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REDUCING GAUGING LEAD TIMES AND OPTIMIZING LAYOUT DESIGN AT GM POWERTRAIN WITH 3D WORKCELL SIMULATION

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ABSTRACT

This paper describes an application of 3D-workcell simulation for assessing feasibility of a concept Powertrain gauging process. It provides a basic introduction to 3D-Workcell simulation and it's associated benefits. It describes the previous process, its limitations and problems, and also the design reviews and iterations that were performed in simulation to arrive at a new, optimized process. This new process minimizes operator handling of product and also reduces the tasks involved in completing the manual gauging operation. This paper describes how 3D-Workcell simulation was instrumental in identifying design and layout flaws prior to equipment build and install.

1 WHAT IS 3D-WORKCELL SIMULATION?

Workcell simulation is the process of analyzing and validating tooling, process, and layout designs in a virtual three-dimensional world.

The software used for this project is Deneb IGRIP. This software provides capability to generate 3D models and the capability to translate models created in other commercially available packages. It has the functionality to assign motion to moving elements of a model. Collision queues can be setup to identify distances between elements. The software also provides extensive programming capability to simulate controls logic to allow elements within a workcell to interact with one another. The software has a library of standard workcell elements like commercially available robots and several percentiles of male and female models. The user has the flexibility to model devices and tooling that are necessary for a project. The software allows users to perform integration and testing of workcell components in the simulation environment versus on the floor.

3D-Workcell simulation should be used at an early stage in the development of a manufacturing process to evaluate and make changes to concepts and designs versus discovering problems and making changes to hardware on the plant floor.

2 PREVIOUS PROCESS

The current gauging process used at an existing GM Powertrain Engine plant uses a gauge cart on which the operator offloads the engine block or head from the manufacturing line using a hoist. The operator then pulls the gauge cart to another location away from the line where the block/ head is unloaded using another hoist to a gauge table. The gauges used in these operations are usually a mixture of variable attribute type. Sometimes computers are integrated into the process. Based on the product that needs checking for a particular operation, the operator inserts the gauge into the feature. The number of gauges to be used varies from 5 to 50. So the lead-time to perform this off-line gauging process is high and also, as mentioned earlier, involves considerable part handling by the operator.

3 MANUFACTURING CHALLENGE

The challenge to develop a working concept workcell in 3D was put forward to the GM Powertrain Manufacturing Validation group, a sub-group of Manufacturing Math-Based Systems, by GMPT Technical Liaison. The goal was to develop a 3D-workcell simulation that shows a gauge cell around the conveyor with tooling to facilitate operator gauging, the required gauges, a gauging computer, and all the associated tooling that would have to be located in the limited area around the conveyor. The tooling would require the capability to remove the engine block or head from the conveyor and locate it for the appropriate gauging operation. It would require sufficient flexibility to allow for the product to be rotated 360 degrees to permit gauging on at least 4 faces. It would also need the capability to replace the engine block/ head on the conveyor. The concept tooling and layout would have to be ergonomically friendly. The workcell elements would have to be designed such that they can be applied to all stations that require gauging. The workcell would have to be developed in conjunction with an engineering company who were contracted to design the tooling based on concepts provided by Powertrain.

4 DESIGN PROCESS OF THE PAST

In the past, the designers would submit a concept in 2D (electronic or hand drawn prints) that would be built and validated either by the same design company or another build shop. Since the design was in 2D, it was difficult to identify potential problem areas in terms of human reach, collisions, layout inconsistencies, etc. Also, it was not possible to completely identify issues arising from interaction of the tooling being designed and other workcell elements.

Sometimes, there are inconsistencies in the 2D drawings, for instance, views do not match. Also, in some cases, when changes are made to tooling on the floor, the 2D details and assembly drawings are not updated. This creates problems when the data is reused for a new engine program or when replacement components of the same tooling are built.

5 SIMULATION AND THE NEW DESIGN PROCESS

5.1 Concept Development Phase

The Manufacturing Validation group first modeled portions of the existing gauging process to develop a basis for the new concept. At this early stage, only a rough concept was required. Figure 1 shows concept tooling that was modeled in IGRIP. This model was developed based on input provided by the process engineers. The goal was to generate early ideas that could be provided to the designers who would have to develop a detailed design.

The figure shows a shuttle that slides the product away from the main conveyor. The idea behind the shuttle was to enable parts to continue along the line while one is being inspected. The model was then modified to show a concept tool that enabled the block/ head to be lifted off the conveyor, rotated and placed in a position that enabled the operator to access the part. The shuttle brings the part to a known location where the grippers of the tooling can grab the part. The arms holding the part then rotate to locate the part in a position where the operator can easily gauge it. The tooling was designed such that the product could be rotated 360 degrees around its pivot at the gauge position to enable gauging of at least 4 faces. This rotation is manual using the wheel shown in the figure. The wheel also has a locking mechanism to prevent the part from tilting when being gauged. Once gauging is complete, the arms holding the part pivot back to place the part back on the shuttle. The shuttle then slides and adds the part back on the main conveyor.

Issues and questions identified with concept –

a. Requires a flexible gripper design to suit multiple part styles.
b. Mechanism of tooling operation to be manual or automatic.
c. Location of hand gauges.
d. Location of gauge computer.
e. Safety fencing required around tooling.
f. Adaptability of this tooling to all stations that required gauging.

Keeping the above issues in mind, the simulator and process engineers continued the model development and refinement to generate solutions.

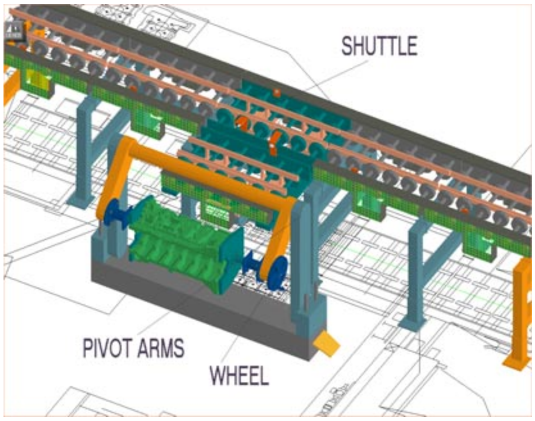

Figure 1: Concept Equipment Workcell

After each simulation iteration, the process engineers and designers were invited to provide direction.

5.2 Tooling Validation Phase

The earlier model was provided to the designers who then proceeded to utilize their tooling experience to modify the rough model and provide detailed drawings. The simulator then updated the IGRIP model after converting the detail to Deneb 3D models. Figure 2 shows tooling that was modeled based on those drawings. In order to arrive at a validated tooling design, the designers and simulators had to perform several iterations. The simulators identified clearances and collisions using IGRIP by setting up collision queues and animated the model to identify issues. The tooling shown is completely automatic. The grippers were designed to have faces identical to the part faces being gripped. The part is pivoted at its center of gravity to enable easy manual rotation using the two large wheels shown in the figure.

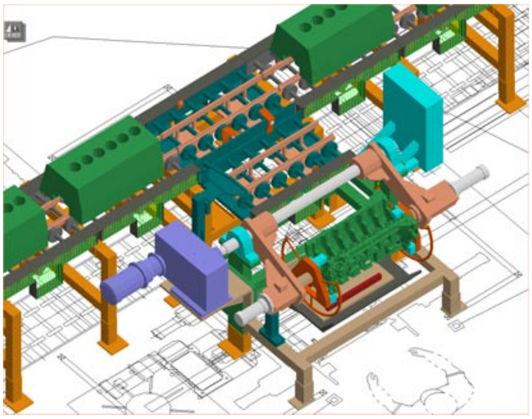

Figure 2: Tooling Detail Validated Workcell

This completed the tooling validation phase of the project.

5.3 Layout Validation Phase, Enhancements to the Model

Figure 3 shows the safety fencing around the tooling. Also, light curtains were added to the fence to deactivate the tooling if the operator entered the workcell. Additionally, a crane with a lift assist was modeled and located as shown. This crane can be used to pick up scrap parts and place them offline or to transfer the parts for fixture gauging and CMM checks. It can also be used to create a part buffer in the event of a breakdown further ahead on the line. The layout shown was then tested for all stations in the process that required gauging. Minor positional changes were made to arrive at a common configuration.

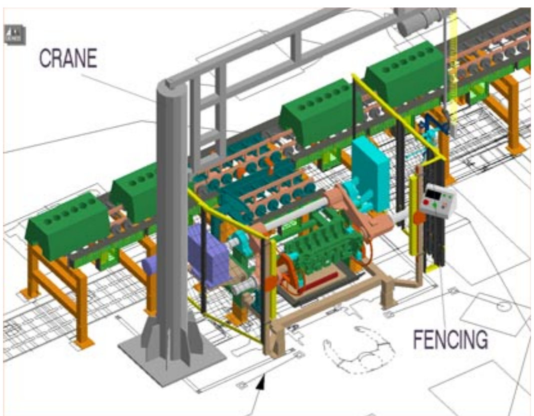

Figure 3: Validated Layout for All Gauging Stations

Figure 4 shows the same layout with additional detail requested by the process engineers. This figure shows the same layout as earlier but with an added gauging computer and gauge cabinet. The computer was attached to a commercially available arm with multiple degrees of freedom. This enables operators to tilt the computer to obtain a desired field of vision. The gauge cabinet holds all the gauges necessary for the operation thereby eliminating operator oversight.

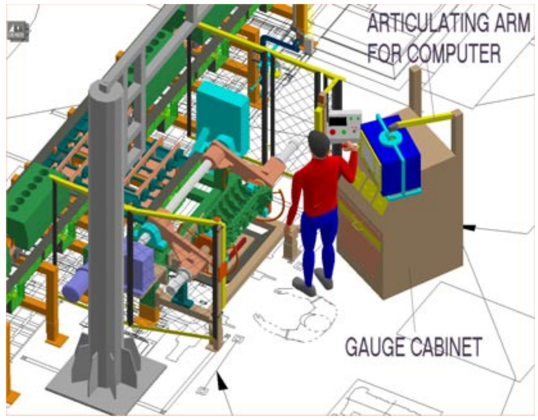

Figure 4: Additional Detail Added to Workcell

6 CONCLUSIONS

For this project, simulation assisted by making a concept in the minds of engineers a reality. It also assisted in validating that those operators from 5th percentile female to 95th percentile male are capable of performing the gauging tasks. This new process results in an overall reduction in manual material handling of 60 – 80%.

The 3D-simulation was instrumental in identifying reach issues for the operator, feasibility of tool design, layout issues, collisions, and also in validation of the entire process. Using input from 3D-Worcell simulation, the designers were able to generate more robust designs. The simulation assisted process engineers to visualize the process and tooling and suggest improvements that the simulator was able to portray within a short duration.

As the use of simulation increases, the associated benefits correspondingly increase and the time required for simulation would decrease. Proper archiving of these simulation models will help by allowing use of the same designs in future processes that are similar.

Simulation can help prevent production start-up delay that could otherwise occur if designers apply themselves only to the stations they are concerned with. It helps minimize changes at the build site thereby saving time and costs. Although not shown in this example, It also results in negligible programming of robots on the floor. In the future, simulation will help reduce programming costs associated with controls by debugging in a virtual mode.

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