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Research paper

DESIGN SOLUTION AND CALCULATION OF IMPORTANT ELEMENTS OF HAND DRILL AND ANGLE GRINDER TABLE STAND

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Abstract: *Design solution of hand drill and angle grinder table stand was developed by using modern approach to product development. Chosen solution represents an optimal one based on two factor criteria. Sketch and 3D model are presented, and critical elements of assembly are identified. Estimation of possible external loads is used to calculate loads on each element. Software package SOLIDWORKS was used for modeling and simulation. Based on simulation results, shape optimization was performed. Work documentation was made and next step should be prototype manufacturing and testing.*

Key words: *Design solution, table stand, calculation*

1. INTRODUCTION

Every product development starts with market analysis, which represents overview of existing products, their price and determination of potential group of buyers. With collected data, first phase of development begins .In this phase, conditions that mechanical system should meet are determined. These conditions are the result of current state on the market, customers and manufacturing capabilities. The second phase in the design provides answer to question on which principle mechanical system will work. Based on phase two, in third phase of product development, materials are chosen, geometry is defined and full assembly is generated. Phase four includes stress and strain examination, safety and reliability. Phase five represents final step, in which work documentation is made, tolerances are prescribed etc.

The main function of hand drill and angle grinder table stand is to except electric drill and angle grinder and to allow desired movement of them. Drilling operation requires vertical linear movement, and cutting operation requires angular (limited rotational movement). Lever mechanism is used for transferring force imposed by user to work piece.

This paper deals with phases three and four. In phase three materials and geometry are determined regarding manufacturing processes. CAD model of entire assembly was created in software package SOLIDWORKS. In phase four loads on each element are determined and FEM simulations were performed to determine stresses and displacements. Results of the analysis were used to correct and optimize geometry in terms of mass reduction. At the end, work documentation was made, and next step would be prototype manufacturing. This product has no specific requirements regarding thermal processing and tolerance prescription. Materials that were used are cheap and easily accessible on market. Geometry was developed based on sketches made during the phase two, shown in figures 2. and 3.

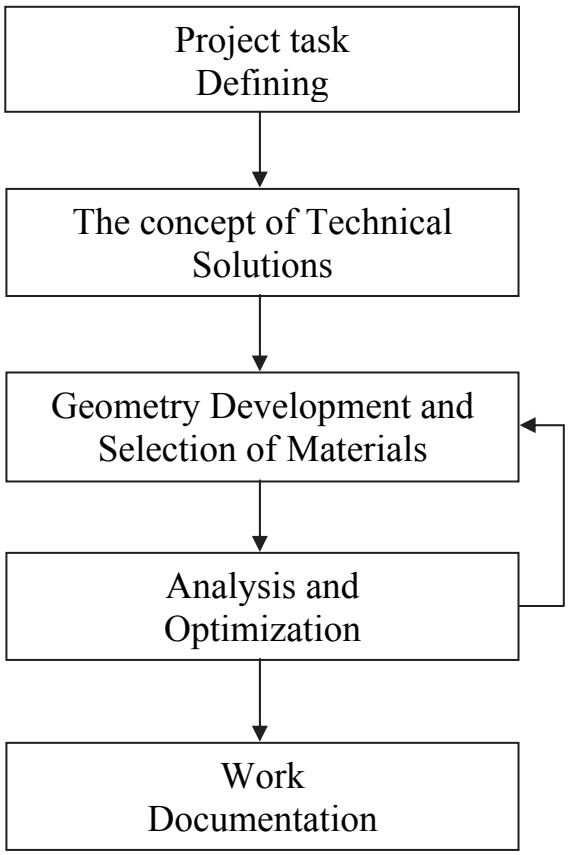

Fig.1. Flow chart of the development process

Sketches that were used as a base to create and define geometry represent just a concept which can be altered in terms of different types of lever mechanisms, size etc.

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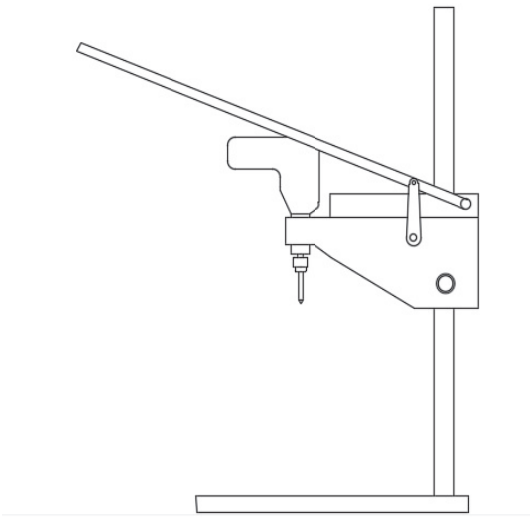

Fig.2. Sketch of drilling module

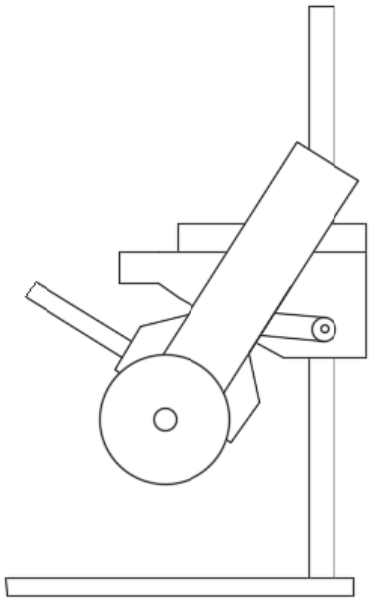

Fig.3. Sketch of cutting module

2. GEOMETRY DEVELOPMENT AND SELECTION OF MATERIALS

Table stand for electric hand drill and angle grinder should be made out of cheap yet reliable materials suitable for easy manufacturing and processing. Most of parts should be made by using casting technology. Aluminium alloys represent perfect choice for this application. Elements that have to resist bigger loads should be made out of basic structural steel. One of the boundary requirements for this product was to use standard elements as much as possible. Whole structure needs to be stable and to ensure precise guiding of tools.
Two anchoring holes on pedestal are left for two M8 bolts used for attaching to the table. Vertical pillar is made out of standard 5/4'' steel pipe. Limitation of vertical movement is achieved via sliding ring that can be fixed by M6 hex bolt. Hand force imposed by user is transferred via steel lever. Euronorm Ø 43 mm is used to except hand Drill and two M8 bolts for angle grinder. 3D model of assembly is shown in figures below.

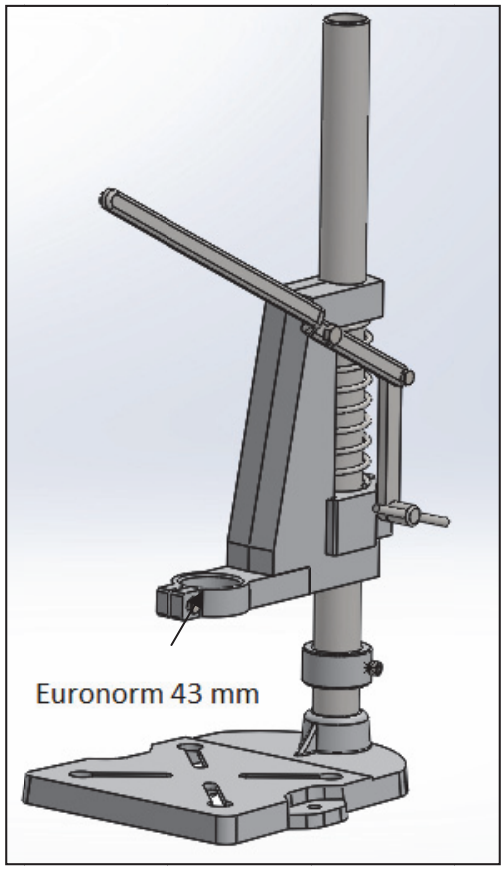

Fig.4. 3D model of the stand with Euronorm attachment

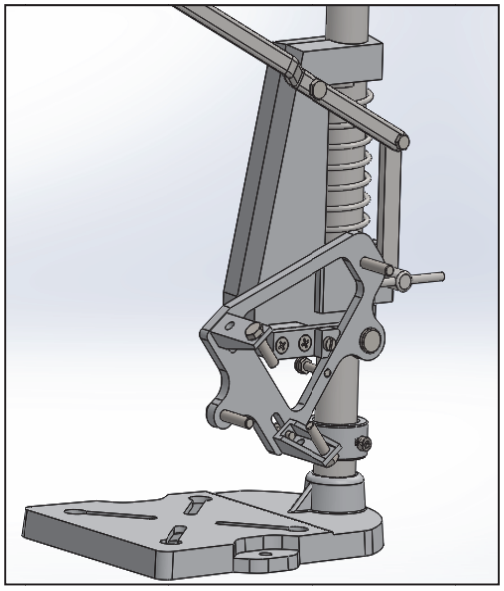

Fig.5. Model of the stand with angle grinder attachment

Geometry that is created in this first stage of its development is estimated and needs to be checked. External loads need to be estimated and determined, as well as boundary conditions. Critical elements and subassemblies are checked separately using FEM simulation integrated in SOLIDWORKS. Load calculations and simulations are part of the next chapter.

3. ANALYSIS AND OPTIMIZATION

To determine loads on each element, estimation of hand force needs to be done. Average force imposed by user is about 100 N, but in extreme cases it can reach up to 200N

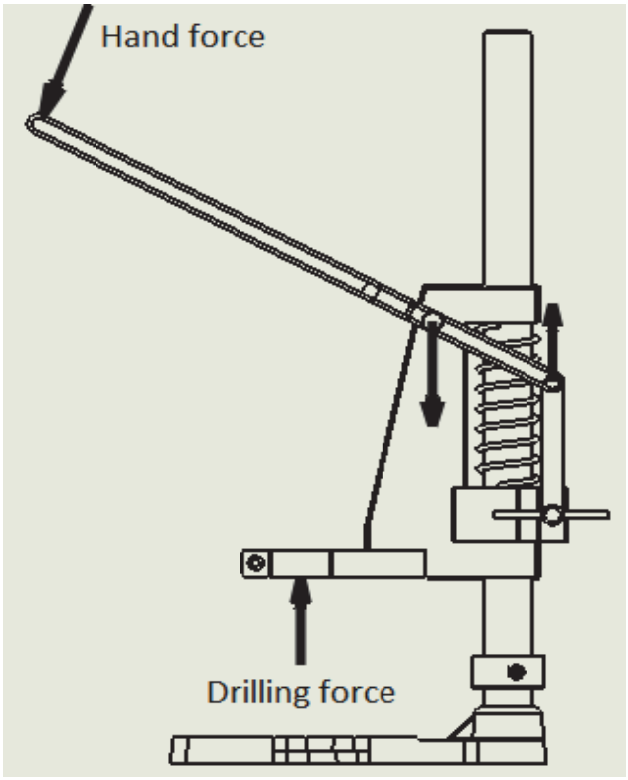

Fig.6. Loads on assembly elements

Considering force distribution shown on figure above, lever can be extracted and loads are calculated.

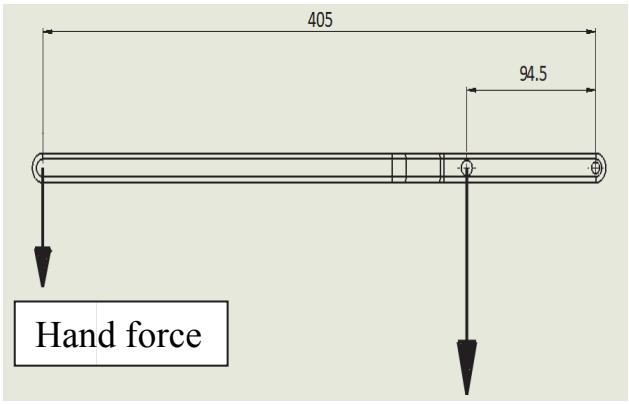

Fig.7. Extracted lever with loads

Force that acts in fixed support

$$F_1 = \frac{200 \cdot (405 - 94.5)}{94.5} = 656.8\ N \quad (1)$$

Force that acts in middle support

$$F_2 = \frac{200 \cdot 405}{94.5} = 852.6\ N \quad (2)$$

After loads and boundary conditions were determined, FEM simulation has been done, as shown in figures below.

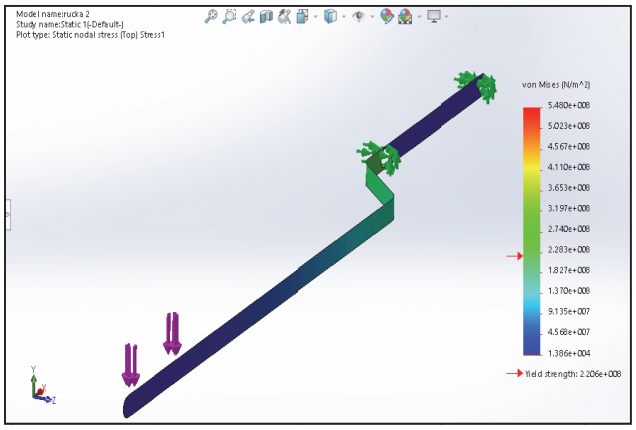

Fig.7. FEM calculation of stress –Lever

Results show that selected material S235 and geometry are adequate with high enough safety factor and tip displacement of 6 mm.

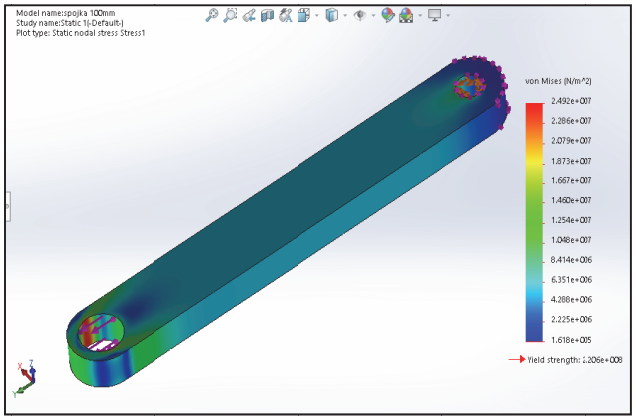

Fig.8. FEM calculation of stress –connecting piece

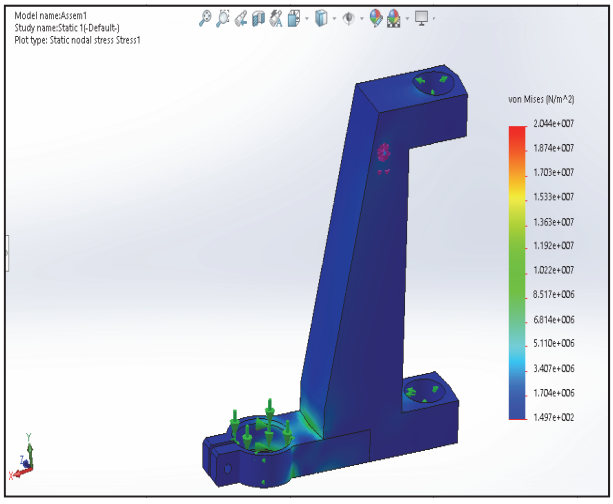

Fig.9. FEM simulation of stresses on subassembly of main slider

Results of FEA analysis show that main slider is subjected to very low stress and it can be optimized in terms of mass reduction. Other parts are adequately dimensioned. In figure 10 optimized geometry of main slider is shown as part of the entire assembly.

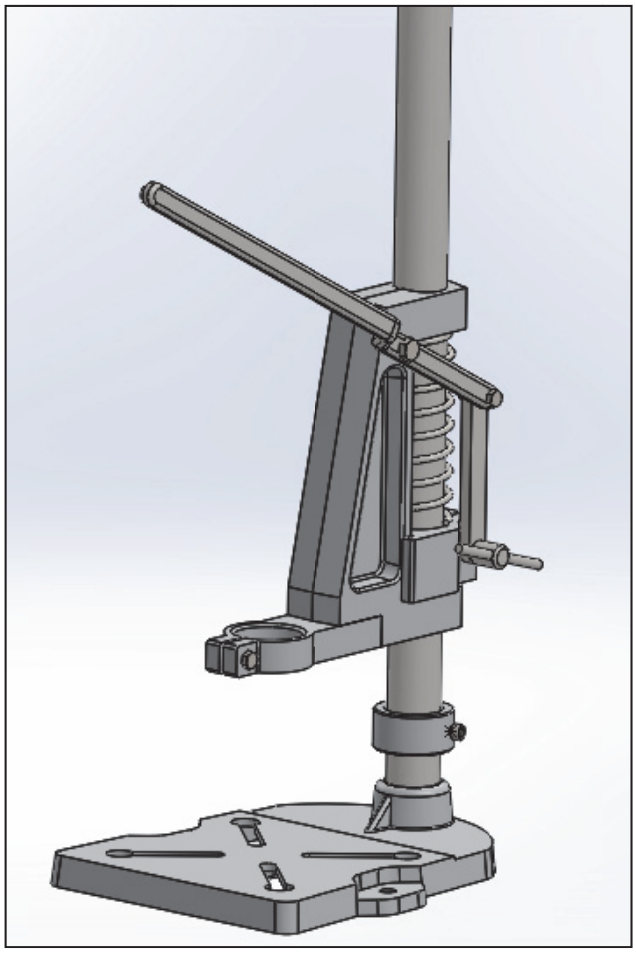

Fig.10. Final and optimized geometry

Cutting module used to accept angle grinder is not subjected to any significant load, so calculations and simulations were left out. Standard elements such as bolts, screws and spring were chosen based on corresponding requirements.

4. CONCLUSION

Product development represents transformation of scientific and engineering skills along with corresponding data in the technical or mechanical system. Modern product development is based on thorough market analysis. Based on collected data project task can be properly defined. Work described in this paper is based on previous market analysis and conceptual design which served as a guideline to define proper geometry and select adequate materials. Table stand for hand drill and angle grinder represents an unique product that has no competition on market. Materials used are easily accessible and cheap. Manufacturing processes required to make it are simple and cheap. Most of part can be manufactured by using casting technology with some basic machining. Optimization and correction of geometry was shown in part 3. of this paper. Working documentation is made and next step would be to make a prototype. This table stand represents simple product, that is easy to manufacture, yet it can achieve good market success .

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