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ASPECTS REGARDING THE BEHAVIOUR OF THE WORK EQUIPMENT OF A LOADER DURING THE WORK PROCESS

PhD. Lecturer Aurora POTÎRNICHE
PhD. Assistant Gigel CĂPĂȚÂNĂ
"Dunărea de Jos" University of Galați,
Faculty of Engineering and Agronomy in Brăila,
Research Center for Mechanics of Machines
and Technological Equipments

ABSTRACT

This paper deals with the study of the work equipment consisting of the bucket and its supporting frame for a front loader. For the two components of the equipment, 3D models were generated in the Solid Edge design software and then they were introduced for analysis in the Algor software, specialized in finite element analysis. The goal of the finite element analysis was to observe the state of stresses and deformations that occur in the work equipment of the loader during the working process, when on the bucket and on its supporting frame appear stresses which can become dangerous. The results obtained provide specialists in the construction equipments domain with information that can be used to improve the working performance of such equipments.

KEYWORDS: Front loader bucket, support frame, 3D model, Solid Edge design software, specialized software of finite element analysis, state of stresses and deformations

1. INTRODUCTION

The multitude of construction works with variable volumes from very large to medium or small determined two main directions of development of machine systems for mechanization of construction works: specialization and universalization. In the direction of specialization, it was produced specialized machines with high powers and high productivity, and in the direction of universalization, multifunctional machines have been made with the possibility of performing different operations by quick and easy changes of work equipment.

2. THEORETICAL APPROACHES

Loaders are construction equipments used for loading the earth or ballast aggregates; the unloading of materials in the means of transport or in heaps; the digging the ground and the transporting it on short distances.

The working equipment of a loader consists of:

- the support frame of the bucket;
- the bucket;
- the hydraulic cylinders for tipping the bucket and for vertical handling of the equipment.

The endowment of universal front loaders can include a diverse range of types of load handling equipments (figure 1):


Bucket with teeth


Bale pliers


Mixer bucket


Garbage fork

Cereal bucket

Claw silo bucket

Fig. 1 Various models for the loader bucket

3. CASE STUDY

For the present paper, following the study of the models from the specialized literature, were considered as known, for the modeling and for the analysis of the support frame and of the bucket of a loader, the main technological and constructive parameters: the power P = 45 HP, the loading capacity of the bucket 0.5 m^3 and the bucket width 500 mm.

The work equipment consisting of the bucket and its supporting frame were made in the Solid Edge software. Solid Edge is a state-of-the-art mechanical design system with exceptional tools for creating and managing 3D digital prototypes.

For modeling, the sketches of the component parts were made with the SKETCH command, the solid was generated using the PROTRUSION command, modification commands such as CUTOUT and HOLE were used to cut regions of the solid and create holes, and at the end ROUND and CHAMFER type commands were used to finish the model.

The modeling results are the solids shown in figures 2 and 3.

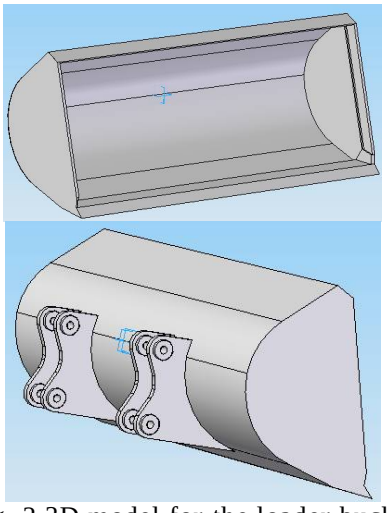


Fig. 2 3D model for the loader bucket

Forward, in this paper, were considered and analyzed two real situations in which the equipment can be found during the work process:

❖ the bucket solicitation in the frontal direction;

❖ the support frame solicitation in the bucket gripping area on support.

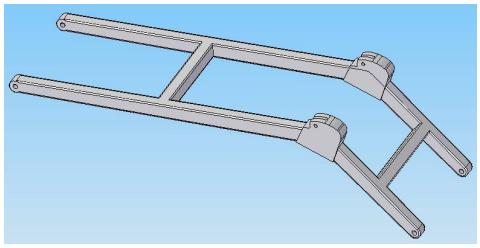


Fig. 3 3D model for the bucket support frame

Both the bucket and its supporting frame were analyzed in a specialized finite element analysis software, ALGOR.

Thus, in a first state, the bucket was considered in the working process and the force of penetration of the bucket into the material was frontally applied along the entire length of the bucket edge. The case corresponds to the real situation of the bucket entering into the pile and hitting an obstacle along its entire length.

The bucket model was introduced into the Algor software and automatically discretized by it (figure 4).

After completing the discretization operation, the support set and the loading set were introduced in Algor. The support was considered of the joint type and dispozed in the clamping lugs of the bucket on the support frame of the equipment, respectively in the clamping lugs of the hydraulic cylinder on the bucket (figure 5). The load was considered as a concentrated force acting frontally along the entire length of the penetration edge, with the total value $F = 23740\,\mathrm{N}$. The value of the force was calculated based on the methodology found in the technical literature and all the nodes from the edge of the bucket were equally solicitated, each node taking over a part of the force (figure 6).

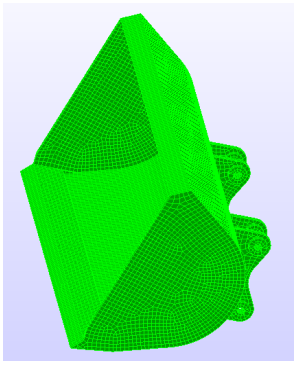


Fig. 4 The discretization of the bucket in Algor

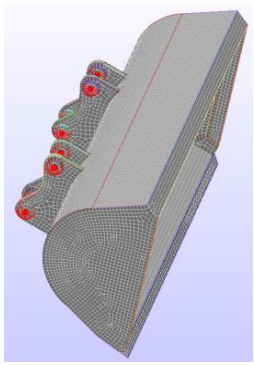


Fig. 5 The defining of the support set for the bucket

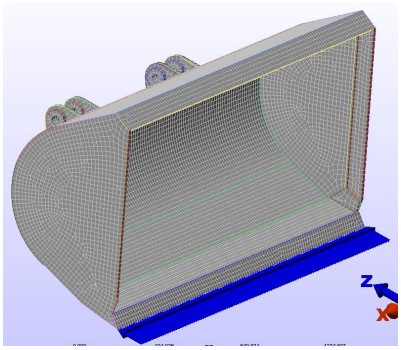


Fig. 6 The defining of the load set for the bucket

From the set of obtained results, it is interesting to visualize the state of stress that appears in the bucket and the displacement of its nodes under the action of the proposed solicitation.

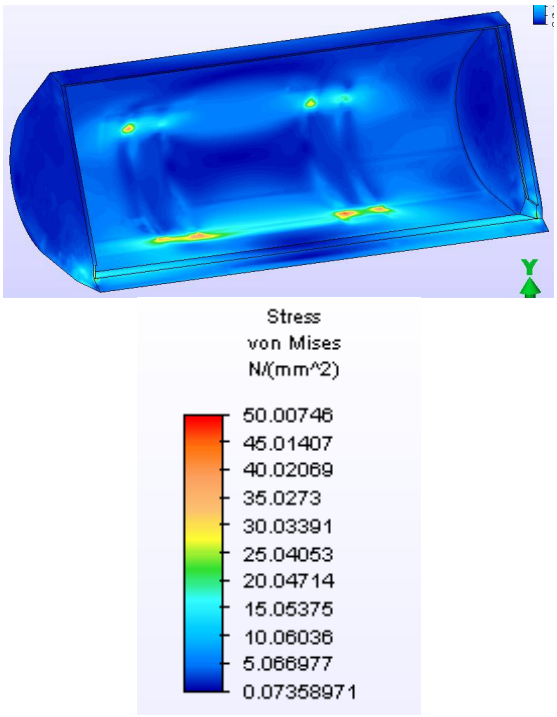
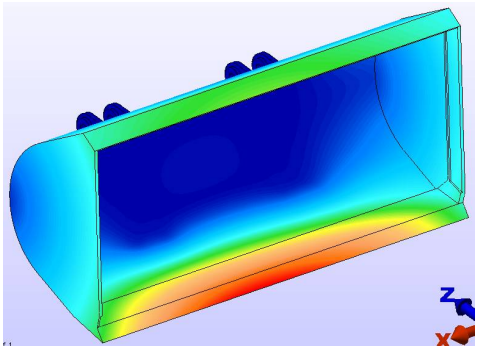


Fig. 7 The viewing of the stress state which appear in the bucket in the case of the proposed solicitation



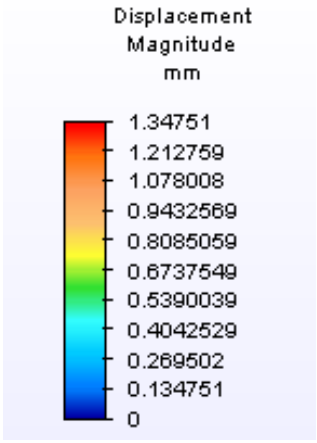


Fig. 8 The viewing of the displacements of the bucket nodes in the case of the proposed solicitation

In a second state, the support frame of the bucket was transferred from the Solid Edge software and automatically discretized by the Algor software (figure 9).

As a support for the support frame joints were considered in the attachment area of the hydraulic cylinders on support and in the attachment area of the support frame on the base machine.

As a load, the support frame was subjected to the action of a force, given by the weight of the bucket full of earth, which corresponds to the real situation in which the loaded bucket is lifted from the ground. The value of the total force is $F = 13538\,N$, calculated on the basis of the formulas proposed by the technical literature. The force was evenly distributed on the two arms of the frame, for reasons of symmetry.

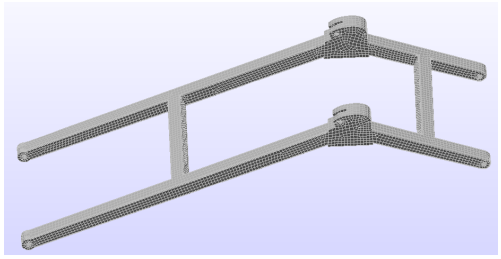


Fig. 9 The discretization of the support frame in Algor

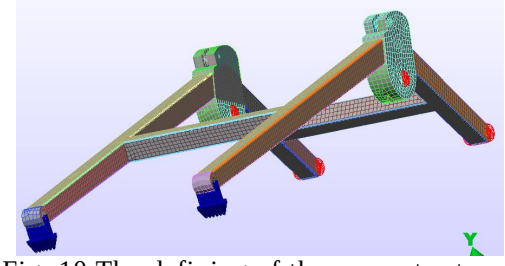


Fig. 10 The defining of the support set and load set for the support frame

The results of the analysis in the Algor software were the state of stress in the support frame of the bucket and the displacement of the nodes on it.

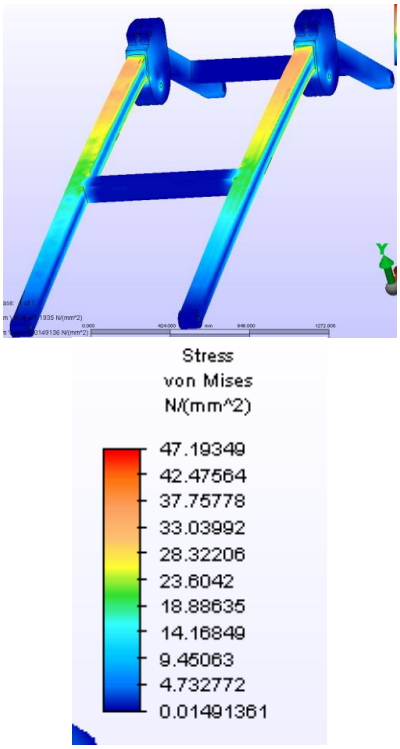
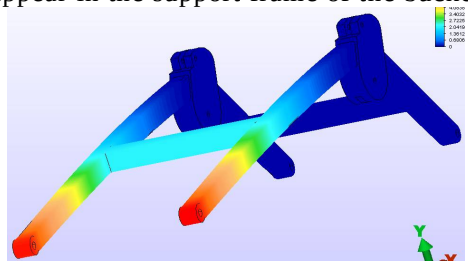


Fig. 11 The viewing of the stress state which appear in the support frame of the bucket



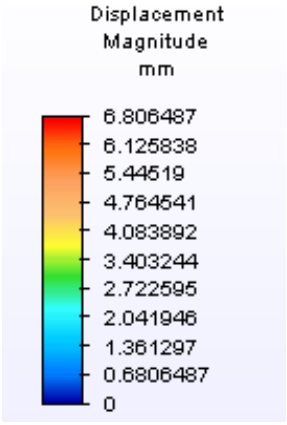


Fig. 12 The viewing of the displacements of the nodes on the support frame of the bucket

4. CONCLUSIONS

In both cases studied, the support tried to respect real cases in which can be found the component parts of the work equipment subject to the analysis process (bucket or support frame of the bucket).

In both loading cases it is observed that both the bucket and its supporting frame are not in danger of yielding in terms of stresses. It is also observed that the displacements of the nodes belonging to the analyzed structures do not have high values in any of the cases.

This paper can be a database that can be used later by specialists in the design domain of loader type machines in order to optimize the functional configuration and operational performance of these equipments.

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