Process Integrated Digital Factory Layout

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Abstract— **Factory layout is one of most crucial information used by Manufacturing, Facility and factory automation engineers for planning purposes. It is important for manufacturing, facility, operations team to work with most up-to-date layout with constantly changing product and process information. Till today there have been isolated approaches for maintaining layout and process planning information. The product never gets into preview of layout during the concept or development phase. Apart from that the layout design does not consider validating process data to meet line design requirements. One of the reasons why the integration of product, process and plant (PPP) does not happen is multiple systems used to maintain this data and they are in isolation, there are also challenges to feed data back from the actual objects on the floor to the planning data.The dissertation is about how factory layout can be developed integrating product, process and plant (PPP) in a single dynamic environment. So far there are no efforts to digitalize every information on the factory floor and able to generate Digital Twin of the factory by connecting physical objects with the digital objects. Paper will present the approach to integrate PPP and how this can become foundation to drive digital twin of the factory.The Paper will also focus about the change control over PPP and how a factory layout can be maintained for configurations and revisions.**

Keywords— **3D Layout, Digital Twin, PPP (Product, Process, Plant) environment, 3D layout development, Change management**

I. INTRODUCTION

The layout for any plant is resource bill of material (RBOM) needed to build a product. Every object within the factory layout is essential for manufacturing the product through its processes. For designing factory layout, there are different tools available in the market. These tools are very simple to use from the modeling perspective but have very little or nothing to offer from managing RBOM like any other PLM solution which manages EBOM of the product. There are few solutions which offer managing repository of factory layout as a single entity rather than RBOM. When there is no PLM solution available for layouts, multiple copies of layout are stored and maintained at different locations. There is no good mechanism to control objects within the layout. As the layout does not have version control and change management it is very difficult to track changes over period. Another challenge is the layout being synched with process/product changes. There is no easy method available to visualize configured layout in case of mixed model line and dynamically visualize it with respect to product and process.

II. 3D LAYOUT

[5] 2D layouts are most common for factory layout designs because of the convenience for drafting and ability to modify quickly based on the feedbacks. Conventionally they are used mainly for facilities changes and commissioning. Today when there is more focus on identifying as many of the issues during planning phase, the need is arising for 3D factory layouts. In 3D factory layouts, 3D objects are placed on the 2D footprint with the help of current generation toolset to get the feel of virtual factory. The virtual factory is used further for various analysis such as, how my product is moving through factory or on a line? Whether current station is capable to manufacture new product? Is there any interference of the product with facilityobjects? etc. These scenarios can be easily validated with the help of the developing 3D layout and help in overall implementation of the plan by taking appropriate actions prior to commissioning. In current scenario where industry is moving towards its new revolution i.e. 4.0, more and more emphasis is on digital information, 3D factory layouts are need of an hour. In the context of Industry 4.0 , focus is on making factories smart enough to visualize real time data on digital models with the help of connected devices makes 3D layout as foundational requirement

III. DIGITAL TWIN

[4] Digital Twin is overlaying the physical data or assets on top of the virtual model and visualize the real-time data of the product and use for further analysis such as when machine is going to break, Is there any potential issue which may cause loss of production etc. Question can be why there is need for digital twin of 3D factory layout? The factory layout contains all the crucial information used by Manufacturing, Facility and factory automation engineers for planning purposes. It is important for leadership to understand what is happening at the factory level while seating in the office and monitor any potential line down situations which may impact the productivity and flow of the product.

IV. PPP (PRODUCT, PROCESS, PLANT)

[1] [2] [3] Product-Process-Plant(PPP) environment is an integrated environment where all key aspects of manufacturing planningare linked with each other which provides information like what **product**is going to make on the line? **Process**which talks about how product to be assembled? **Plant** which talks about where product to be assembled& resources required to assemble product.

What is the purpose of having product, process and plant view?Today, when we talk about bringing more collaboration between multiple functions to enable concurrent engineering, there is requirement to provide the integrated view to all stakeholder who are working in related areas. When design engineers work on their design, focus is always on fir and function. Design for manufacturing is overlooked because of the non-visibility to the manufacturing processes. At the same time when manufacturing engineers work on designing the process, facilities aspect of the layout is ignored which has big impact on the flow, quality and safety of the process. In an environment where all three aspects are available to view, will overcome the challenges above. In connected factory scenario,each object within the factory layout can be tagged with physical object on the floor and data can be collected to for insights. This will help further enhance product, process and plant.

V. CONCEPT OF PROCESS INTEGRATED 3D LAYOUT

Approach for process integrated layout: PDM is used usually used to manage product data management along with Creo for cad data. The factory layout is modelled to follow product modelling practice of creating CAD objects and checking-in them to PDM, How the product data can be managed through assignment of ECN objects, same thing can be done over factory layout objects to bring then under change control. Once the factory layout is available, define process in the context of layout using process planning tool. Below are the visuals for the steps to get integrated factory layout.

Steps to integrate 3D layout with process and product

Step1: Import skeleton from existing layout

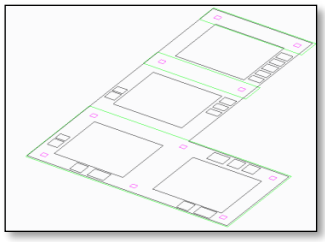

Fig. 1 Example of an imported skeleton

Step2: Develop referencing system to build the solid foundation for developing 3D layout and place reference.

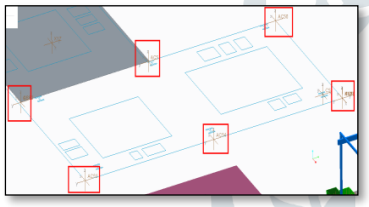

Fig. 2 Example of reference system on skeleton

Step3: Develop the complete one station by assembly of objects from the library

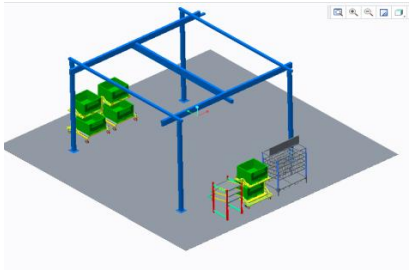

Fig. 3 Example of complete station

Step4: Develop complete line layout after assembly of all stations

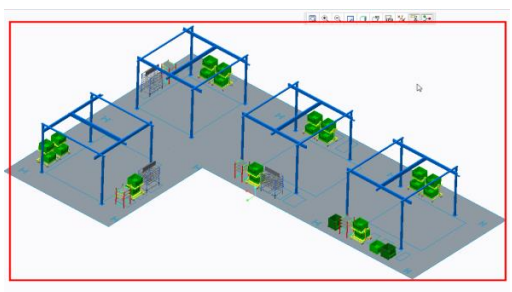

Fig. 4 Example of complete line

Step5: Visualization of layout in product process and plant environment

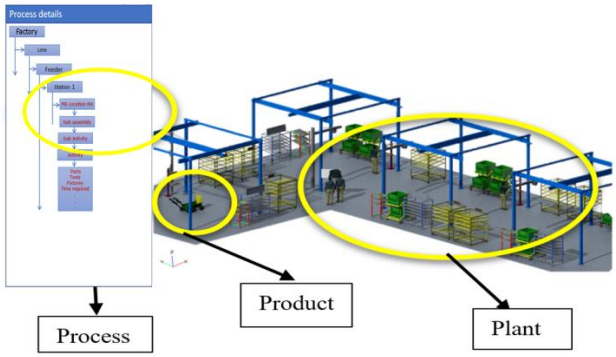

Fig. 5 Example of integration PPR

VI. CHANGE MANAGEMENT

Layout is developed, what next? How it can be managed with effective change management process? While developing layout initially layout objects should be added to Engineering Change Numberand once it is available in system usershould apply the proper date filter to view right version of the layout. Each of the layout revisions can be on different ECN and effectivity date. The filters will enable visualizing right revision of the layout based on the ECN effectivity date. For example, let's say layout1 Rev.A is effective on 01/09/2019 and due to new product introduction on same line there are some changes required on the layout to accommodate changes, layout1 will be revised to Rev. B for accommodating these changes and will be on another ECN which is going to be effective on 02/02/2019 . With the help of a filter for effectivity date, right version of the layout will be visualized.

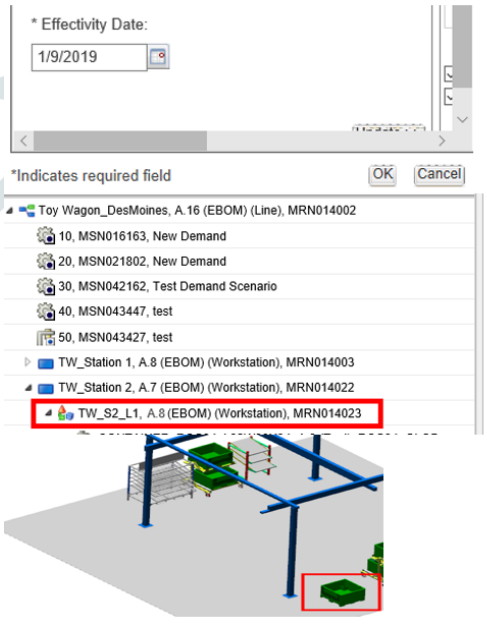

Fig. 6 Example of initial layout with A version

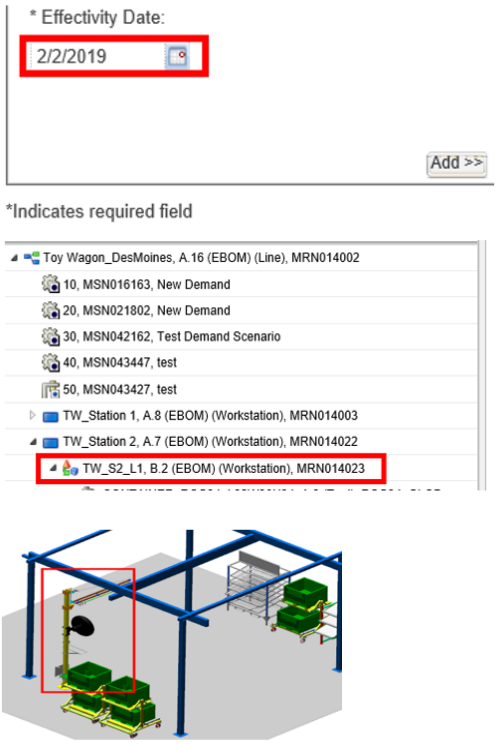

Fig. 7 Example of change controlled layout with B version

CONCLUSIONS

Above methodology describes how 3D layout can be developed and managed with effective change management system and this methodology describes the use of Product, Process and Plant information within single tool which enables Digital Twin of the system.

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