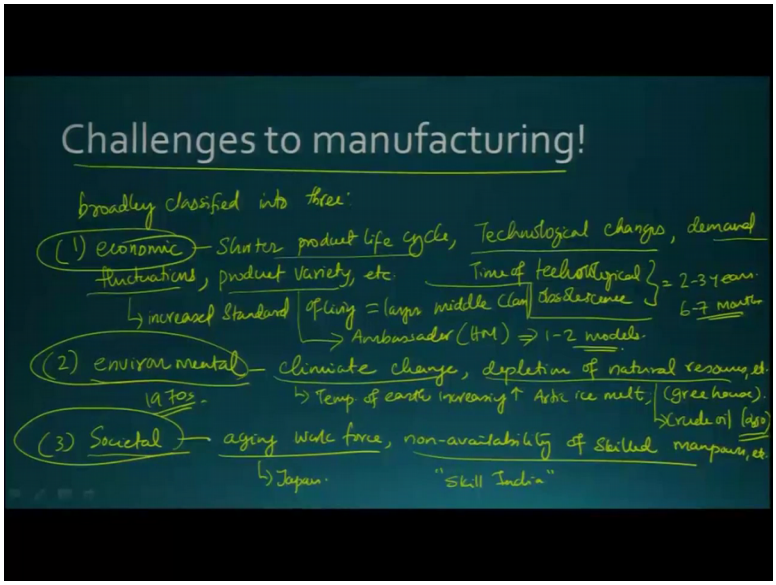

When we talk about the sustainability and the as I said earlier manufacturing organizations they do face a lot of challenges, broadly these challenges can be broadly classified into 3, number 1, they can be economic there where Economic challenges typically like shorter products like product life cycle, then technological changes, we can think about it as demand fluctuations, we can also think about product variety etcetera. If you look into this scenario the economic stuff shorter product life cycle is an important factor that we all need to look into.

So, earlier days if you look into it let us take an automotive a car a model of a car, we take in the earlier days like in sequence 60, 70's and 80's, a product a car that was

designed by a company like a Mercedes s class that is w 2 10 or something like that was designed. It typically usually that life cycle of the product use to be 10 to 15 years, it definitely over shorter decade, the product had a long life cycle you built you model built a car use to be in sale for 15 years or 10 to 15 years.

If you look at the current 2015 or 2017 car manufacturers their life cycle of models are not any more than like 5 to 6 years by the time you come up with a new model you are basically like this model is outdated. It is very few vehicles at this point how longer product life cycle, earlier days; it was the same thing with mobile phones if you look at the Motorola sap track that model which is a flip phone mobile phone which lasted quite about 8 - 10 years, now any other mobile phones are produced then have their long of a life cycle. The product life cycle becoming short literally means that the manufacturing organizations are forced to bring up with new products to meet the competition quickly.

That means, you are also what happened to the all the product then do you cannot consume them you basically throw them away, it also adversely impacts the environment. Technological changes is another example; earlier in the example; in the mobile technology, the earlier days time of technological obsolescence, it used to be in mobile technology used to be 2 to 3 years, now it has come down to what you call as 6 to 7 months. So, when the technology changes so rapidly you want to change you want to bring new products that imbibe these technological changes.

Demand fluctuations another example as the ask people used to say in India every time I pay revision comes into picture more and more people move into the middle class or upper middle class. The standard of living, increased standard of living contributes to larger middle class in earlier days for example, people talk about air conditioner in earlier days air conditioner used to be a luxury and now a day it has become a necessity for many people. This is an example of how demand fluctuates in earlier days, demand for air conditioners in India was very very small. Now during the summer season the air condition demand goes through the roof because more people can afford air conditioner.

Similarly, variety of the product everybody in this case if you remember the product called I am talking about this as Ambassador car again manufactured by Hindustan Motors if you look at it they had 1 or 2 models they following the old tradition if you building a car maybe one maximum 2 models are sufficient. Now you look at any of the

new manufacturers they have like lx, gx, vx, dx, g all alphabets in the English letters are used for naming the models. So, larger product variety is also required some peoples says I want power window, some people says I want all airbags, some people says I want all leather seats, this particular color, depending upon the features and creature comfort that is added into the system, the variety of the product also changes. All these challenges these are typically economic in nature or what happens is these are basically driven by the economics of the system.

The second we can talk about is the Environmental challenges what do we mean by the environmental challenges one example is the climate change, we can talk about as the depletion of natural resources etcetera. When we talk about climate change everybody hears about this right that the temperature of earth is increasing and in that process the artic ice will melt, flood all those kind of things which in a way we called as greenhouse effect on those kind of stuff or pollution when we are many ways people talk about this. Then similarly we say there is a depletion of natural resources like crude oil, people say that until 2050 the crude oil reserve of the world will be over something like that.

The environmental challenge is also another aspect that is been first into the manufacturing. So, earlier people use to like in an example is in 1917 in this regard in 1917s, if you look at the history of united states you can find that up to that point united states used to drive gas cars that were not fuel efficient because gasoline was very cheap and then all of a sudden the price of gasoline increased and they because of the scarcity and other all other kind of things and guess what people started looking into cars that have better mileage.

Then you were like I want to drive a car that will actually consume less amount of gasoline or petrol, so that or increased mileage per liter of petrol that I use in the car. So, that my petrol consumption reduces my money is saved, by doing that what is happened is the reserve of the depletion of the crude oil as reduced the rate at which it has been depleted got reduced. If the cars were not fuel efficient we would there would have been no crude oil available or no petrol available for the vehicles to move around, these kind of challenges are also faced by the manufacturing systems.

Then come to the third challenge which we call as a societal challenge some example of this is aging work force you also call as you can also think about as non availability of

skilled manpower etcetera. A classical example of the aging work force is if we think about the country called Japan the work force is really really aging you will see people who are 70, 80 and all working still continued to work because that is not sufficiently available manpower to do the work, that is one thing. Another is the non availability of skilled manpower, you might be able to get manpower, but you might not be able to get the skilled manpower. When you talk about initiatives like skill India and all this is like the aim of creating is great man power with the skill that is necessary to be part of the society or be part of the manufacturing, production, services processes.

These challenges these different challenges societal, the environmental, the economic these challenges all 3 put together put different type of stresses or requirements or needs for the manufacturing organizations and these challenges in some sense contribute to or force the manufacturing systems to be more focusing towards sustainable development where they would be looking at how do we conserve the resources what we have how do we do manufacturing without compromising the capability of the future generations, etcetera.

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So, in thinking this lines, we can next get into the concept of what are the factors or what are the drivers the drive the concept of sustainability in a system called manufacturing. Typically the old school the traditional manufacturing if you think about is traditional

manufacturing had major you know the 3 major factors you can think about it as cost, time and quality.

Talk about cost I mean quality as a traditional manufacturing thing where is the modern manufacturing thing what we talk about it is the you know to this we are the environment driven objectives then we get what we call as sustainable manufacturing. The major drivers of it I would classify the drivers of it into 5 categories, we will try to look into what these 5 categories are. The number 1 we call it as the Market factors or market drivers the market drivers include customer requirements, then demand changes, then there is cost increase, we will see what all these factors later down the road resource depletion, etcetera.

The second set of drivers we can call it as the Technology drivers what are those drivers they will be efficient processes, then new manufacturing philosophy, we can think about it as 3 D printing is an example we will talk about this later. Then we talk about Societal drivers which are global warming these are some examples or representative things about it corporate image, then NGOs, etcetera, we will look into each one of them after we list all of them down. The fourth one we can call it as Regulative factors or regulative drivers regulative drivers these include like things like emission, norms, energy limits, then carbon credits, then we have is government initiatives, research funding, penalties, etcetera.

And then the fifth one we talk about it is the Vision or Visionary drivers this is like self commitment, then we also have something called as corporate image etcetera. If you look into this scenario the 5 categories the market drivers as said earlier any manufacturing from the aim is that you have a transformation process, you have raw materials coming from one side and you have a transformation process and then you get the products outside. These products need to be sold in the market to generate more money so that you can sustain this process this is where the money comes into picture. So, when you have a system like that the market drivers, this market, this economy is the one that is very powerful and can actually make the manufacturing system accomplished things as required.

Some of them will be customer requirements like a classical example of the changing customer requirements is a company call Tesla, who makes electric cars. In earlier days

there are so, many companies who was succumbed at making electric cars and nothing survived very well because people who were like it was inconvenient, but now when you look at the car like Tesla, models or whatever you see around and when the charging stations are available and stuff like that people started moving more towards the electric systems same is with the e rickshaws electric rickshaws across the country and different major cities uses e rickshaws because there is charging and battery availability. Similarly the changes in demand earlier people use to buy big cars so, but now if you go to Europe in many places people are moving towards compact cars, the change in the demand of compact cars all of a sudden increased rapidly.

The another one is cost increase another example is the how the parking space or parking fees increases or the cost of maintaining a car like if you go to Singapore or big cities like that you will actually find that people tend to use more public transport system rather than maintaining a car because the cost maintaining a car is extremely large resource depletion is another example where if you are keep on consuming the iron ore at some point of time the iron ore is not available from the earth then you will have problem making steel, you should be very careful about that part as well. These kind of market both the raw material and as well as a finished good markets to a large extent do drive the need of sustainability into the manufacturing system. The market drivers are one a one factor that actually force the hands of manufacturing organizations to be conscious about the environmental objectives.

Second factor that we talked about which is a technological drivers those are actual those are outcome of the modernization technology or the modern processes that dark coming out of it. So, one example is that when we are able to develop efficient processes or like efficient machines the classic example of this is CNC machines; Computer Numerical Control machines. These machines are way much more efficient in a manufacturing a part depending upon the drawing that you are given or what we can think about it as FMS flexible manufacturing systems is another example of an efficient process where the entire manufacturing process is being made much more efficient than words normally in the conventional way.

Then there is another example of this is the new manufacturing process or 3 D printing or what we call is additive manufacturing because classical manufacturing you take a raw material and use different machining processes like turning, drilling, grinding, all

those kind of things milling those kind of things where you are basically focusing on removing the material and then getting the finished product.

Whereas in 3 d printing it is more following the natures approach the environmentally conscious approach of your adding the material to get the final product. The wastage the aim of the additive manufacturing is more to minimize the waste because in any other manufacturing process whenever you are doing drilling, milling or something the metal parts or the scrap that we call about or we actually the cut bits or that comes out of it or the metal shavings that comes out of it is actually a waste which need to be disposed, whereas, in additive manufacturing that kind of a problem can be sorted out.

Then come is societal drivers classic example of this is there are quite a lot of thought process is that goes about one is the global warming everybody talks about global warming everybody says that the ice is going to melt and it is going to increase the sea level and the whole world will be sum merged under water and the climate studies experts have been talking about the adverse effect of greenhouse gases carbon dioxide on increasing the temperature of the earth.

Everybody knows about that same way it is corporate image like for example, when we talk about certain public sector companies people might say oh these guys are certain big polluting company where as some people when we talk about a certain other companies they will have a very good positive like there environmentally supportive in nature they produce that do a lot of environmental stuff. Then there are NGOs, NGOs is nongovernmental organizations they are nonprofit organizations classic example of it is green peace and all kinds of things who actually work try to increase awareness against organizations that do not do environmental protection or they are not being conscious about environmental impacts of what they are doing. So, these are the factors from the social side of the societal aspects that actually driver force the manufacturing organizations to consider the environmentally driven objective as well.

Then the some of these as I said earlier like for example, the corporate image and those kind of things these are incentive kind of things like for example, Johnson and Johnson we will probably discuss the case some point of time the how they became one of the most loved company or a people concern that as a sustainable organization those kind of stuff, we will see that at some point of time.

Then we study about regulatory drivers, regulatory drivers are kind of basically can think about the mar some of the mar lot of the mar print even nature or if you violate them then you get punished, like for example, is emission norms. In vehicles when the government came with the Bharat stage 4 emission norms the when they it was simply murid on the trucks or commercial vehicles many of the manufacturers in India were caught at a tough situation where they could not even actually sell a product because they none of the trucks were actually being you know ready for the Bharat stage 4 emission norms.

So, and if you sell a truck which does not meet the emission norms, then you will your truck will or your vehicle will be confiscated and you would be fined and those kind of things, there is legal aspects that goes along with it. Similarly other things is about energy limits we can all says is water limits like for example, the amount of water is limited in major cities for 130 liters a day similarly energy can also be limited by the you can consume at the max of this many units day or a week or whatever it is.

Similarly carbon credits is another initiative there is happen this is not a primitive thing this is actually more of a rewarding initiative like if you enter producing your carbon credits or if you reduce the carbon dioxide emissions from your facility then; obviously, you can use that reduced quantity to gain subsidy on things and this was initiative that is put by the government which is not of a regulatory in nature, but it is more of a rewarding in nature.

Then there are other government initiatives like Swachh Bharat Abhiyan is another example where you would like to may say that the development of the country should also focus on environmental aspects of it that is another thing. Then there is about research funding like for example, there could be schemes the like national science foundation schemes says fine if your organization is working on environmental initiatives which will actually minimize the impact of climate change then there is additional research funding available for that. Those kind of research funding might even drive the drive the organizations towards achieving sustainability then and penalties like in the organization finds is found that if you are dumping pollutants into the atmosphere or the gland or water bodies, something like that.

Then the pollution control board like an example is the pollution control board who actually find out whether you are feel whether you are being conscious about the

environmental impacts if you are not conscious then fine is taken away like classic example of this is the Volkswagen group who has been fined by the various bodies in the world for cheating the emission norms, this kind of things are example. Then the fifth one is the visionary drivers visionary drivers is more like the vision that is related to the organization or is the leadership of the organization who drives this.

So, to a large extent there are certain organizations who are self committed we are like we will to like textualized in example, they are committed towards the cause of minimizing pollution due to the fossil fuels. They focus toward lot towards building electric vehicles, then similarly the corporate image certain times the corporations are worried about the corporate image how people perceive the company and depending upon how they perceive the company the people might be interested in buying the product or not. So, these kind of visionary how you envision yourself how the top management of the organization is interested in following these or championing the environmental objective, environment focused objectives along with the traditional cause time and quality objectives. The manufacturing that is the point at which the typical tradition manufacturing becomes or most towards becoming sustainable manufacturing.

We are still talking sustainable manufacturing and in between you might be worried or you might be thinking when where did this green manufacturing comes into picture a green is a one aspect where you are actually talking about minimizing the energy consumption or you are also focusing more towards using renewable energy sources and those kind of stuff.

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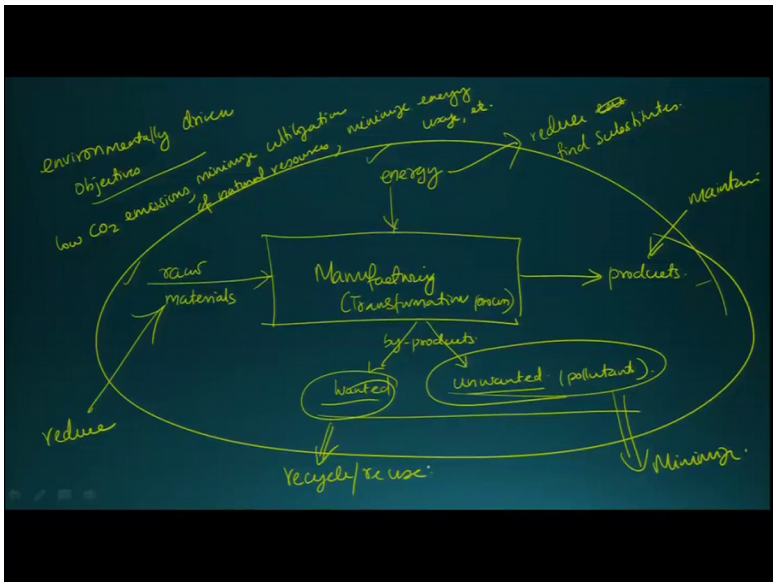

Now, one other they I would like to talk about this is we all we can think about a system diagram in which you have a manufacturing which is also a transformation process and what are we doing in this transformation process we get raw materials from one side and these raw materials along with energy you utilize energy and you create products the case of manufacturing case of otherwise it is services and from here you also create what we call as by products.

Some of them can be wanted by products, some can be unwanted by products, unwanted you can call it as pollution pollutants and stuff like that. So, this is the typical manufacturing system in which you take raw materials energy to produce the products in the same way you create by products. One aspect of this is the when we talk about this the environmental or environmentally driven objectives these objectives include low CO2 emissions, minimize utilization of natural resources, minimize energy, usage, etcetera.

These environmentally driven objectives when added to the manufacturing system together, where you are basically saying that I want to reduce the unwanted emissions, I want to minimize them, I want to reduce raw materials, I want to maintain the same products or production, I want to reduce energy or find substitutes. So, wanted raw materials will say re cycle slash re use all these kind of things put together move towards make you move towards sustainable or green manufacturing when we talk about. In this

course we will use the term sustainable and green manufacturing in an interchangeable format because it is necessary for us to understand it that way.

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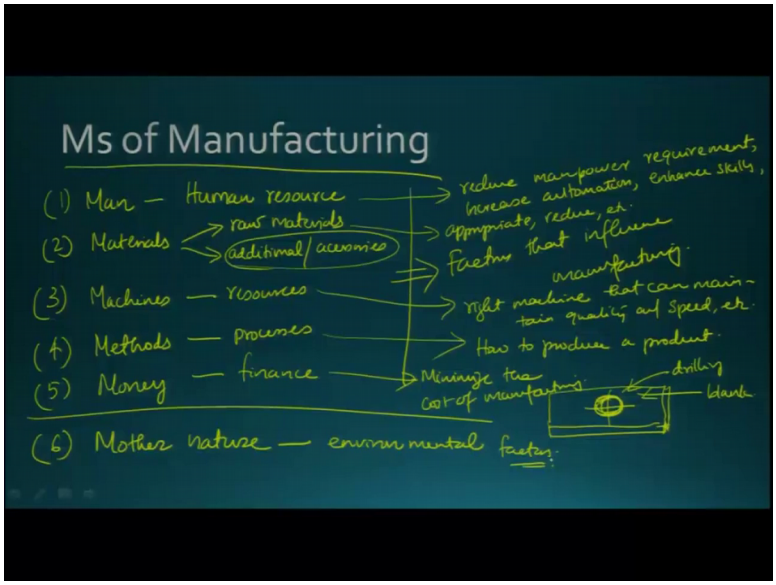

We talk about the Ms of manufacturing many a times people talk about there is multiple Ms that is related to manufacturing and the most common 5 Ms initially we talk about it as man this is the human resource, second is the materials it can be you can think about it as raw materials and then you can think about it as additional or accessories like coolant and stuff like that, you can think about third one as machines different type of machines many a times people call it as resources the common term resource calls are a first machines in simulation typically, fourth one is methods over the simpler time to it is process not processes and fifth one is money or the simpler time to this finance, these 5 Ms are they typical factors that influence manufacturing.

There are many a aims to this if you think about the human resource then you can say there is like reduce manpower requirement is one goats which would be translated to increase automation or increase automation another example is enhance skills like Japanese do cross training stuff like that, these are all aspects related to man or human resources. In materials you will say appropriate raw materials reduce the consumption etcetera, additional accessories similar aspects you can think about it, machines that can maintain quality and speed etcetera, it is a fine which is the machine to do right machine

to do the job methods or we will be call as processes is the what is a how to produce a product.

So, like for example, if you think about it let say you have this as your work material work piece, rectangular work piece and you want to put a hole in between of some dimensions. We can use a drilling machine to do this as one option or you can use a what you call as a blanking operations where blank you can punch it a punch a hole through it. So, depending upon how you want to do the hole based on the finish and other requirement choosing the appropriate technology is an important thing.

Then; obviously, finance how to minimize the cost of manufacturing, an example would be sometimes the one of the most expensive thing is that you end up using is the mineral oil or for coolant when you are doing machining, if you are machining a very complicated part then the coolant usage will be also be pretty high and let us some point let us you came up with a nice method to substitute the coolant the mineral oil with vegetable oil which is cheaper then that is that will reduce your financial requirements, these are the typical 5 Ms that everybody considers.

We now add one more M to this which we call it as mother nature or in a simplest sense let us talk about it as what we call as environmental, in a way here we are talk about is the environmental factors. So, one way to think about this yes we discussed the environmental factors like minimizes societal impact, minimize carbon dioxide, emissions, reduce energy all those kind of things, if you think about all these things then by managing this factors you would be able to create a manufacturing system which is more sustainable.

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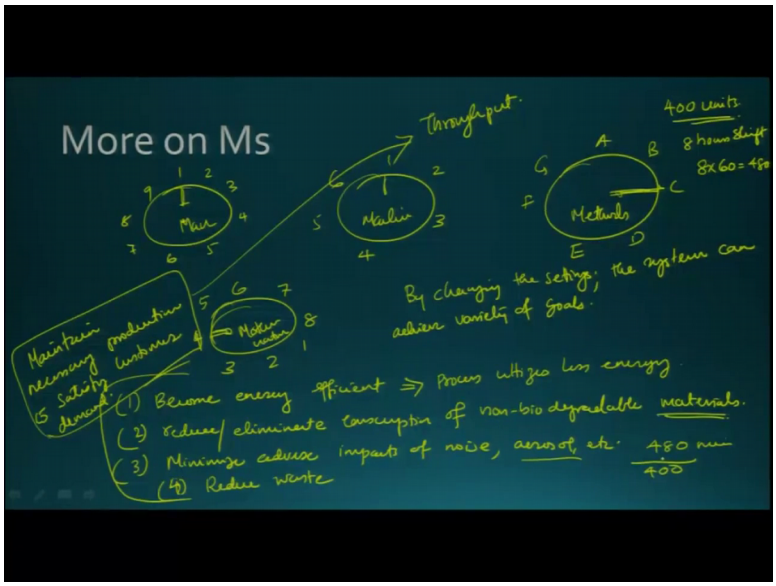

If we think about this if you think about this think about each M we can think about each M as a dial, you have 1, 2, 3, 4, 5, 6, 7, 8, 9 something like this, another dial might go from 1, 2, 3, 4, 5, 6 something like this, another dial might be A, B, C, D, E, F, G something like this.

The another dial will be again somewhere here 4, 5, 6, 7, 8, 1, 2, 3 something like this, if this can be the man, this can be the machine, this can be the methods, this can be like mother nature all this kind of things. Think about 6 dials like these and each of these dials by turning them by moving them around from different settings by changing the settings the system can achieve variety of goats some of these goals actually include number 1 would be you know become energy efficient here, one thing that you might be doing is you might be changing the dial of the methods or the process, that the process utilizes less energy.

Another example of this you can to think about it is reduce or eliminate consumption of non biodegradable materials this is where you are actually influencing the M, of material M where you are reducing the consumption of a particular type of a material where in making the dial turn to0, then you are thereby achieving whatever you are supposed to achieve. Let us look at another example also the, we can think about it as minimize adverse impacts of noise aerosol etcetera this is another example, if you are coming up

with a new machine which will actually reduce the noise pollution then that is actually a good thing.

There were you are influencing the machine aspect of it an aerosol is where the spray or the let us say for example, your process has a very high speed cutting drill or a drill bed which is running at a high speed then and the coolant is touching when it comes in contact with that it will actually become very fine particles or a spine spray which becomes an aerosol and most of this is cutting fluids are chloride or sulfides based mineral oils which can actually create in much dangerous health hazards to the worker. So, here you are thinking about the man aspect the human aspect, the better work environment those kind of stuff.

And another example of this can also be forth one can be reduced waste is another example all of these if you think about is all of these are good you can keep on attaining changing the dials, but you should also maintain necessary production to satisfy customer demand and what we call here is that there is something this maintain the necessary production to satisfy customer demand there is a nice term that exists for this that is called as through put. So, for example, if you are making 400 units of something product and you are having an 8 hour shift to make this, then 8 hours is 8 time 60, 480 minutes.

So, if you have 480 minutes and you have to make 400 units, then we can found out how in how many units you need to make per minute. So, if it says you have make more than one unit a minute one point 2 units a minute then you will be like or in other words if you find out how many minutes are required or within every how many minutes you should make one product you take there one over of this ratio then you will be able to get that value as well. Then this is the through put that you need to maintain, if you how to maintain the through put to satisfy your demand then how can you maintain that through put by achieving all these environmental initiatives is one of the major aspects of sustainable manufacturing.

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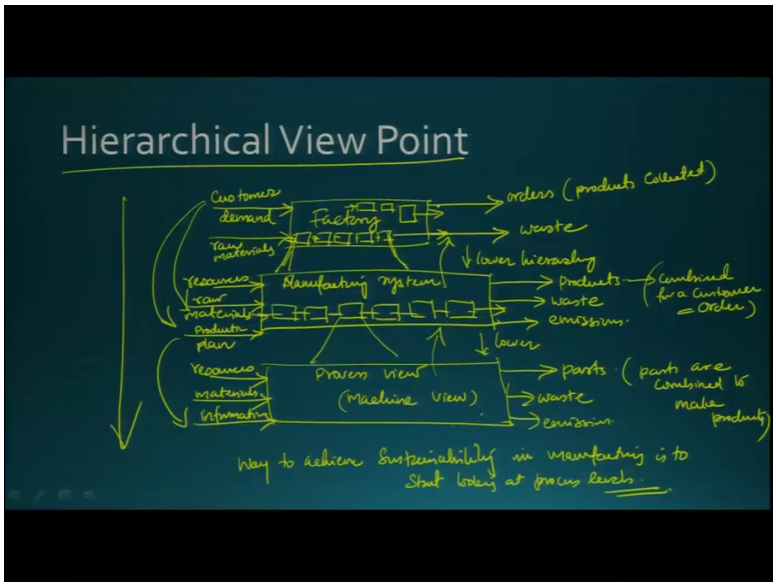

And we will conclude this discussion about the sustainable manufacturing on the you looking into the concept of hierarchical view point and the hierarchical view point is nothing complicated it is actually this view point is necessary because the entire time when we are talking about sustainable manufacturing we are actually using this as an analysis process.

Let us look at the first view point of the factory, there is a factory available some place a big factory in which there are so many processes goes on there is one process products arrive go through them and the final products come out here is another one that actually happens here and then, different processes happens. The input of this is number 1 is the customer requirements or customer demand we said earlier that you have to satisfy the demand of the customer and then you also give one input called a raw materials, these to inputs will provide what typically we call as orders or in another way these are products collected.

I might order 5 cars in all those 5 cars put together will be the order and I will also end up producing what I call as waste, in a factory level in a very global level this is what we talk about then if you will just look at this concept of it then we are looking at what we call as the next one which is the system view or the manufacturing system. This is a lower level a lower hierarchy of the factory, this is a lower hierarchy you are digging deeper you are looking more closely into this the here you have again a collection of

machines as I said earlier you know arranged in a particular sequence so that the product moves from one machine to another you get the final product coming out of it.

Here the input is your resources which include human resources etcetera raw materials; obviously, or materials you want to call it that way and then you also have instead of the customer demand you have a production plan. The customer demand gets translated to what he call as a production plant and type of raw materials I need to be taken, from there you will get what you call as products individual products you also generate what we call as waste and you also create what we call as emissions. So, when you combine these products all of this products put together combined for a customer gives you what you call as an order.

All the products are ordered by customer when is put together and delivered to the customer that is called as an order. Then if you take one of these you look at it further this is what we call as the process view or the process level of the system where you are basically looking at a particular machine view you are looking at the machine that is delivering or creating a part. So, here you have again resources could include electricity, water, heating, cooling, lighting, those kind of things you have what we call as materials or raw materials whatever you want to call it and then you have information, the production plan gets translated to information. It says take this particular raw material use this particular tool bit and use this coolant and do this type of machining for next 3 minutes, then you will be able to get this particular part.

Here the output is what we call as a part or parts, you are looking at individual parts and parts are combined to make products, the machine view machine produces the parts we also will; obviously, produce waste you will also end up reducing emissions. So, to make a green manufacturing or a sustainable manufacturing you are looking at the hierarchy it keeps going down the hierarchy goes down as you follow the hierarchy is low this way, but as we go down the system we need to the aim of way to achieve sustainability in manufacturing is to start looking at process levels.

If you are able to achieve sustainability in the process level itself then processes combined to become manufacturing system or a production line and production lines combined to become a factory. So, as you move up in the level of hierarchy, higher up in the level of abstraction then you will be able to obtain sustainability for the entire factory

level though you will start at the process and you move up to the system manufacturing system then you move up to the factory and that is exactly what we will be discussing in this class is how to achieve sustainability through this hierarchical view point or analyzing the manufacturing system at different hierarchy how to be able to get that.

With this we come to the conclusion of today's lecture I hope you are able to understand the much more details of the technical or technological background in the philosophy behind this thought process and from the next lecture onwards you will be looking into the necessary tools that are required to do this kind of a hierarchic analysis of a manufacturing system.

Thank you very much for your patient listening.