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Issue in Focus:

Digital Prototyping in the Plant

Improving Manufacturing Agility with the Digital Factory

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Introducing the Issue

One thing is for certain, the manufacturing industry landscape has changed. There have been plant closures and consolidations, particularly in the automotive and transportation industries. More change is on the way as companies adjust their plans to survive the current economic downturn and prepare themselves for the recovering market. In this environment, manufacturing plants must adapt to changing product lines, new product mixes, different production volumes, and more as external market forces and corporate strategy drive change to the factory floor. This is in addition to changes from cost reduction programs, quality initiatives, and – hopefully – some innovative new products.

The resulting changes coming to manufacturing facilities will require significant retooling of plants. Production lines and tooling will need to be moved, consolidated, and potentially repurposed. There is a lot of work to do in order to reconfigure today's manufacturing facilities to become the productivity and profitability engines of tomorrow's leading manufacturers. Manufacturing agility will be an important competitive capability. As Pat Frey, Vice President of Production Control and Logistics for automotive supplier Android says "*You have to be nimble in this industry, or you'll be gone.*"

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Wolfgang Röder, Manager IT Department, Robert Bosch

Those companies that will be agile enough to react to the changing market will be able to reduce cost to survive in the current economy, and react more quickly to revenue opportunities brought about by the recovering market. "*The biggest impact we are seeing is that our products are changing,*" explains Wolfgang Röder, the Manager IT Department for automotive and industrial technology, consumer goods and building technology supplier Robert Bosch. "*For example in past ten years more than 95% of our customers were from automotive, but now Bosch has acquired new companies in the energy sector. Our product portfolio will change within the upcoming year, and our plant equipment design requirements and challenges will change drastically.*" Speed is critical, and agility is the key to profitability. Now, more than ever, manufacturers need be able to make changes in their plants quickly.

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Beyond change, one other thing is certain – there will likely be very little extra capital budget to go around in order to make the required modifications. Companies will have to be very efficient in the way they reshape their plants to address today's new reality. How can companies adapt their production facilities quickly, inexpensively, and make sure that they are getting the most return on their infrastructure? Flexibility and reuse are mandatory. Moreover, companies will need to ensure the changes that they make are right before committing to expensive and disruptive plant modifications. Manufacturers need to do this right, and get it right the first time. Digital prototyping in the plant is a significant key to success in these times.

Adapting and Optimizing Workstations, Lines and Plants

New product mixes, run-rates, and products require updates to work cells, lines and plants. Getting these changes right up front saves wasted time and expense chasing late problems, and can also avoid problems that result in slower line speeds that cripple future productivity. Given the challenging economy ahead and the lack of budget to afford rework, manufacturers need to be certain that their changes will result in an optimized manufacturing facility before any physical work begins. It's important to get it right in the design phase, when flexibility is still high. As Pat Frey of Android cautions, "*Once you start facility projects, you start to erect monuments that can constrain any productivity improvement going forward. Those constraints can force you into a no-win decision to either spend money to move monuments or forgo future efficiency gains.*"

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Leading manufacturers are taking advantage of 3D plant and production line designs to optimize changes in a digital prototype prior to physical changes. As Bill Campbell, Global Manufacturing Plant Layout Lead Engineer for automotive OEM General Motors explains, "*We execute a 'virtual validation build' to catch potential problems in a virtual environment. It really helps to validate plant layout, robotics, and conveyor lines virtually before committing to construction."*The goal is to improve the ability to integrate equipment and tooling within the factory and develop efficient production processes. "*We have built a 'Virtual Factory' – a 3D plant layout – to help us plan our manufacturing processes,*" says Steve Schuchard, Central Layout Technical Support for General Motors.

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Combining the plant infrastructure with the lines, the tooling, and the products allows manufacturing and industrial engineers to understand how these different elements relate to one another. "*Using the CAD layout, we can overlay very exactly where to place the bins and totes, where tools are hung, where the CRT is positioned if they need to touch the keyboard at the end of the cycle, and then slide things around the lines visually,*" says automotive consultant PMC's Bob Burns. "*Part and tool location and sequencing become obvious because of simulation and the ability to move things around visually on the CAD layout,*" Mr. Burns continues.

A digital prototype of a facility can incorporate architectural details, infrastructure such as piping and electrical, layout of equipment and tooling, product inventory, and zones for material movement. By understanding these elements in advance, issues can be identified in the digital environment where they are easy to change, before the expense and disruption of physical changes begins. "*We are using Building Information Management (BIM) and virtual validation from a manufacturing perspective,*" comments General Motors' Bill Campbell. "*Integrating digital models together allows us to conduct virtual layout validation reviews, we find hundreds of issues per session early in the process.*"

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Early validation of workstation and line layouts help ensure smooth production in the plant when modifications are brought online. Digital prototyping can be applied at different levels of granularity, from individual workstations to entire facilities. Large scale aggregation of data enables engineers and operations managers to optimize the overall facility, study sequencing of changeover projects, and sets the stage to simulate the manufacturing facility. Unfortunately, many facilities do not have full 3D models available for their plant.

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Remodeling the plant is time-consuming, but it's important to have accurate information. Fortunately, alternative approaches are available if there is no existing 3D "*We need to be able to capture the plant data and reuse it versus painstakingly creating it,*" says Steve Schuchard, Central Layout Technical Support for General Motors. GM's Bill Campbell explains further. "*If we share a model in 3D and engineers work from it, they assume it is correct, so it has to be accurate. We are using 3D laser scanning (LIDAR) to capture 3D point clouds of existing brownfield sites and pulling those into our CAD models.*"

Whether plant data is available from previous design projects, is recreated, or captured via scans, it is a valuable asset to allow companies to optimize production and validate changes prior to spending time and money to make changes that will need to be changed all over again later.

Designing Optimal Tooling and Equipment

In the same way that manufacturers can take advantage of digital prototyping for facilities and lines, they can also leverage 3D to design optimal tooling and equipment. Plant equipment can be virtually validated using digital prototypes of the products to be produced. Using 3D product geometry directly in the design of manufacturing tools, jigs, and fixtures reduces errors and allows manufacturing engineers to get it right the first time. "*We design the machinery around the product using simultaneous and concurrent engineering approaches*," says Wolfgang Röder, Manager of the IT Department at Robert Bosch, "*This enables engineers collaborating deeply with external design suppliers to see the changes much faster and with less errors than in the 2D world.*"

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Using prototypes of the product allows engineers to design optimal tooling and workstations, and also offers the ability to develop tooling that is flexible to manufacture a range of products from the same product family, reducing tooling costs. Digitally designing plant equipment in 3D promotes reuse and flexibility, saving time, reducing cost, and increasing quality. "*All conveyors are parametrically designed,*" General Motors' Bill Campbell. "*This ensures that we follow standards and helps to reduce design checking time."*

Using a model representing the product and tooling together also permits more accurate manufacturing planning. Understand how the tool fits into manufacturing equipment, access to perform processes such as welding or machining, and human factors can all be considered. Bill Mitchell, Manager North American Manufacturing Services for a construction and agricultural equipment manufacturer explains, "*We bring product data in, and manufacturing analyzes it to ensure that it will work in manufacturing and what they have committed to is possible.*" This is particularly important in assembly tooling, where for example it is useful to understand different poka-yoke / error-proofing schemes and how they will function. Using digital prototypes, products, tooling, equipment and lines can be designed to work together. "*We get instantaneous access to product design, which drives our tooling design, which then drives our layout. Access to all of the information is very important,*" says General Motors' Bill Campbell.

As GM's Bill Cambell explained earlier, integrating models helps find issues earlier in the engineering process. This is similar to what Bill Mitchell says above about integrating product and tooling designs. There is a trend towards greater collaboration and integration between design disciplines. This is also true in the development of plant equipment, which frequently incorporates mechanical, electrical, and controls software design elements. Wolfgang Röder explains how Robert Bosch is integrating mechanical CAD (MCAD) with electronic CAD (ECAD) designs. "*We are prepared for the near future, where we aim to integrate our 3D MCAD design with our ECAD designs,*" says Mr. Röder, "*Then, we will be able to simulate and derive software for the control units before parts for the machine are purchased or assembled on the shop floor.*" Clearly there is benefit in integrating digital prototype models early in the design process.

Collaborating Electronically to Retool the Plant

Digital prototyping helps manufacturers collaborate on plant, equipment, and tooling design to reduce cost. Most major manufacturers are global, and travel budgets are strapped. Tooling and equipment vendors are also increasingly globalized. This means that the opportunity for on-site collaboration is reduced, and the cost and delays caused by errors is higher due to logistics and travel. 3D digital prototypes and viewing and markup tools improve the ability for distributed teams to collaborate efficiently.

Not only are we saving a lot of money in field change orders, but we are saving a lot of money by avoiding sending out engineers from four different disciplines with tape measurers.
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Allowing disparate teams to share models and see how they work together in advance can prevent last-minute changes that can reduce efficiency, delay the introduction of changes, or disrupt production. Collaboration is important internally and externally. A shared model can help facilitate greater collaboration and result in higher quality designs in less time. "*Not only are we saving a lot of money in field change orders, but we are saving a lot of money by avoiding sending out engineers from four different disciplines (architecture, conveyor, manufacturing, industrial engineers) with tape measurers,*" says General Motors' Bill Campbell. "*We are bringing the plant to the engineers.*" Bosch's Röder also comments on the importance of digital prototypes to collaboration, "*Our strategy was to integrate external design suppliers, 3D is more helpful to work with them online.*"

Conclusion

The benefits of digital prototyping for manufacturing include fewer tooling errors, more flexible manufacturing operations, more accurate facility project management, and optimized facility planning. "*We went from the paper car to the paper factory as a part of our bill or process (BOP). Now that we are doing the virtual factory, it all works when it starts up,*" explained Android's Pat Frey. Digital prototyping in the plant also helps companies work remotely with global partners, enhancing collaboration and reducing travel cost. Perhaps most importantly, digital prototyping helps manufacturers implement the changes they need to adapt their plants and instill the agility and flexibility required to survive the current downturn and retool to prosper as the market eventually recovers.

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Recommendations

- Leverage product 3D to develop, repurpose, and reuse tooling more effectively and more efficiently
- Leverage plant models to optimize plant layouts and redesigns to get the layout right the first time, and take full advantage of limited capital expense budgets
- Capture and reuse product, tooling, and plant 3D to optimize the way parts, tooling, equipment and plants work together
- Consider supplementing 3D models as needed for existing, brownfield sites through the use of 3D laser scanning
- Collaborate on changes internally and externally using visualizations created from 3D models
- Leverage digital prototyping to implement short-term changes, but also to achieve long-term advantages through manufacturing flexibility and agility

About the Author

Jim Brown is the President and founder of Tech-Clarity, an independent research and consulting firm that specializes in exposing the true business value of software technology and services. Jim has over 20 years of experience in application software for the manufacturing industries, with a broad background including roles in industry, management consulting, the software industry and research spanning enterprise applications such as PLM, MPM, ERP, SCM and others.

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