Aspect related to 3D modelling and finite elements study of the lifting platform

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Abstract. 3D modeling of the lifting platform was done in Catia V5R20 software. This soft was chosen as it gives an integrated solution, besides facilities related to modelling with solids which are common to all representative applications this also offers modules intended for stylists this way allowing extension of computer use also on previous stages of constructive engineering. The truck undercarriage is of LT28 type from Volkswagen producer. For 3D modelling, a leaflet from producing company was used. To represent the assembly of lifting platform firstly we realized a 3D model of the vehicle, and thereafter we realized the model of the nacelle type system and the manner of fixing on undercarriage. The finite elements study of the lifting platform was done by using Autodesk Inventor and for starting we determined the initial conditions type of network and material used. The main boom structure is calculated to stand for all stresses the platform is subject to. The structure is so designed that it can be fixed on the vehicle undercarriage frame. As a result of study, its maximum allowable stresses, travels and safety factor can be noticed. The first finite elements study was done on joint area between lifting platform boom and machine undercarriage, initial conditions were set within the study as follows: material mechanical properties type of performed study, force loading. Further to static study, data related to stresses, deformations and safety factor resulted. Maximum allowable stress in the boom of lifting platform has very small values wherefrom results that this stands a force applied on the other end.

1. Introduction
The lifting platforms are intended for performance of construction assembly and repairs on air lines, also being advantageously used within other industrial, commercial, etc., fields.

The lifting platform is a self-carried installation, mounted on the truck crane undercarriage and driven by the truck engine. But, recently, the group of lifting equipment also include lifting platforms located on: truck’s standard undercarriages, especially built undercarriages, trailed undercarriages.

Various types of lifting platforms are known worldwide. However, there is a limit in development respectively increase of technical characteristic parameters, namely framing within provisions related to road traffic (transport overall sizes, loading on wheels, etc.); standards related to engineering, construction and operation of lifting mechanisms.

Most of lifting platform builders choose the special truck-undercarriages solution, framed within travelling lifting platform families that allow their better use, in the same time with diversifying on
types and capacities. Worldwide, more upgrades and special solutions are known both for self-propelled platforms and trailed ones.

The constructive particulars of the lifting platforms put such equipment within the most difficult technical solutions. Considering the possibilities for grouping the constructive solutions, the following are highlighted: travel realizing; work equipment realizing; ensure the primary power source; placing the control installation.

The self-propelled multipurpose lifting platform consists of the following main sub-assemblies: truck undercarriage for transport in (4x2) system; platform support (with pressing-on earth devices); work equipment.

The frame is so designed and built that to take over the stresses transmitted from platform to ground through the elements of pressing-on earth legs from the undercarriage.

The structure is so designed that it can be fixed on the truck undercarriage frame.

The vehicle stability is ensured by one or two stabilizer groups, each group consisting of two stabilizers (pressing-on earth legs), located on both sides of the undercarriage.

 Movements of various elements of the boom are ensured by means of double effect hydraulic cylinders, provided with double effect shut off valves. Rotation movement of the turret column is ensured by a hydraulic motor and a gear box. Operation of hydraulic motor is ensured by a pump driven by cardanic joint of the vehicle. Besides this main pump, there is installed a pump that can only be used in an emergency situation.

Based upon customer’s request, this can be either an electrically driven pump with 12 V / 24 V voltage (from the vehicle), or a manual pump. Optionally, upon customer’s request, there is an auxiliary hydraulic motor available, electrically driven from the vehicle. Continuous lifting of the platform is got by means of hydraulic system that that always keeps the platform in vertical position depending on movement of the main boom [1].

The lifting platform height can be manually adjusted through a distributor from the control station. The platform can be of two types:
- Open, made of round steel or aluminum tubes;
- Closed, made of fiberglass.

The work equipment is an assembly of mechanisms provided with driving elements that realize the movements and specific forces of the lifting platform. The work equipment of the platform consists of the elements: work platform; boom and the system for keeping the work platform horizontal.

 Two constructive solutions were adopted for work equipment:
 a) Work equipment with jointed boom;
 b) Work equipment with boom consisting of two quadrilateral mechanisms.

The structure of the main boom is calculated to stand all stresses the platform is subject to. Platform features are shown in table 1. (Lionlift GT 18-10):

| Table 1. Platform constructive features. |
|-----------------------------------------|
| Constructive weight \( G_c = 2000 \) daN |
| Load weight on axles: \( G_1 = 945 \) daN; \( G_2 = 1055 \) daN |
| Turning radius \( R = 6.5 \) m |
| Diesel engine power \( P = 51 \) Kw |
| Gear box \( 5 \) stages |

Table 2 shows the main parameters for machine engineering. That is the required data for our experimental research.
Table 2. Input parameters for machine engineering.

| No. | Engineering parameters | Symbol | M.U. | Work equipment with double jointed boom | Work equipment with jointed boom |
|-----|------------------------|--------|------|----------------------------------------|---------------------------------|
| 1   | Nominal torque         | M      | Tm   | -                                      | 1.1                             |
| 2   | Nominal load           | Q      | kg   | 200                                    | 200                             |
| 3   | Operation group        | -      | -    | M6                                     | M6                              |
| 4   | Class of use           | -      | -    | T6                                     | T6                              |
| 5   | Stress condition       | -      | -    | L2                                     | L2                              |
| 6   | Lifting height         | H      | m    | 6                                      | 12                              |
| 7   | Outreach               | R      | m    | 6.25                                   | 6.25                            |

Work platform – is a steel structure consisting of a platform and four walls provided with rail, one wall being collapsible for access purpose. Usually, the work platforms are mounted on a support jointed to the boom and quadrilateral mechanism for horizontal positioning purpose.

Table 3 shows the producer’s constructive dimensions for the work platform (Lionlift GT 18-10).

Table 3. Constructive dimensions of work platform.

| No. | Parameters | Symbol | M.U. | Work equipment with quadrilateral double boom | Work equipment with jointed boom |
|-----|------------|--------|------|---------------------------------------------|---------------------------------|
| 1   | Width      | l      | mm   | 800                                         | 800                             |
| 2   | Length     | L      | mm   | 1500                                        | 1500                            |
| 3   | Height     | î      | mm   | 1040                                        | 1040                            |

The form and dimensions of work platform have direct implications upon activities transmitted to the boom as well as the cost of manufacture.

The multipurpose lifting platform installed on the truck undercarriage is driven by truck’s motor. Use of the self – propelled platforms on truck undercarriages in a greater extent was mainly due to some undisputed advantages of such, among which we can remind:
- Great mobility;
- Commissioning does not need additional personnel;
- Being equipped with an independent driving system of fixed electric power sources they can work in various conditions of unarranged field or with few arrangements;
- They can be used on a wide range of works.

The double quadrilateral boom is a steel construction consisting of a support, two box-type elements, jointed to the platform and connection plates thus creating the first quadrilateral of the boom. The 2-nd quadrilateral consists of 2 bars placed symmetrical to the medium plane of the support. The bars are jointed to support and connection plates, making this way the 2-nd quadrilateral. The boom is driven by hydraulic cylinder. Considering the working cycle of the platform during lifting – lowering process, the boom should provide the following conditions, by its dimensions and shape:
- To have suitable strength and stability;
- to provide reaching the kinematic parameters so that the work platform to keep a horizontal position from the beginning to end of the boom lifting stroke.

For the carrying elements of the platform (boom, platform), killed steels will be used having guaranteed weldability under conditions provided by STAS 7194-79. The fluxes used for welding shall be selected according to base and filler matrix so that to ensure obtaining a welded joint with properties at least equal to those of the base material. For welded construction of the lifting platform the following steels were chosen:
- Booms (upper, lower) – OL 52.4 steel plates; Rolled pipe OLT 45; Profile OL 50.1
- Work platform – OL 52.4 steel plate; Rolled pipe OLT 45; Striped plate;
- Fixed platform – OL 52.4 steel plate; Rolled pipe OLT 45; Profile OL 50.1
2. Parametric modelling of the truck and platform

To represent this assembly we made 3D modelling for the truck, and, thereafter for nacelle type system and the manner of fixing on undercarriage. The truck sketch (Daimler-Benz) was used to start (figure 1).

![Figure 1. Truck sketch.](image1)

Starting from this sketch we proceeded to 3D modelling of the truck by using the Catia Part Design module to represent each component. After representing each component, Catia Assembly Design module was used through Cumulative Snap control (figure 2).

![Figure 2. Platform components.](image2)

After their assembly, the 3D model of the truck below was done, as seen in figure 3.
The next stage consists in 3D modelling of the nacelle using device. This was analogously done according to previously presented truck modelling. We started with 3D modelling of the nacelle’s boom (figure 4) by using Catia Part Design module, by means of Sketch control we drawn the boom profile and by means of Pad control the extrusion was done resulting the model below [2].

The main elements of the lifting platform are: lever boom (1), telescopic lever bracket assembly (2), shift joint grip (3), telescopic lever (4), nacelle support (5), nacelle (6) and fastening / connecting element (7) as seen in figure 5. To represent the components the controls Pocket for cutting and Chamfer and Fillet for chamfers and radii were used, resulting the following components: To assembly the components the Cumulative Snap and Snap to Object controls were used as in the below examples in figure 6:

Figure 3. 3D model of the truck.

Figure 4. 3D model of platform boom.  Figure 5. 3D components of lifting platform.

Figure 6. Self-lifting platform components assembly.
Analogously, the same controls were used and boom assembly of the lifting platform resulted as seen in figure 7.

Figure 7. Nacelle boom assembly.

3. FEM study for lifting platform
Finite element study for lifting platform was done by using Autodesk Inventor program, and for starting we determined initial conditions, type of mesh and material used as seen in figure 8.

Figure 8. Post-process study.
Further to study, maximum allowable stresses, travels and its safety factor can be noticed [3]. The first finite elements study was done on the joint area between the nacelle boom and machine undercarriage, during the study being established the initial conditions as follows:

a) Mechanical properties of the material:

| Name                      | Steel, High Strength, Low Alloy |
|---------------------------|---------------------------------|
| Mass Density              | 7.85 g/cm^3                    |
| Yield Strength            | 275.8 MPa                      |
| Ultimate Tensile Strength| 448 MPa                         |
| Young’s Modulus           | 200 GPa                         |
| Poisson’s Ratio           | 0.287 ul                        |
| Shear Modulus             | 77.7001 GPa                     |

b) Type of performed study:

Study Type: Static Analysis

| Study Type                  | Static Analysis |
|-----------------------------|-----------------|
| Last Modification Date      | 6/11/2020 -9:29 PM |
| Detect and Eliminate Rigid Body Modes | No |
| Separate Stresses Across Contact Surfaces | No |
| Motion Loads Analysis       | No              |

Magnitude

| Force          | Vector X | Vector Y | Vector Z |
|----------------|----------|----------|----------|
| 10000.000 N    | -992.2926 N | 3925.411 N |

After establishing the initial conditions, we proceeded to establishing the constraints (figure 9(a)) and loading the other one (figure 9(b)) with force, as shown in image below.

Figure 9. Lever platform.
Further to static study, data related to stresses, deformations and safety factor resulted. Due to finite elements study, it can be noticed that the maximum allowable stress in nacelle’s boom has very small values, wherefrom results that this stands to application of a force to the other end (figure 10).

![Figure 10. Maximum allowable stress.](image)

In figure 11 is noticed that the maximum travel is 0.461mm, that is a normal value considering the operation conditions and material used for study.

As it can be noticed in figure 12 the safety factor has minimum value of 3.98 so this platform was oversized.

### 4. Conclusions

The lifting platform should stand to stresses which it is subject to during operation and during transport. For the chosen model we performed a static study (modal study) for any component. If the lifting platform behaves suitably, we perform dynamic tests. In this case, dynamic test was not needed. If we perform dynamic study, this is done with a nominal load increased by up to 10% and consists in repeated performance of all admitted movements, checking the normal operation of all components (mechanisms, braking system and safety components). Further to the study performed we can state that this lifting platform meets conditions for a good operation, taking into account that according to ISCIIR standards for lifting equipment, as the maximum allowable stress, maximum travels have normal values. The safety factor should be 3.5 – minimum value of safety factor is 3.98 meaning that this designed platform is oversized, successfully stands to our stresses but in the same time, this platform can be optimized in order to reduce its own weight and making the design more efficient.

### 5. References

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