Design and Analysis of a Panel Using FEA

V. S. Shaisundaram, L. Karikalan, S. Ramasubramanian, S. Baskar, and R. Balaji

Abstract The proposed design of the device comprises a steel support built akin to a crane. To this, some procured pre-assembled components and drive systems are mounted. The drives, in total, are multi-axis modular systems formulated to execute the desired panel handling operations. The mechanism is operated using pneumatics and has rudimentary linking and mounting assemblages. Every other modular drive systems put forth amongst constituents of the machine design are incorporated with analogous interface systems. Employment of modular drive systems benefitted copiously, some of which include: time-saving and less complex design and efficient, project scheming procedure, a prompt system aggregation of the system, high mechanical rigidity, and access to pre-existing CAD drawings for ideal designs. The proposed design encompasses three significant pneumatic-driven modular systems. The horizontal and vertical translations of the panels are assisted by the two linear gantries. And, the two actuated swivel drive systems and two gripper jaws execute a 180° panel rotation and help safeguard the panels throughout the entire procedure.

Keywords Radiator panel · FEA · Structural analysis · Machine design

1 Introduction

The present design of the MTM's equipment needs a physical operation of individual radiator panels, with the help of a pair of operators that transfer the panel from roll form press to that of the consecutive spots and seam welding processes. This assemblage of radiator panels (from the roll press) needs manual rotation of the first of each pair of panels; it's the placement and alignment on the successive panel and preparing for the spot welding operation. The linked panels, at the indexing work station, are protected and propelled by a hydraulic arm, preparing them for the ultimate seam welding process. An automation process is used in the machine design to help eradicate the manual handling of radiator panels that MTM demands. Primary

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to the design project, MTM necessitates is the necessitation and anticipates the team to cultivate a theoretic automated machine system for the purpose of orientation, alignment, and indexing radiator panels while they exit the roll form press [1–3]. There are certain requirements for the machine design, they are capacity to provide room for variable panel dimensions, mechanical reliability, and a rotation of about 180° along the horizontal axis exclusively on the first of each two panels. Prior to indexing the paired panels into a spot welder and making ground for the subsequent seam welding operation, MTM additionally needs a machine design that facilitates a source to align them (paired panels). Lastly, it requires a machine aggregation design that could exterminate human panel handling and contribute to quality development through amplified alignment accuracy. All along the entire design process, MTM mandates the team to study and contemplate the potential variations in assembly-line setup and building space and consider the varied identified panel sizes and speed conditions of the roll form [4–7].

1.1 Design Overview

The automated panel rotation machine integrates the use of a crane-like design for rotating the first of each two panels that come out of the roll former [8]. Fundamentally, this design pulls the panel escaping the roll former from the top, grips the other end and lifts it, and rotates and seats the panel back on the bed. The adjacent panel is taken and positioned on top of the first one along the end of the table. In enabling the crane to accomplish the desired task, varied motions and components are employed [9–11].

The linear gantry, a more recent innovation, has limited features. A practical CAD model for it, in a specifically required length, was unavailable at FESTO, the manufacturer of a bunch of components used in this design. The structures/components missing include connection plates and parts between the two horizontal drives, the joining between the vertical drive and the pneumatic drive, and also a meticulous analysis of the connection to the structure. For the aforementioned ones, assistance shall be sorted from a FESTO representative [12–16].

2 Design Methodology

Knowledge of the forces experienced by the components is essential to accurately specify components. These forces are attributed to the deflection of the panel, a large one, because the panel is very long and thin and is only being supported at two end locations. The completion of static force analysis is followed by dynamic analysis.

2.1 Static Force

The model used was a replica of the wide panel. On account of the complex nature of the geometry, the model was studied using Finite Element Analysis (FEA). The thin nature of the panel required that a shell mesh was performed.

The FEA was done using Solid Works. Defining the shell features and meshing the panel were the initial steps performed. The default mesh relevance was picked up for the current model. Two permanent supports were used to support the flange risers' margins in each panel. The upper jaw is intended to recline on this face, hence it's here. Gravity was the only force operating on the panel in all of these situations, resulting in an even weight distribution.

Initial tests using the small displacement option revealed a solver error, indicating that bigger displacements were predicted and recommending that the model be run with the alternative. A simple hand calculation was done to give an approximation for the panel's centre deflection to verify the FEA estimation. A beam deflection equation for a simply supported beam with an evenly distributed load is used to calculate the panel's highest deflection. The above equation represents the uniformly distributed load, the length of the panel, the elastic modulus of the material, and the moment of inertia for the entire panel. This panel was chosen because it exemplified the worst-case scenario (as if there is play at the gripper end). Based on the panel's volume and density, the uniformly distributed load is calculated. Because the panel is formed of A36 steel with a density of and a modulus of elasticity of the dispersed load, the associated deflection is equivalent to the following. The models can now be compared to choose the best depiction now that the panel's deflection has been approximated. Using the minuscule deflection, the maximum deflection of the panel was determined, and this displacement is shown in Figs. 1 and 2.

These are more significant than the analytical calculations, indicating that the larger displacement model is a viable choice. It is accomplished by relocating the fixtures at one end to a roller support, allowing one end to move. The huge displacement option would, therefore, allow for the calculation of the fixture's displacement. The path to be taken can also be determined at some point. On the flange riser and

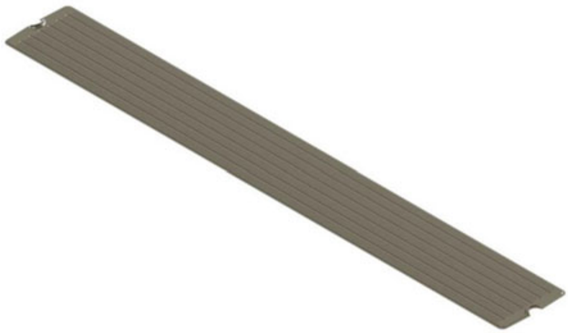

Fig. 1 520 × 4000 mm panel CAD model used in FEA

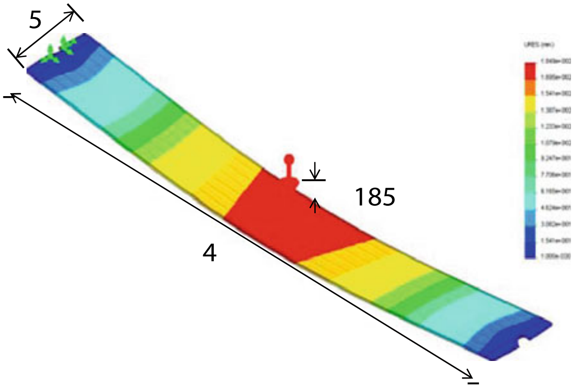

Fig. 2 Displacement of 520 × 4000 mm panel with small displacement setting

the flat surface of the flange riser, the prototype features one fixed support and one roller support, respectively.

2.2 Location of Roller Support

Following the trial, the roller support displaces to a comparatively longer distant position. Owing to this dislocation, FEA could prefer larger displacements within the solver (Figs. 3 and 4).

A large displacement option was thought to be necessary. The panel's displacement, accompanying stress, and forces were studied as they passed through the system. With the fixed support in place, the panel's maximum displacement was calculated, and this deflection is illustrated in Fig. 5.

Since the yield strength of the material is high and there is no chance of yielding, this test certifies the maximum stress that the panel is exposed to. The location of

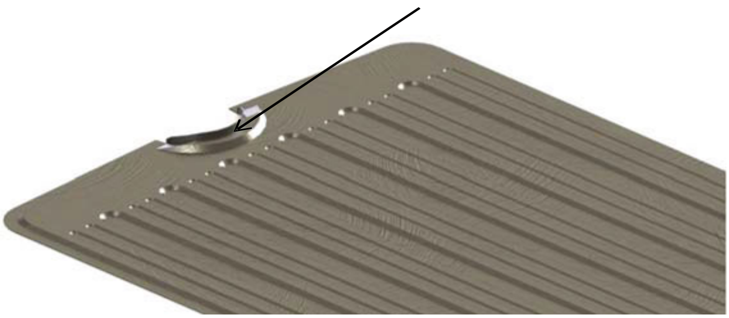

Fig. 3 Location of roller support for proof of large displacement test

Fig. 4 Displacement of panel relative to the roller support

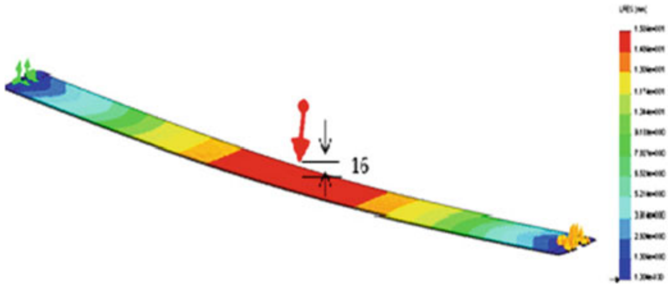

Fig. 5 520 × 4000 mm panel displacement

high stress is shown in Fig. 6. It first appears on the flange's adjacent fillet. The moment that this zone passes through can be attributed to the occurrence of the highest stress in a certain region. The stress concentration in this area is exacerbated by the fillet's radius and its change in geometry. The reaction forces on the fixed support and in both directions of the gripper were then discovered. These forces are significant because they will be experienced by other feasible devices on the gantry arms in axial or moment forms.

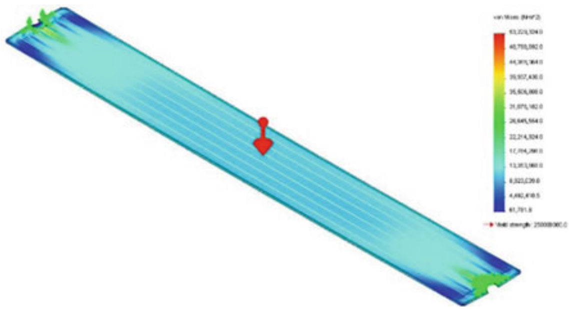

Fig. 6 Stress distribution in the panel

3 Conclusion

All panel handling induced static and dynamic forces were analysed as part of the design process. The panel's static and dynamic clamping forces were discovered and allowed, allowing precise gripper forces, motor torque, and lifting force conditions to be determined. These tests were necessary to see if the panel handling methods and forces may distort them perpetually. The utmost forces resulting from the panel handling courses were discovered to be beneath that of the panel materials' yield stresses. In addition, an inference that there is hardly any possibility of persistent panel deformation through panel handling methods was made.

Additionally, an examination of the gripper jaw attributes and its boundaries was performed. The gripper jaw constituents must be efficient, robust, and failsafe. The last analysis graded the gripper jaws with safety factors that make it improbable for them to fail. Because the upper gripper jaw was designed with a bevelled edge, this was possible. As a result, the jaws were able to centre and pick up the panels properly and consistently. Furthermore, these gripper jaws are designed to retain panels that have a minor skew or are slightly off-axis when they exit the roll forming. As a result, the proposed grippers are better equipped to complete the task.

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