amt
applied manufacturing technologies, inc.

WHITE PAPER

BENEFITS OF ERGONOMIC SIMULATION

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Abstract

3D simulation, while a widely accepted tool for assembly and robotic operations, is just now becoming a major tool for assessing ergonomic stressors in the workplace. Simulation has proven to be a very powerful and effective tool for ergonomic simulation if used properly.

Introduction

Many elements of a production process have a level of human involvement which can translate into business costs. Millions of dollars are spent each year in worker compensation claims and other work related injuries. Additionally, the efficiency of the manufacturing workplace is often below an optimal level, costing the manufacturing industry millions of dollars in lost productivity. Many products are manufactured with less than desirable quality simply because workers are performing operations under ergonomic stressors, which do not allow them to properly maintain/observe quality checks. Many times, a final product is not purchased by the consumer due to the fact that it is uncomfortable and/or difficult to use. Ergonomic Simulation can be used as a tool to alleviate most of these problems, along with added benefits such as lowered design time/cost, reduction of physical prototypes, increased employee morale, and effective communication.

Use Cases

The following are just a few examples of ergonomic simulation scenarios from Applied Manufacturing Technologies (AMT), a leading automation company with expertise in using ergonomic simulation as a tool to evaluate and improve manufacturing and design processes.

Worker Compensation and Work Related Injury

An assembly line or manufacturing workcell must be designed in order to accommodate specific demands such as:

- Available Space
- Available Money
- Pre-existing Machinery

Usually, we tend to focus on these demands because they are the most quantitative and openly visible to us at the beginning of a project. Unfortunately, these are only part of the “Big Picture”. These demands often show up as upfront costs and are therefore easy to keep track of. What often eludes us is the indirect cost of worker compensation due to work related injury. This cost not only shows up in the form of insurance bills, but also as law suits and disability.

To minimize such costs the assembly line/workcell should be designed with the human factor in mind. One way to do this is to put together a physical mockup. Unfortunately, building a physical mockup is very expensive as prototype parts and assembly line components must be purchased. Also, due to lead time on physical parts, the physical mockup can often not be studied until later in the design process when changes are more costly to make. (Figure 4) A more effective way to design with the human factor in mind is with the use of ergonomic simulation.

Through ergonomic simulation, an entire virtual workcell can be setup and modified dynamically. Also, a range of manikins (virtual human models) can be inserted within the workcell in order to see how they interact differently. In that manner, a workcell can be designed so that it accommodates from a 5' tall woman to a 6' tall man and everything in-between. Tools, parts and equipment can be arranged so that shorter workers do not have to reach above shoulder level, while taller workers do not have to reach below their waist. Designed tools can also be included within the virtual workcell in order to make sure that the worker does not have to assume an awkward posture in order to use them. (Figure 1)

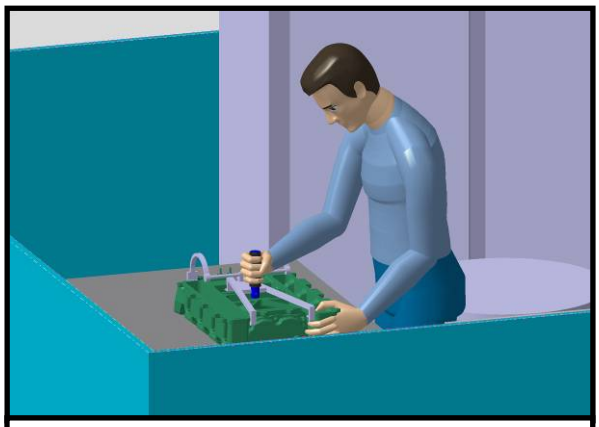

Figure 1: Displays interaction between the human model and concept tooling in the simulation environment.

Efficiency in the Workplace

Waste is something that always costs the manufacturer money. If you can cut waste, you can cut cost. This gain can be seen very clearly by decreasing the amount of waste material. However, this is also pertinent when it comes to wasted time and resources. Large amounts of manufacturing cost can be saved by eliminating waste in the workplace.

Ergonomic simulation can be used both to design a new workcell with human efficiency in mind and also to evaluate an existing line to see how it can be made more efficient. Using the virtual human model, energy expenditure for a specific operation can be determined. Using this as a baseline, the workcell layout, tooling, and equipment can be modified in order to optimize the worker's motions.

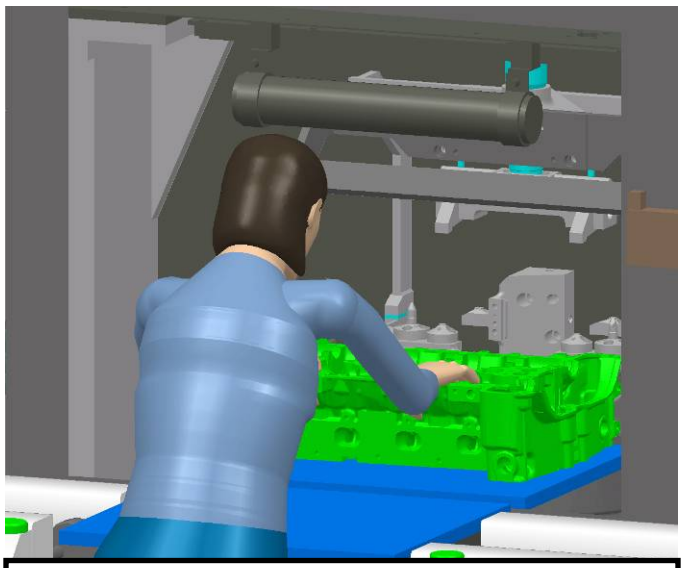

Figure 2: Displays a worker performing one step in a complicated process.

By using the visual elements of ergonomics simulation, non-value-added operations (such as excessive walking) can easily be identified and minimized. The layout of a workcell can also be adjusted so that the worker as a resource is optimized. By using realistic human motion in the ergonomic simulation software, a cycle time estimate can be generated and used for throughput simulation in order to develop a more efficient line, for the entire process. Every step of a complicated process can be analyzed, in detail, to ensure that nothing has been left out (Figure 2).

Quality Control

One of the most important characteristics of a product is its quality. Product quality is often directly linked to how effectively a worker can do his/her job. Usually, if a specific job is difficult or uncomfortable to do, the quality of that operation is less than other operations. Also, if the tooling needed to perform a specific operation is difficult to use, that tooling is often improperly used or not used at all. Operations not performed as designed will lead to quality issues. Designing a virtual workcell can address these types of issues.

Very often, an operator can be overloaded with tasks and may accidentally skip steps, leading to quality control issues. In this case, ergonomic simulation can be used in order to evaluate all the operations performed by a worker. Wasteful operations such as part reorientation can be identified and addressed within the virtual environment. By minimizing or possibly eliminating wasteful operations that a worker must do, the worker will have more time to ensure that quality is maintained when performing manufacturing operations.

Discomfort in the workplace often leads to worker distraction. If workers are not able to focus on the job, they often overlook quality indicators that would otherwise be caught and fixed. Ergonomic simulation can be used to measure specific factors of an operation that are related to the amount of discomfort associated with that operation. The workcell layout and/or operation may then be modified in order to minimize the factors that are related to operator comfort.

The interaction between tooling and the operator can also be evaluated using ergonomic simulation. Portions of the tool such as handles and buttons can be evaluated to determine what is reachable by the operator. Also, the extent to which the tooling blocks the operator's view can often lead to quality issues. Operations can be seen from the worker's point of view in order to determine whether or not the tooling is blocking the operator's view. (Figure 3)

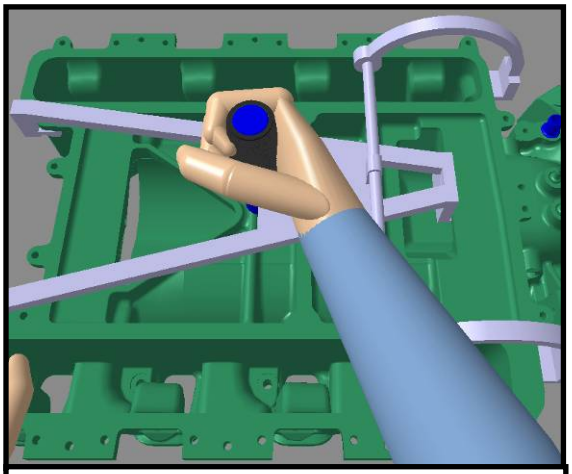

Figure 3: Displays the view point of the worker within the simulation

End Product "User Friendliness"

How easy and comfortable a product is to use often determines whether or not the end user will purchase it. Often times, this "user friendliness" is evaluated by producing a prototype part and actually using it. This gets the job done, but comes with some limitations. Prototypes are expensive. Often they require specific manufacturing before equipment is purchased, so fabrication must be done by an outside source. A product redesign requires another design to be established and another prototype to be built. This becomes a vicious circle as prototype production time eats into design time and product redesign time sets back the amount of time needed to produce a prototype.

Ergonomic simulation can be used to evaluate the "user friendliness" of a product before any physical parts are made. By using a virtual human and product in the same 3D simulated

environment, their interaction may be studied and any problems encountered are identified, before developing physical parts. Hand clearance can be analyzed in order to ensure that a product can easily be used and maintained. Such clearance can use multiple virtual hand models in order to ensure that this study is viable for a variety of populations (Figure 4). In some cases, the results of an ergonomic simulation study can be exported from the software as 3D geometry and given to the product designers as feedback on design modifications. (Figure 5) This feedback closes the design loop. Changes to the product can be made at an earlier design stage, which costs less since no physical parts have been produced. (Figure 6)

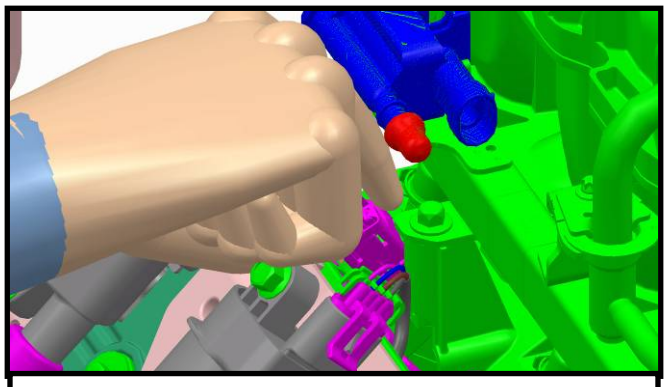

Figure 4: Displays a close view of a hand clearance analysis.

Figure 5: Displays the 3D geometry generated from the human model's reach envelope

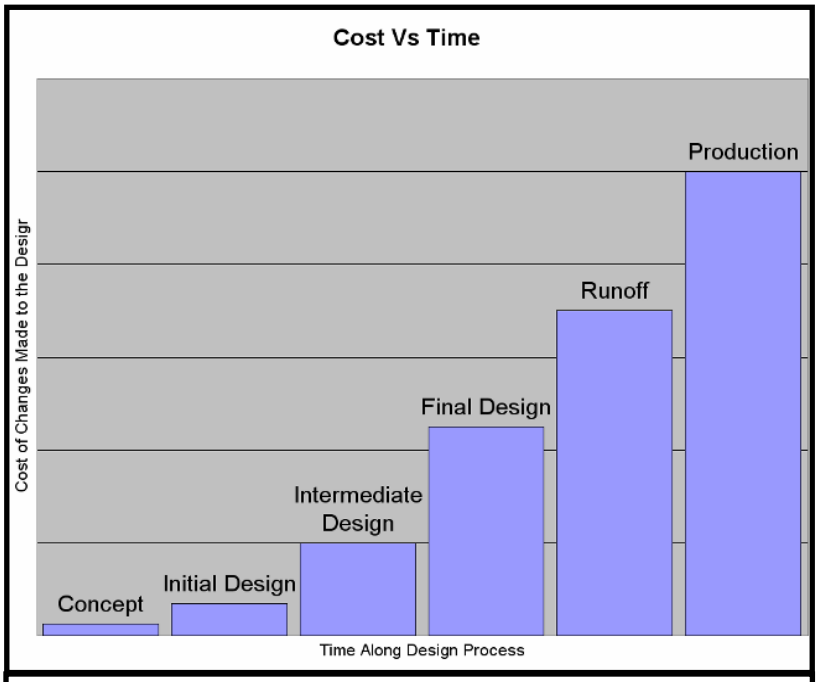

Figure 6: Displays the relationship between the cost of making changes to the design at different phases of the design process.

Making Ergonomic Simulation Work for You

Realizing all of the possible benefits of ergonomic simulation is easy. The difficult task is to evaluate your current and future processes, determine where improvements can be made and how ergonomic simulation will help you make those improvements. AMT has helped companies in the automobile, aerospace/aviation and defense fields make just such improvements. The company has close ties to several universities who are revolutionizing the ergonomic simulation field through ongoing human motion/behavior research. AMT's software development group can write macros that embed a company's specific ergonomic standards into the ergonomic simulation tool. The company specializes in several ergonomic simulation software tools, such as:

- DELMIA D5 ERGO
- DELMIA V5 HUMAN
- Tecnomatix eM-Human

Handling Ergonomic Simulation "in-house"

Even if you have all of the resources necessary to perform ergonomic simulation studies in-house, you may still wish to consider an experienced third party to help you get started. Outside objective insight can often help pinpoint ways to increase your manufacturing efficiency. Additionally, no matter how good training classes are, problems will arise once you begin doing real work with real results. Having an experienced professional to call on will help you get through such roadblocks more quickly. You also want to make sure that you aren't spending too much for software. With so many different software vendors providing a multitude of packages, it is difficult to know you are choosing the right tool for your process. An experienced software consultant can guide you through the selection process.

Getting Started

After exploring the many benefits of Ergonomic Simulation, you may be ready to get started or simply interested in what it would take to get started. Following is a list of typical questions that would be asked when putting together an Ergonomic Simulation Study.

Current Process

- What is your current process for ergonomic evaluation?
- At what stage do ergonomic evaluations take place?
- Is your process focused on Manufacturing, Product Development, and/or Maintainability?

Data

- What form is work cell/plant layout data in? At what point in the process is it available?
- What form is machinery data in? At what point in the process is it available?
- What form is tooling data in? At what point in the process is it available?
- What form is product data in? At what point in the process is it available?
- Should ergonomic models represent a specific regional group?
- What range of sizes should be considered for ergonomic models?

Problem Definition

- What is the general problem?
- Why is this a problem?
- Are there any known problems?
- Have problems like this one been encountered before?

Results Desired

- Would you like suggestions on how to change the operation(s) to eliminate/minimize ergonomic stressors?
- Would you like problem areas of a specific operation(s) highlighted in a report?
- Should specific ergonomic standards be used in order to determine evaluation results?
- Is a full-motion simulation required?
- Is there a company specific report template that should be used to report results?

Conclusion

Ergonomic simulation is becoming a major tool for assessing ergonomic stressors in the workplace and can be used as a tool to alleviate many of your workplace challenges. Additionally, it can result in many other benefits including lowered design time/cost, reduction of physical prototypes, increased employee morale, and effective communication.

AMT will:

- Help you determine which tool best fits your business.
- Work with you in order to define/refine your process.
- Work on-site and/or remotely in order to simulate ergonomic operations.
- Develop ergonomic simulation tools custom-designed for your company's ergonomic standards.