Carbon Accounting and Sustainable Designs in Product Lifecycle Management

Prof. Deepu Philip
Department of Management Sciences

Dr. Amandeep Singh Oberoi
Imagineering Laboratory

Dr. Prabal Pratap Singh
Department of Management Sciences

Indian Institute of Technology, Kanpur

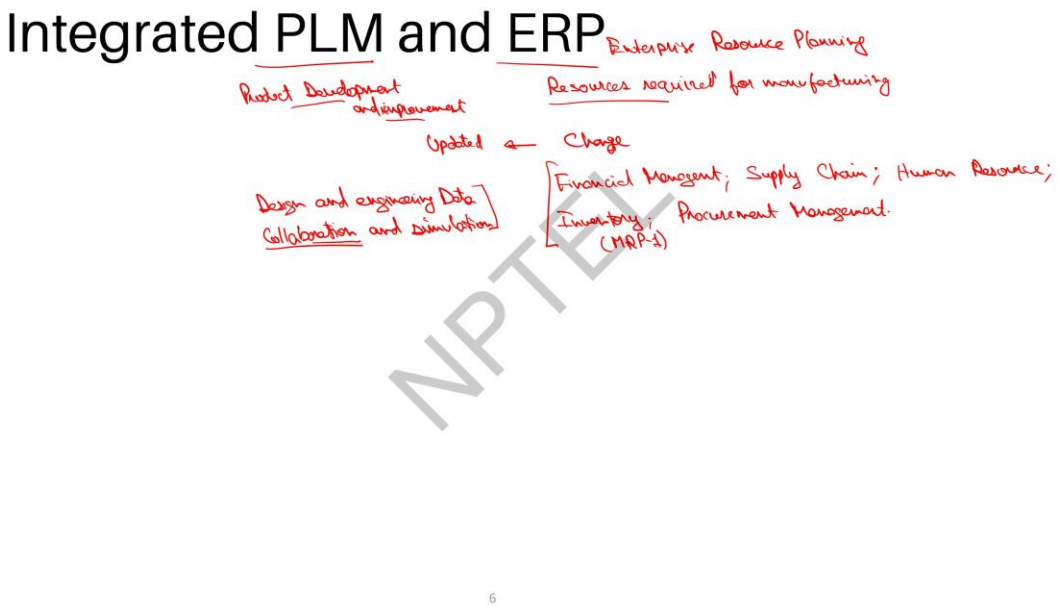
Week 06

Lecture 25

PLM Integration (Part-1)

Welcome to the second part of the lecture on PLM Integration. We are in the course Carbon Accounting and Sustainable Designs for Product Lifecycle Management. This course is co-taught by Professor Deepu Philip, Dr. Amandeep Singh oberoi and Dr. Prabal Pratap Singh. I am Amandeep. So, we talked about the levels of PLM before that we talked about the framework of a carbon accounting that we will work through this course.

We talked about the model that we will use in the carbon accounting framework and we talked about the levels of PLM. The levels of PLM would be now mapped with, what are the different systems or steps in enterprise resource planning.



That means I would like to see the integration between PLM and ERP. PLM is Product Lifecycle Management. ERP is Enterprise Resource Planning.

The two systems can establish a connection resulting in increased accuracy and benefits for both. PLM primarily emphasizes product development and improvement. However, ERP focuses on the resource required or the resources required for the manufacturing. Manufacturers are nowadays compelled to imply both the systems in parallel that is in a sequential manner in which the product that was conceived.

That was being developed, that is being delivered due to persistent rise in customer demands and big competition and smart products are coming there and the stringent demand.

Norms are there for the carbon accounting that is required. So carbon accounting that is the carbon credits that you need to gain. All those systems are to be taken care and PLM helps you to maintain or record the data from the very beginning itself when you are working with your regular ERP system. So, let me try to see a little more small differences between the two systems, I would like to mention. So, I will just like to mention here that when the product is ready for production.

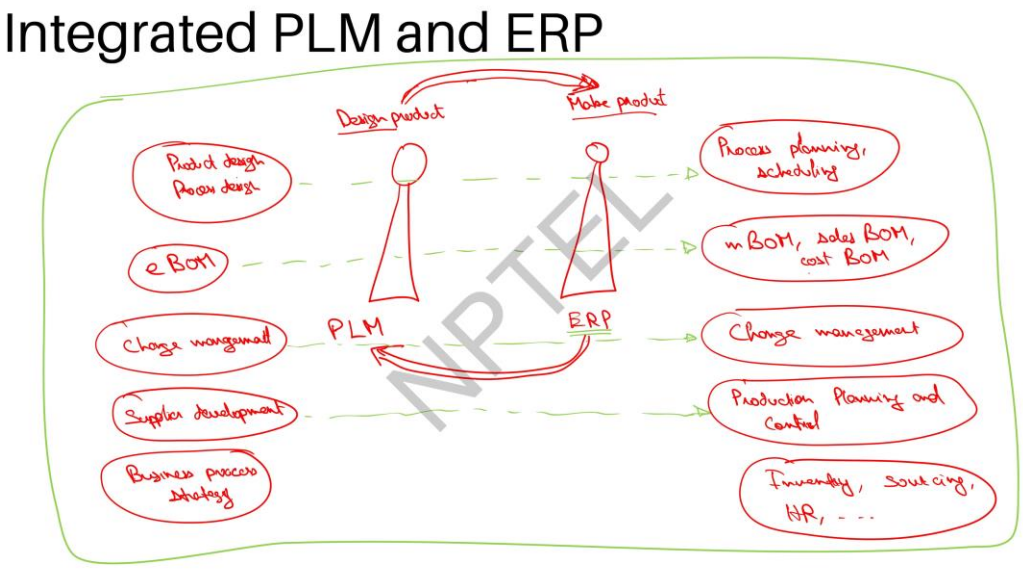
PLM system will contain all the relevant details that if there are any changes in the resource preparation in work routine PLM could be updated accordingly. That means

PLM keeps getting input from ERP to get the information updated whenever any changes here in ERP. Integration of two systems is necessitated because they both process identical information as well as the most current data at all times. However, there are certain differences the purpose of PLM is either said is majorly the product development and improvement. The purpose of the ERP is to collect the resources which are required.

The scope of ELM is definitely majorly in the manufacturing industry for example, aerospace, automobile, mobile systems and anything. Definitely, the PLM next form is their service lifecycle management, application lifecycle management which use the same principles. Which were there in PLM for the softwares for the services as well. So, those are the major purpose points here for PLM. And the key functions of PLM is to manage the change, to manage the configuration, to manage the data to have collaboration and simulation.

The key functions for ERP is financial management. I would also put here supply chain or I could put human resource inventory management that means. We have Material Requirements Planning 1 (MRP 1) where majorly material inventory management system is there. Then MRP 2 is there where manufacturing resource planning was there and we have procurement management. In contrast PLM helps you to manage design and engineering data along with it the collaboration of different parts or the areas or the offices or the departments.

And it helps to give you a data that comes and output of the simulation that, how would the system run when you take the collaboratives endeavor including different departments of your management.



So, this is PLM and ERP how are they integrated let me try to put them as my two different entities. Cycle management system and this is my ERP that is Enterprise Resource Planning system. The major purpose of PLM is to design product and ERP then makes or manufacture that product. Yes obviously in the beginning information flows from the design to make that means if I have product process design here it is product design process.

On the other hand in the ERP side, I would have whatever process is designed here planning of that. The process is designed by a PLM system. We need to manufacture a new car. We need to manufacture a new design of the maybe the fuselage in an of an aircraft. This design is given by the PLM system.

Now, when this design is given, they also design the process. With this design, the engineering bill of material is this. The MBOM, that is Machine Bill Of Material, you call it manufacturing bill of material is this, that these machines are required. Now, availability of these designs and the process planning, that will be taken care by ERP. Now, ERP does process planning and along with process planning because the process has to be executed it also does scheduling.

Process planning and process scheduling this is done by ERP. And as I said the input material system is engineering bill of material where will be including all the components, their sizes, their numbers those will be given. In engine wheel of material we give the list of all the components which are required to manufacture. Whatever the design that we have made and the number of components the all the different sizes. Even suppose there are sheets which are required one sheet is 2 feet by 2 feet, another sheet is 2 feet by 3 feet; these two becomes separate components.

2 parts or 2 numbers of this sheet, 2 numbers of the other sheet or maybe 4 numbers of another kind of a nut, another 5 numbers of currently washers. All those things will put an engineering bill of material. And these engineering bill of material because whatever we are presenting here would also has to have our bill of processes. So, here parallelly we have manufacturing bill of material in ERP. And when we talk about the enterprise resource planning, this is not only manufacturing resource planning.

Enterprise resource planning also takes into account the activities beyond the manufacturing, that is the sales. Sales bill of material will also be here. Sales bill of material and when we talk about sales, we need to understand what the market is and we need to also understand allocate the cost here. That is why the ERP systems helps you to always have an integration with the PLM system. Because PLM systems will help you to put the data along with the sequence the way ERP is running.

Finally, the credits which are earned in carbon sequestration in reducing the carbon footprint helps you to have it reflected in the cost as well. So, that is why the cost below fuel becomes a part of the enterprise resource planning and definitely change management is there both the sides.

Change could be there when we try to plan it for the resources and change was always there in the PLM when we went through certain flows, here certain iterations were there. In the PLM we talked about the change, we talked about the suppliers. If you remember the components of the PLM, there was one thing that was known as the vendor management or vendor development or supplier development.

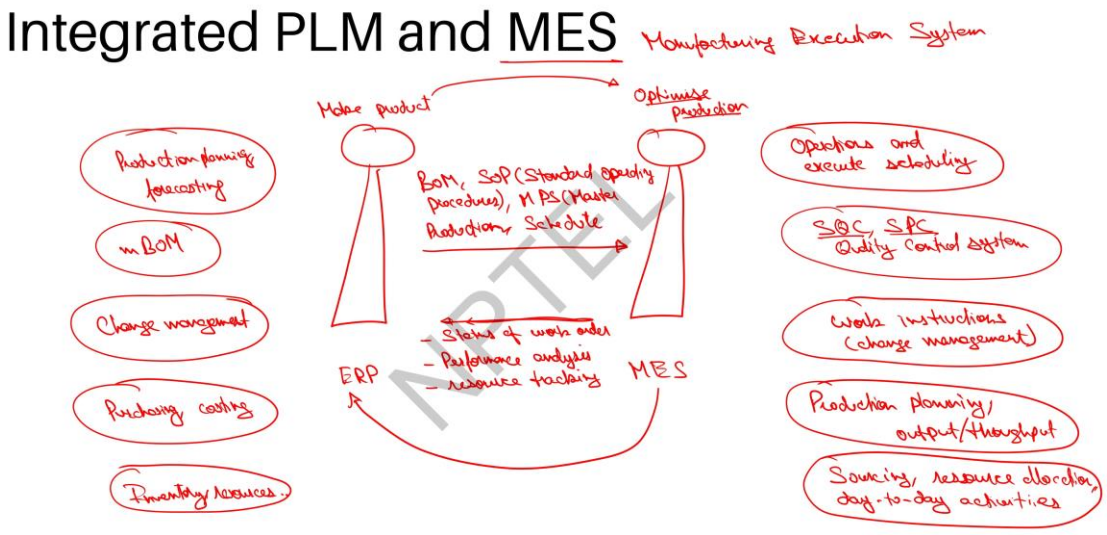
So, I will put it as supplier development parallel to this. So, prior development we will have production planning and control. So, if I quote an example I could talk about the maybe hero cycles or maybe hero motorbike. Hero Cycles in itself has a almost a complete facility where the all the components are manufactured majorly within the facility itself. Let me talk about Hero Motorbikes.

Hero Motorbikes whatever model, you pick Splendor, Passion or any of the higher end models. The components which are there, which are taken from the ancillary units are majorly local. Local means those are there in Ludhiana or the close by cities. So, that is the production planning and control when the supplier development is there. The production planning and control that when would it reach the transportation of the components from the local people is easy.

That is how they plan it. Then in PLM we have business process strategy. When we talk about business process strategy, we have inventory sourcing lot of other things that are missed in the above list, I could put inventory, I can put the sourcing, I can put the human resource or whatever you call it missing points. The above four points, I can definitely connect here product design and process design to the process planning.

E-bill of material would be reflecting to get your manufacturing bill of materials. Then change management is there on the both of the sides. Supplier management would give an input to the production planning and control and this becomes your envelope. Where ERP and PLM systems are integrated together. So, if a firm utilizes only ERP system and PLM system is ruled out.

Then there will be a big gap because the data, the change which whatever is there in the ERP is not being recorded. When the change is not recorded, next time also the issues could come. So, only ERP is not something that the firms goes nowadays. So, increased cost would be big challenges. Monitoring the processor will be big challenge if we do not apply or employ PLM along with the ERP. But this is how the PLM and ERP goes hand in hand.



8

Let me also try to see another system that is Manufacturing Execution System. Now, incorporating real-time data that is concerned with a schedule of resources across the entire supply chain. With ERP systems can help manufacturers reduce their unnecessary interruptions and further delays. Now, there is a system manufacturing execution system that allows placing machine information, operation information, traceability data to work to address more important functional difficulties.

So, once the ERP and MRP are integrated, so that becomes a more agile and well organized engineering system. So, any change that is there in engineering in functioning that might be from the internal or external customer. That has to be transferred to them in flexing system as soon as possible to prevent any delays so that to satisfy the customer work orders. So, PLN helps us to integrate ERP and MES, that we will see in the further slides. Let me first try to see what was our ERP system.

Now, this is my ERP, this is my MES, here my ERP system is there, here MES system is there. In the above slide, I will also have to put here, you get the design here from the PLM that gives an input to the make product, ERP systems gives you a feedback down here. Now here ERP definitely helps you to make a product, as we discussed in the

previous slide. Now MES (Manufacturing Execution Systems) whatever ERP has planned the process planning production planning manufacturing bill of material purchasing costing. That is all executed by a manufacturing execution system.

That means we try to optimize the production and we get information from made product to optimize the production. Here what we had different components, we have production planning, we have the forecasting. We had the MBEOM, MBEOM was our Manufacturing Bill Of Materials. So, those were here, we had change management, we had purchasing costing inventory or you call it any other asset management. We call it HR, we call it any other I would call it resource management.

So, along with this manufacturing education system helps you to have an optimized production line that means, whatever production plan get you are made here. Operations and activities and tasks would be scheduled here. That means, we have operations and we execute scheduling. So, here as always when you talk about, optimizing the production. When we talk about the optimizing the production line or we talk about the activities to be scheduled.

There are certain processes which are already planned, production planning is there, that is to be executed, there are control systems. Control systems we have with us the statistical quality control, statistical process control, these are SQC or SPC, that is the quality control systems. Manufacturing bill of material is there, that is manufacturing or bill of processes are there which helps you to execute it using the statistical quality control. That how would you minimize your time in manufacturing. That means you take here input from the bill of material from the SOPs are Standard Operating Procedures.

Then you have MPS that is Master Production Schedule. So, this all master production schedule this is one line this all goes as input to the manufacturing agglutination system. And from the manufacturing agglutination system because change management is here on the left. We have work instructions for change management. And in the front of purchasing and costing, we have production planning and control.

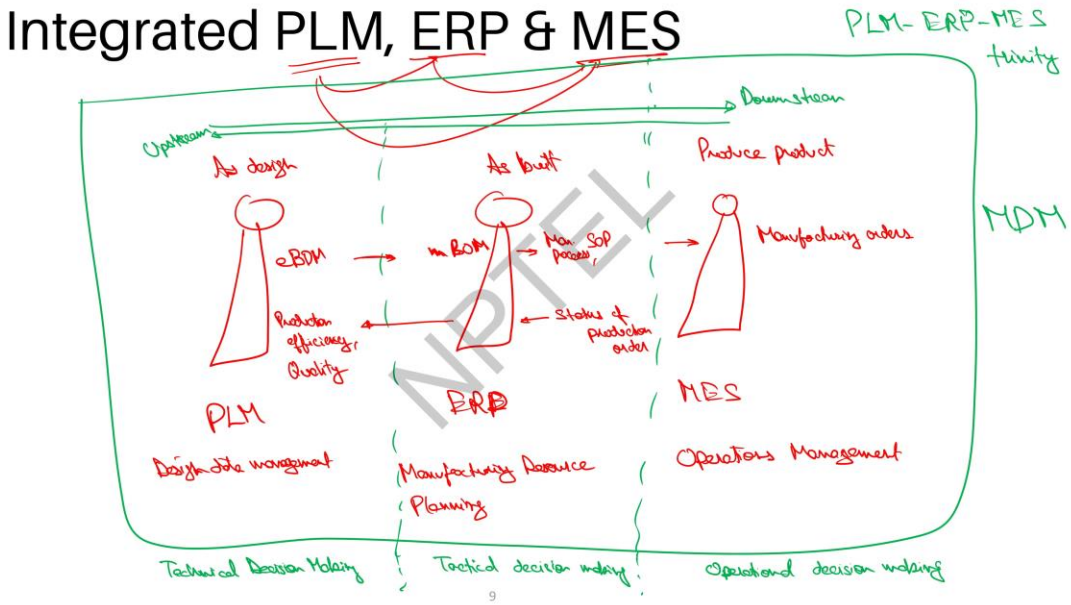
Production planning is not regular production planning that we do in the ERP system. This is we try to understand what is the yield, what is the output. Output or I call it throughput. Along with this we have sourcing, then resource allocation and so on. That is software equipment, day to day activities whatever the things which are required.

Because the system is now being executed that becomes part of our manufacturing aggregation system. Now, the feedback that we get here from manufacturing aggregation system to the ERP is your status of work order. Then the performance analysis is the components that you have put input here or the process plan that you have put here. You have estimated in a time for example, in a day may be 300 bicycles you will produce in hero by bicycles right in hero cycles industry. Now, this schedule, the plan that you have made and the actual production that is there that is the performance analysis.

Performance analysis regarding the quality of work, regarding the number of PCs, regarding the overall design that you have given the planning. You have given that is there in performance analysis. That also goes through the SQC, SPC and all the statistical tools. Then definitely as I said QMS helps you to have the resource tracking. So, this is PLM and manufacturing execution system.

So, PLM boosts the advantages of ERP system by enabling a comprehensive monitoring of all technological data in a single manner. ERP relies upon the comprehensive understanding of the product and its surroundings provided by PLM to optimize data flow management. For any production any logistics as well as to have access to the product data references as well. So, how do we now have a integrated system where PLM, ERP and MES all of them work together? You now have seen that PLM helps you to design a product.

ERP helps you to make a product and optimization of the production system is taken care by the manufacturing acquisition system. That means, you design a product in your PLM system. ERP helps you to make that product to have a full manufacturing bill of materials and all the change management is there itself. MES is then executing everything. ERP lies in between your PLM and MES system. This is how it goes.



So, let me try to see another relationship between PLM, ERP and MES. The three I would say primary practical applications. Are these which are used to support the manufacturing industry. ERP is primarily concerned with management the physical resources required for production such as materials, manpower, machinery and so.

MES deals with your complex manufacturing systems and data streams. And PLM integrates the various aspects of product development process which includes people specification processes usage and so. PLM also enhances the flow of product information to ERP and through ERP to MOS and maybe sometimes PLM to MES direct. So, this is how it goes. So, we have here PLM, ERP and MES.

This is as design, this is as built, this is produce product put in different. So, I am talking about the information that is going now here downstream from PLM to MES. This is downstream and definitely upstream information is also there when it flows in the other direction. Whatever feedback, whatever change is there that is to be recorded in a PLM

system. Here just to put only a few pointers, we had E bill of material which turned to the M bill of material here in ERP.

And this with your manufacturing process or your standard operating procedures helps you to develop your manufacturing orders. So, here it is data going from this to this direction. The status of the production order status of production order is taken from your MES that is a feedback status given to the ERP system. That status then goes back to your PLM regarding a data to be recorded as production efficiency. Or in simple terms you call it as quality it goes back here.

So, majorly to put in the more traditional terms. I would like to call MAS, the (Manufacturing Accumulation System) as my operations management. It accrues to operations management here, ERP includes your MRP that is Manufacturing Resource Planning and here we have design data management. This is how making use of the statistical process control systems. The statistical quality control systems and various other components.

MES allows manufacturing to have a control over the forecast and visual track. What is to be needed to be performed and it gives the feedback as a status to ERP. ERP then gives our feedback and ERP further transfers the feedback to PLM that records the data and production efficiency and quality is recorded there. The enterprise data flows concurrently through the PLM, ERP, MES, Trinity. Here what it is.

A complete envelope, I will have to call it as PLM, ERP, MES trinity. This undergoes various degrees of adaptation at different phases of product life cycle which encompass multiple detailed version and structures. The fundamental ideas taken into consideration with the amalgamation are to get the MDM that is your master data management system. The strategic positioning of product and business information is here for the whole product life cycle. This facility is the communication throughout the entire services.

PLM focuses on technical decision making. I will put it here technical decision making that is PLM then ERP handles tactical decision making and MES manages operational decision. All these three together as a trinity helps to collaborate to establish a framework for a modern study, a solid lean manufacturing system in a way. So, this enables manufacturers to exchange relevant information throughout the whole enterprise. So, that is why PLM, ERP, MES go hand in hand nowadays.

When we need to have a complete and model for the carbon accounting. And because we are talking about not only the carbon accounting in this course, we are talking about the sustainable designs. Carbon accounting in unison does not play a big role. Carbon accounting could also be taken in the manufacturing execution system itself with the carbon. That is the carbon footprint of each of the resources, each of the processes that happens there.

That could be recorded in manufacturing execution system. But in this course we are also talking about the sustainable designs. carbon accounting and sustainable designs in product life cycle management. When we talk about sustainable designs that, whatever we have learnt through the current change that has happened in our manufacturing aggregation system. All those operational changes have to be given as a feedback to our technical decision making and this helps to have a design that is more sustainable.

Sustainable design is always gotten when all of these three work in unison together to have a design that is in future as well accounted well for its better carbon performance. With this, I am closing this lecture. We will meet in the next lecture where we will talk about different levels of a manufacturing system and how we try to see the carbon accounting in them.

Thank you.