Diging simulation of a narrow trench

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Abstract. In this paper, we realized digging process simulation for a narrow trench using special equipment located at a mini excavator. These types of machines digging perform the longitudinal direction to the direction of travel, making trenches with widths of 0.4 m and depths of 3.5 -7.0 m. These are necessary for the location of underground cables or draining water in agriculture. For Parametric modelling of parts included in ensemble has used software from Siemens NX 7.5, we produce sketches of each piece, using following commands: Sketch, Profile (Line), Arc, Circle, Quick Trim Quick Extend, Constraints. Depending on the layout of each piece can also use other commands such as: Chamfer, Rotate, Mirror Curve, Offset Curve, etc. After completion of sketch and dimensioning commands was: Extrude, Revolve, and at this stage the play may various modifications such as: drilling, removal of certain volumes of piece showing various forms or change the appearance of surfaces (thread cutting, bevelling). This paper was realized with this parametric modelling software because presents major advantages including: control over the design, making design speed and increasing productivity; increasing product quality, reducing design risk recovery and time work, less human effort and reduced financial resources throughout the process.

1. Introduction

Equipment trencher narrow is used most frequently for laying underground cables and better agronomy irrigate said. These grooves can vary from 20cm to 50cm in the case of the scraper Elinda and depths up to 2m.

It can catch the back of the agricultural tractor or a mini excavator and driven by the PTO of the machine base.

Body work digging machine consists of an endless chain which cups are fixed cutter; chain running on a frame placed perpendicular to the driving position, called the ladder. It consists of a movable ladder frame, bucket chain, chain wheels or rollers. Elinda articulated body is caught and suspended basic machine with cables so that can be raised above or lowered below the moving; thus enabling higher stops work both on the face and lower. Soil moved by machinery, and lifting in high cups to download the conveyor belt, which stores one side of the trench that is dug or loads it directly into the means of transport.

Digging is done by operating the chain bucket machine simultaneously moving very slowly. Earth cut cups are loaded into the bucket is raised and discharged from cups on a conveyor belt for transporting earth. Earth is flat side of the carrier, forming a prism of land along the trench.
control and switching equipment in the trench-dig in the transport position is achieved by hydraulic cylinders, [4, 7].

In the face of this ladder is an auger which removes land in front of the equipment in one party.

After the trench can attach equipment running a pipeline that delivers usually in the form of coil, [4].

This method of modelling equipment can be included in virtual labs for students, which proved more effective both for understanding and learning, but were reflected in exams students’ results, also [8].

2. Modelling device trencher narrow

The device cable-laying is in fact a mechanical system composed of: machine base, namely small-dredge a device excavated Chain scraper, a drum that winds the cable, a screw helical settles excavated soil and two discs arranged in "Figure 1 V" for covering the ground Figure 2. It can see the mechanical operation posed underground cables attached to a mini excavator [3, 6]. To enlarge the underground cable from tactical acting hydraulic cylinders that are attached device digging chains with screws support. After he began to dig the ditch, adjust the positioning of the cable into the ditch. After I adjusted, the system works automatically once the cord stretches small-dredge movement. Particular attention should be paid small-installation movement that will be correlated with the speed of excavation of the trench. NX 7.5 is part of the upper class systems engineering design with CATIA, Pro / Engineer, SolidWorks, Solid Edge [1].

![Figure 1](image1.png)  ![Figure 2](image2.png)

**Figure 1.** Mechanical cable-laying 1-machine base 2 - digging device with scraper chains, 3-cable reel, 4-helical screw on settlement land, 5 - support reel, 6- disc covered the earth

**Figure 2.** 3D assembly model trenchers narrow 1-side fixed, 2-port scraper chain, 3-scraper, 4-screw helical guard

This software is among the most comprehensive CAD 2D / 3D that uses synchronous technology for accelerated design, faster change, and improved re-use graphical representations.

Parameterized models are obtained, i.e. components designed shape and dimensions are controlled by dimensional parameters that are available by viewing, editing, updating, modification and networking. 3D modelling of equipment trenchers narrow we realized it using 3D design program not Nx 7.5. NX software is a fully integrated CAD / CAM / CAE, the latest generation of the company SIEMENS PLM product. Functions 3D CAD product design addresses what we have achieved in this paper.

With the help of this software, we designed 3D general assembly that comprises the fixed chain, scrapers, helical screw aprons ground. We brought to the practice of all working window subassemblies that make up the general assembly then used their coercive commands such as: DISTANCE concentric TOUCH ALIGN, PARALLEL, FIX, CENTER, and PERPENDICULAR.

In Figure 3 is modelled 3D format port-scrapers chain and two-wheel drive. The wheel is one wheel and two wheel idler wheel is: To achieve 3D models we used then SKETCH command orders,
drawing sketches LINE, CIRCLE, ARC, POLYGON and actuations amending TRIM, MIRROR, FILLER, CHAMFER etc. In figure 4 it can see the 3D model of chain with scrapers. Application Modeling enables 3D parametric solid model building. Overall, the 3D model is based on sketches (Sketch) that can be created in under Sketcher app, which occurs when the command is used Sketch. As a first step, building lines, curves and apply constraints in draft mode, then we can use to create solid or sketch only surfaces through modeling operations (extrusion, revolution etc.). Subsequently, these bodies can be modified by adding additional operations to bring the body to the desired shape (connections, gradients etc.). To achieve the basic elements of assembly "ansamblu called trenchers were used in guste" also special orders change as apple as "Move face" tilt faces, "Pattern" for multiplication of an entity called the parent entity in-a table or circular structure. NX 7.5 enables modification of solids using buttons chamfer edges and Round (chamfering and rounding). Ensemble called „narrow trenchers ensemble“ is made of objects ie individual parts or subassemblies components referred to a higher level assembly. A subassembly is an assembly used as a component in an overall higher level. Thus, we might consider a set as a collection of links to its components, together with the constraints established between them. We applied constraints for assembly of:

- **Touch Align** constrain two components so that their elements involved in coercion (faces, edges, axes) will be either in contact (Touch) or aligned (Align)
- **Angle** allows the constraint of two components, so between the selected elements of the two portions (faces, edges, etc.) to be an angle which can be controlled by means of an expression
- **Distance** constrain the two components so that, after the selection of the two references, the distance between them would have a value controlled by means of an expression
- **Fix** constrain a component so that it will remain fixed in space longer be moved later by other constraints
- **Bend** constrain components so that they will remain fixed to each other and can be moved all at once as a whole
- **Parallel** is applied to constrain the selected reference objects so they become parallel to each other
- **Concentric** by selecting the circular edges of two components belonging to both constrain them so edges will become concentric and coplanar.

To generate solid entities drawings are generally closed. Open profiles can also be used when building modeling entities intersecting sides of the piece. The following commands allow the construction entities modeling using multiple profiles and can be grouped into: Extrude generate solid translational entities; Extruding a profile obtained by turning around an axis; Command Hole to obtain holes, with multiple options regarding form: simple holes, threaded, tapered, chamfered holes, screw the spot face. To do so commands Hole, Edge Blend, Chamfer, Unite, Subtract, etc. On the basis of parametric modelling in NX 7.5 are called Constraints restrictions. These restrictions apply to solids as well as components of a whole. The dimensional and geometric constraints we have are solid and the whole assembly constraints.
In figure 5 we modelled wheel. This is a gear with involute profile. In figure 6 is presented strap that is catching digging knives. It is a subassembly connecting tab consists of two plates which are fastened by four screws. Figure 7 shown the modelled 3D digging a knife. These are wear and interchangeable. After making all the assembly of components we achieved them. For this, bring files into the workspace window parts (spare) parts and assemble sequentially. To achieve more accurate assembly we used assembly constraints such as ALIGN TOUCH, ANGLE, FIX, and PARALLEL concentric DISTANCE.

Due to the particularity of cutting process with this type of equipment, cutting resistances that appear to have a periodic producing dynamic loads of the same type, both in the work equipment in actuators and parts of the machine subassemblies. The unfavourable work situation, in terms of dynamic requests is where the digging process, the teeth of the chain there is a rigid barrier that leads to blocking, [5].
3. Structural analysis (a tooth, chain drive wheels and breadth) for equipment digging

This step is the most important in finite element analysis as the starting point in solving the problem correct use of the finite element method requires knowledge of strength of materials engineering, mechanical vibration and IT know. Stages of modules for solving model designed using finite element method are to achieve physical model, achieving mathematical model, mesh model analysis method selection. This takes into account the user experience software. The next stages are the calculation and obtain the solution. The last step for finite element analysis methods is that during post processing. At this stage, it interprets the results and validates the digital prototype. This step provides information essential to the acceptance or rejection of the solution and modifying data initial (input) to obtain satisfactory solutions. Post-processing via a graphical user interface is probably the simplest part of the process finite element because we offer some of their lateral will be interpreted. For the model to be analysed, we will consider fixed mounting holes and the use of force on its edge.

3.1. Analysis of the tooth

Tooth geometry is shown in the figure below:

Prior to mesh model, we said bar material as construction steel S235 with the following properties may: E=2.1x105, \( \rho = 7.85x10^5 \), \( \sigma_a = 60N/mm^2 \).

After declaring material is finite element offset property. In this case, finite element type is solid i.e. tetrahedron. For the mesh model, we first conducted a mesh control the size I chose ELEMENT finished namely finite element 1mm. Finally, the 2793 model is meshed into finite elements and 1,049 nodes.

The discretized can be seen in Figure 9. Before selecting the method of analysis will be on the boundary conditions on the meshed model. The boundary conditions are as in the calculation scheme: an insert at the end of the bar and applying a torque force on the disk gives the torque. After applying boundary conditions choose the type of structural analysis that is static analysis. After however, accessing command for analysis. In the following, the steps are presented in a graphic form to be examined for patterns. Wheel was calculated assuming that the equipment encountering an obstacle. In this context, the teeth are those requested.

3.2. Analysis of wheel drive

Wheel geometry engines can see in figure 11.

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3.3. Analysis of the tooth

Tooth geometry is shown in the figure below:

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In the scheme of calculation we considered three teeth coming into engagement with the chain to be embedded in the centre of the wheel and apply a time equivalent to 1000 Nm. In figure 11 it can see this. The geometry has been discretized in 12522 nodes and 2060 finite elements. Mesh network can be seen in figure 12.

After calculation, the resulting state of tension and strain the wheel. Thus we can see in figure 13 deformations of the teeth. Maximum deformation is 0.01 mm.
In figure 14 it can form the tensions condition from wheel during an obstacle. As seen from the distribution and maximum voltage is 12.7 MPa after the fourth criterion Von Mises strength and underpins the tooth. To see if this tension calculated, is within the limits of the material safety program and we can provide a factor of safety of operation with calculated time. In figure 15 it is represented this.

3.3. The analysis of chain

To test the resistance chain we brought the chain calculation diagram above and chain. We considered for calculation diagram in figure 16. We built one end of the chain and applied a moment of 1000nm in the centre of the wheel. Analysis before we defined earlier in this analysis and some contact between the chain and sprocket and chain between the elements.

Figure 16. The scheme of chain calculation

Figure 17. Networks mesh subset analysed

In the centre of the wheel we defined a fulcrum for the wheel to execute revolving around its axis. The assembly review was meshed into 196 459 knots and 36 626 finite element. Mesh network can be seen in Figure 17.

Figure 18. Distribution strain on the geometry analysed

Figure 19. Status analysed tensions geometry

After the analysis we obtained states and deformations in the chain. The graph deformations of the geometry of the FEA calculated can be seen in figure 18. Maximum deformations in the chain are 0.03 mm. These deformations are very small. From voltage distribution in figure 19 there is a maximum voltage of 10.47MPa. As shown in the graphic chain tension is subjected to tensile and shear bolts request.

In conclusion, the analyses of resistance to the active elements of equipment and trenchers they withstand extreme conditions, [7].
4. Conclusions
In this paper, we conducted a narrow and equipment trencher sits at the base of 3D modelling for finite element analysis of active components by equipment trenchers. These ditches are most common in agricultural pipe layout and installation of underground electrical cables.

Using NX 7.5 software modelling to equipment trencher narrow, because it has several advantages such as: starts from simple conceptual models, with minimal details, this approach complies with the design philosophy of 'form before dimension '; stability updating the entire system, including parts, assemblies and drawings after changing a parameter; the possibility of rapid exploitation and evaluation of various options and design alternatives to determine the best solution.

We watched application modeling tools used to generate three-dimensional pieces taking into account the specific technological conditions. Practically three-dimensional models were obtained for each item separately echipamnetul digging narrow trenches.

Finite element analysis was performed for active components by the equipment trenchers namely: tooth wheel and wheel-assembly chain. I followed all the steps for solving this chapter for each component mentioned above. Wheel was constructed in the most disadvantageous case, rather, when it meets an obstacle. Maximum deformation is 0.01 mm and it appears in the teeth. Our analysis on the tooth notice that it shows a stress concentration in the middle and in this area it changes its shape.

The chart analysis of blood resulting from element finished, the chain is subjected to tensile and shear bolts request. For this reason, the design phase must be examined carefully choosing materials they are made. DU's are very small deformations of 0.03 mm. using the finite element method in determining sustainability is a fast and highly efficient, thus producing significant reductions of effort in design, material and energy consumption, which is reinforced through the research presented.

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