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# Impact Stress Analysis for the Welding Joint in a Rotary Dryer

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**ABSTRACT:** This paper discusses the failure phenomenon of the welding joint for the flight bars in a rotary dryer under impact loading. The flight bars are utilized to provide a curtain of particles and to avoid direct cohesion of the production to the steam tubes. In addition, some gravitational hammers knock off the shell's outer skin to fall off the product buildup on the shell's inner surface. The condition monitoring has revealed that periodic impacts of hammers on the outer skin will result in welding joint failure between the flight bars and the shell followed by a complete detachment. Assuming that the hammer impacts the shell by a constant rotational speed, finite element software is employed to simulate the mentioned problem. According to the results, severe stress concentration and plastic deformation arise around the roots of welding joints. To prevent joint failure, different mechanisms are proposed such as relocation of the welding joints, employment of the stiffening angles, and an increase in the thickness of the absorbing pad. The outcome of the current study showed that relocation of the welding joint toward the flight bar end and the application of a stiffening angle can decrease the maximum von Mises stress by a factor of 18% and 43%, respectively. Moreover, using a composite absorbing pad will decrease the von Mises stress around the welding joint root by about 80%.

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## 1- Introduction

The impact behavior of welding joints is an important issue in metallic structures. The filet welds are designed to provide a higher static strength compared to other joint components. The welding joints have low ductility and their impact strength is sensitive to the strain rate and the plastic work softening. Huo et al. [1] studied the dynamic behavior of the welded H beams. They showed that an increase in the width-to-thickness ratio for the flange significantly reduces the beam impact strength. Chen et al. [2] investigated the impact behavior of the beam-column joints. Their results indicate that the impact speed has a more pronounced effect compared to the mass of the impactor.

## 2- The Problem Statement

The flight bars are devised to provide a uniform distribution of the product within the dryer and to enhance heat transfer. The flight bars are welded to the shell using Tungsten Inert Gas as shown in "Fig. 1". The cyclic impact loading of the gravitational hammer on the outer shell skin can induce a significant localized stress distribution around the welding joints' corner. The elastic constants for all components are approximately taken as $E = 200\text{GPa}$, $\nu = 0.3$ and the yield strength is set to be $\sigma_y = 275\text{MPa}$. The welding joint elastoplastic behavior is adopted from TIG-welding of type 304 stainless steel referring to [3].

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## 3- The Finite Element Modeling

The finite element model schematic is shown in Fig. 2. Abaqus general-purpose tetrahedral (C3D4) and linear brick (C3D8R) elements are employed to provide an appropriate mesh refinement around the welding joint corners. The interaction between the impactor, the absorbing pad, the outer ring, and the shell is assumed to be a frictionless normal contact utilizing the Surface-to-Surface contact option. The tie constraint is used to model the welding joint between the flight bar and the shell. The gravitational hammer knocks off the absorbing pad with a constant rotational velocity of $\omega_0 = 9\text{rad/s}$. The dynamic explicit approach is carried out to extract the transient behavior of the localized stress distribution around the welding joint corners. An acceptable convergence is obtained for a total number of 60,000 elements.

## 4- Results and Discussion

The early-stage analysis revealed that a high-stress gradient occurs at the welding joint corners as illustrated in Fig. 3. The variation of the von Mises stress versus time for the corner points ($P_1$ and $P_2$ in Fig. 3) is provided to study the effects of design parameters, namely: longitudinal position of the welding joint, application of the stiffener, the weld dimensions and the absorbing pad structure.

The center of the original weld aligns with the impactor centerline. The center of the welding joint is moved forward


Fig. 1. The location of welding joints on the flight bars

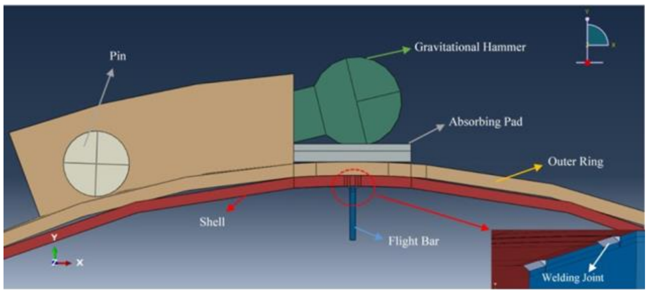


Fig. 2. The finite element model of the problem

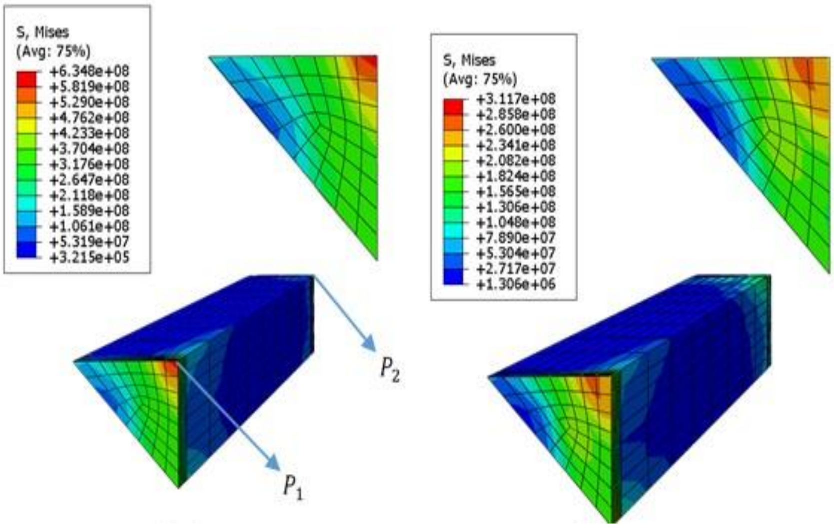


Fig. 3. von mises stress distribution for the welding joint

or backward longitudinally for a distance equal to its half-length. The corresponding stress distribution is given in Fig. 4. For the forward placement, the maximum von Mises stress at the corner points decreases by a factor of 18% with respect to the original model. On the other hand, the backward placement of the welding joint may increase the maximum von Mises stress compared to the original placement.

The welding joint strength may be increased with the aid of a longitudinal stiffener as shown in Fig. 5. The stiffener is a right-angle section with a thickness of 3mm. It can be observed that the maximum von Mises stress decreases by a factor of 43% in comparison with the original welding joint.

As an alternative solution, the absorbing pad thickness and the material combination is altered to reduce the impact loading transferred to the shell. The results indicate that an increase in the pad thickness has no significant effect on the maximum von Mises stress. On the other hand, a bi-layer absorbing pad (which consists of an aluminum layer bonded to the original steel pad) can considerably decrease the severe stress gradient around the welding joint corner as shown in Fig. 6.

Finally, we study the effect of welding joint geometrical dimensions on the maximum von Mises stress behavior. Both the length ($L$) and the leg ($W$) of the weld are increased by a factor of 50% with respect to the original weld dimensions. The results presented in Fig. 6 indicate that the stress reduction is around 14% and 6% for a 50% increase in the length and the leg, respectively.

## 5- Conclusions

The impact stress analysis for the welding joint of a rotary dryer was investigated. The effect of several design parameters on the welding joint strength was studied by means of the finite element method. According to the results, the application of longitudinal stiffener offers a significant reduction of the severe stress gradient in comparison with the original model. As a simple alternate remedy, the welding joint longitudinal placement can decrease the von Mises stress by a factor of 18% with respect to the original model. A composite bi-layer pad can considerably suppress the impact energy transferred to the welding joint.

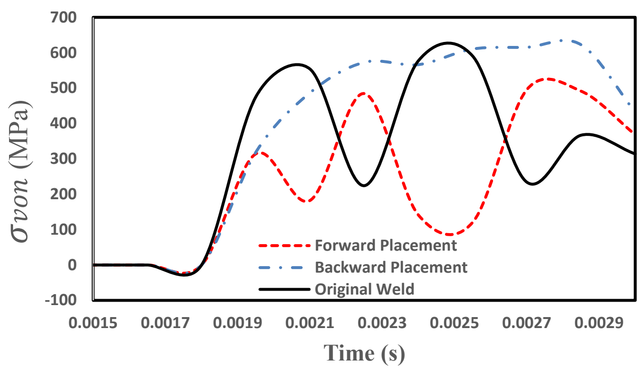


**Fig. 4. Variation of the maximum von Mises stress for different longitudinal placements of the welding joint**

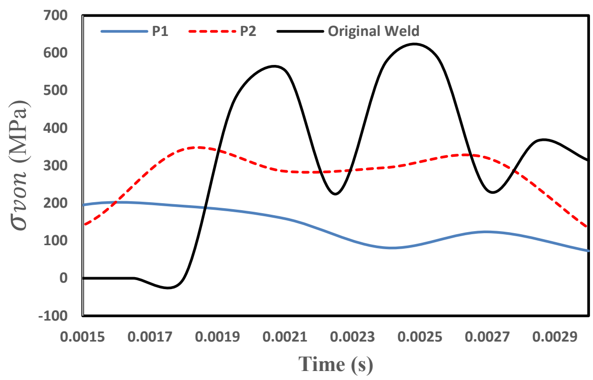


**Fig. 5. The variation of von Mises stress in presence of the longitudinal stiffener**

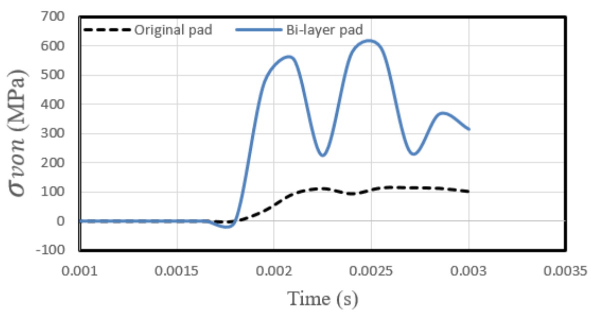


**Fig. 6. Variation of the maximum von Mises stress for a bi-layer absorbing pad**

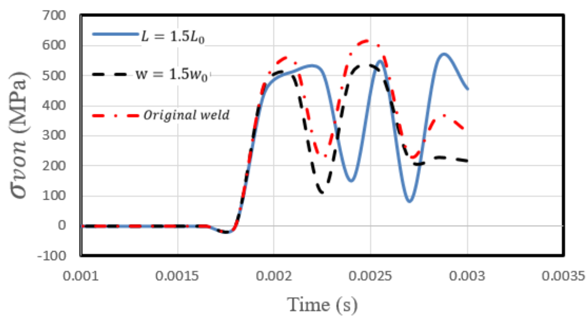


**Fig. 7. The effect of welding joint dimensions on the maximum von Mises stress**

## References

[1] J. Huo, J. Zhang, Y. Liu, F. Fu, Dynamic Behaviour and Catenary Action of Axially-restrained Steel Beam Under Impact Loading, Structures, 11 (2017) 84-96.

[2] K. Chen, Y. Zhang, K.H. Tan, Behaviour of steel beam-column joints subjected to quasi-static and impact loads, Journal of Constructional Steel Research, 183 (2021).

[3] E.O. Ogundimu, E.T. Akinlabi, M.F. Erinosho, Study on Microstructure and Mechanical Properties of 304 Stainless Steel Joints by Tig–Mig Hybrid Welding, Surface Review and Letters, 25(01) (2018).

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