Unverferth Manufacturing

Customer Success Story

Algor® Professional MES

Using Algor on this project likely saved at least one generation of prototypes, which amounts to tens of thousands of dollars.

—Richard Anderson
Product Engineer
Unverferth Manufacturing

Shorten design cycles.

Unverferth Manufacturing uses Algor® FEA to optimize design of innovative agricultural equipment.

Humans have been using tools to make farming easier since the dawn of civilization. Since the turn of the 20th century, the use of mechanized power to till and sow fields has enabled farmers to realize incredible efficiency gains in the production of low-cost, safe, and nutritious foods and other crops, such as fibers. Today, bigger machines require less manpower to plant the crops that feed and clothe a swelling world population.

Unverferth Manufacturing Company, Inc., has been serving the changing needs of America's farms since 1948. To design a more robust product and meet a tight deadline, Unverferth Manufacturing recently used Algor finite element analysis (FEA) software to speed up the design cycle for its new 12-row, folding-frame Ripper-Stripper® strip-till subsoiler, which prepares 10-inch-wide seedbeds spaced 40 inches apart, a width that is commonly used in cotton production.

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Engineers at Unverferth Manufacturing used Algor linear static stress analysis to optimize the thickness, shape, and material of the frame, hitch, and hinge components to reduce high stresses.

Challenged by Deadline

Just a few years ago, engineers at Unverferth Manufacturing based designs on experience, hand calculations, and field testing. When FEA was necessary, they outsourced their analysis work. Their investment in FEA had been the answer to the question of how to more quickly develop reliable new products.

"When choosing an FEA package, we were impressed with the direct CAD/CAE data exchange and meshing tools of Algor's InCAD technology and the option of using Algor's Mechanical Event Simulation for combined motion and stress analysis," says Richard Anderson, product engineer. "We even tried an analysis add-on to Mechanical Desktop that was geared toward the design engineer, but the analysis controls were oversimplified and when we got unexpected results, it was too difficult to figure out why. Once we started looking at the capabilities Algor offered, we quickly became convinced that this is what we wanted and needed."

Through 2001 and 2002, engineers at Unverferth Manufacturing used Algor FEA on a number of projects, most of which involved the analysis of single parts or small assemblies. At the end of 2002, a much larger FEA project presented itself. The company was looking to expand its Ripper-Stripper product line.

The Ripper-Stripper subsoilers are designed to prepare seedbeds for planting by cutting through growth from the prior year. The subsoiler's long, slender frame attaches to a tractor using a standard three-point hitch. Pointed, curved shanks extend below the frame to break up soil as deep as 18 inches. By breaking up the soil, roots, moisture, and nutrients can move freely through the subsoil to promote plant growth. Unverferth Manufacturing's new addition to this product line would save cotton farmers time in preparing their fields for planting by offering a subsoiler that would prepare more rows simultaneously.

Work on the project began in late autumn of 2002. Since cotton planting begins in southern United States in February, Unverferth Manufacturing had less than three months to design and produce prototypes of this new product and get them into the fields for testing. To meet the challenge, Director of Engineering David Smith put together a team that included Product Engineers Richard Anderson and Bill Maenle and Design Engineer Tom Steffan.

These engineers had never attempted a project of this complexity with such restrictive time limitations. "Prior to this project, all of our FEA projects had been far less complex, and we had up to six months to optimize the design before a prototype was produced," explains Steffan. "When the plan to design the larger subsoiler and build prototypes in less than three months was presented to me, my first reaction was that it could not be done. We had analyzed a similar but smaller, rigid-frame subsoiler that allowed for a maximum of eight 30-inch rows for a previous project and based on those results, we had serious concerns about whether this design could be made wider to work on a greater number of rows."

The new design would not only accommodate up to twelve 40-inch rows, but would need to incorporate a folding frame, which increased the complexity of the design and introduced additional loading scenarios. "The folding frame must consider the loads in the hinges as well as the cylinder loads needed to fold the frame, and those can be significant," explains Anderson. The team was counting on FEA to help them quickly optimize this new product.

Putting the Ripper-Stripper Subsoiler Through Its Paces with FEA

The team started with a few new ideas that would not completely change the design from the smaller version and would be made of parts that were already in stock for existing products. By minimizing the number of unique parts that the new subsoiler would use, the team hoped to keep manufacturing costs down.

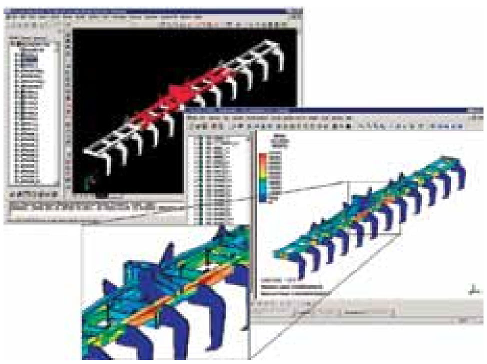
Maenle modeled the design in Autodesk® Mechanical Desktop® software. Steffan then prepared the assembly to be brought into Algor. "I used Mechanical Desktop to eliminate the tolerance gaps that are built into the original design for manufacturing purposes," says Steffan. "This ensured that parts mated properly for FEA. I also removed small parts that were insignificant to the analysis results."

Steffan then used InCAD technology to directly capture the 177-part Mechanical Desktop assembly for a series of linear static stress analyses. "I value InCAD technology because it enables me to produce an FEA model by simply clicking a button," he says. "I also appreciate that Algor is continuously improving meshing technologies to make them faster, more foolproof, and easier to use."

The 12-row Ripper-Stripper subsoiler project is the largest of a dozen projects for which engineers at Unverferth Manufacturing have used Algor software in the last year.

Steffan tried various mesh sizes before finding one that best suited his needs. "The design uses a lot of tubing with thin walls," he says. "The mesh needed to be large enough that the analysis would run quickly, but small enough to accurately capture the detail around the weld joints."

The design was then put through its paces with a series of linear static stress analyses that simulated conditions the subsoiler would experience while pulling through hardpan soil, lifting out of the ground, folding up its massive 10-foot wings, and being transported. "For the load cases we had planned, we decided that linear static stress analysis would provide the insight we needed," says Anderson.



For each analysis iteration, Steffan looked at displacement and von Mises stress results. "I like to look at displacements first because if the loads or constraints are not quite right, the problem will be obvious," comments Steffan. Stresses were then compared to the material yield point with a factor of safety applied.

The overall strategy was to first optimize the geometry, including the thickness and shape of the components, to distribute the loads as much as possible while minimizing the weight and then consider stronger steel alloys for high-stress areas. They also minimized the size of the parts that used more expensive alloys to control material costs and tried to stay with materials that were already used in other products. Making changes was complicated by the fact that the subsoiler has several possible configurations to accommodate different widths of rows and allow for a variety of attachments. "In all, there were 16 different configurations that needed to be considered," says Anderson.

The first scenario was a calculated "pull" load that simulated the stresses the subsoiler would experience when the shanks pull through approximately 18 inches of soil. For this scenario, the hitch was constrained and a horizontal load was applied to the point of each shank. The part of the assembly most affected by the pull test was the three-point hitch. "This 40-foot wide machine is pulling at about 3 feet wide in the middle," says Steffan. "We tried several hitch options and optimized the most robust design by strengthening the cross members until it passed."

The second scenario was the "lift" load that simulated the stresses that would be produced when the subsoiler was lifted out of the soil. Again, the hitch was constrained. This time, a vertical load was applied to the point of each shank. Based on these results, the shape of the large mast plate in the center of the subsoiler was optimized to reduce stresses to an acceptable range without adding weight. After optimizing this part, the pull test was rerun to verify that these changes did not affect the performance of the subsoiler in that scenario.

The third scenario looked at a worst case involving an attempt to fold the frame under full tractor hydraulic power. With the frame in its flat operating position, constraints were applied to the hitch and the two ends of the frame. The full hydraulic load was applied as forces to the wings.

In this scenario, analysis results revealed high stresses in the hinge area. After a half dozen iterations to optimize the design for the folding load, the team repeated the first two loading scenarios and found that the new design did not pass the pull test. Further alterations had to be made to the hinge to accommodate all three load cases.

The final scenario that the team considered was road transport, in which the fully constrained hitch must bear the dead weight of the assembly. The least demanding of the four scenarios, the analysis verified that the design would withstand road transport.

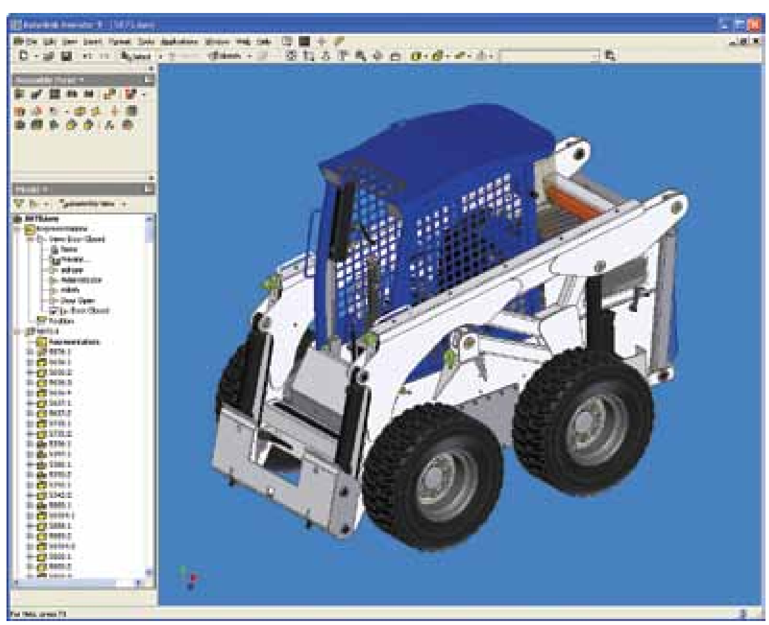
Finishing Strong and on Time

Overall, there were nearly three dozen iterations performed. "Using Algor FEA, we were able to increase the capacity of the frame tenfold with a total weight increase of only about 60 pounds of steel, which is less than 1 percent of the total weight," says Anderson. "We were able to accomplish this because the FEA results consistently let us know what parts needed to be optimized and where we could reduce material to keep the weight down. As a result, the subsoiler can be lifted with many tractors' three-point hitch. We developed an optional lift-assist wheel package for tractors with lower hydraulic lift capacity."

The final design did not require the company to work with any materials that were not already in use, but it did create a number of new parts. "Our first concept consisted primarily of existing parts," says Anderson. "The FEA results told us that this was not a good design. Although the final design looks similar to our other products, 50 percent of the parts are unique."

The Ripper-Stripper subsoiler exceeded field-test expectations during the 2003 planting season and is available for the 2004 planting season.

"Using Algor software on this project likely saved at least one generation of prototypes, which amounts to tens of thousands of dollars," says Anderson. "Also, if the lift-assist wheel package had been mandatory for all tractors, the cost of



the final product would have increased by several thousand dollars. Beyond these direct costs, we got the project done on time and therefore saved the indirect costs of a minimum one-year delay. A tillage attachment like this one is only used four to six weeks out of the year. If we had not produced workable prototypes for field testing and delivered them by mid-February, the entire project would have been delayed a year and we would have missed an opportunity to quickly get the product to market. In addition, the final design is stronger, which will save us the cost of field fixes that probably would have occurred in the second or third year with the initial concept. The final design we arrived at using Algor FEA not only performed well in field testing, but indicated that its long-term durability and reliability will be outstanding."

That long-term durability is good news to Unverferth Manufacturing's director of engineering, David Smith, who comments, "I sleep better at night knowing that we optimized our design with Algor FEA software."

FEA Changes Unverferth Manufacturing's Design Cycle

The 12-row Ripper-Stripper subsoiler project is the largest of a dozen projects for which engineers at Unverferth Manufacturing have used Algor software in the last year. "Algor FEA has changed the way we design products," says Steffan. "Two years ago, FEA was not part of our standard design cycle and now we do not hesitate to use it."

The company has seen benefits not only in the length of its design cycle, but in the quality of the designs their engineers can achieve. "On average, we find that by adding 2 percent to the material cost of a product, we can increase the design's ability to withstand loads in the field by up to tenfold," says Anderson. "That makes FEA a valuable tool for us."

For more information visit **www.autodesk.com/algor.**

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Images courtesy of Unverferth Manufacturing.

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