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# A NEW CONCEPT OF BELT GRINDER DESIGN WITH IMPROVED FRAME RIGIDITY

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Abstract: For the purposes of this research two of the belt grinder concepts have been developed. The biggest attention is given to the rigidity of the belt grinder frame, functional and ergonomic aspects. After developing these two concepts, the CAD models have been made. Both concepts are evaluated through a couple of industrial design aspects. After evaluation, the prototype has been made and tested. All of the industrial design aspects were proven by prototype testing in real working conditions. At the end of the paper, the conclusions have been drawn and future research directions on this topic were given.

Keywords: belt grinder; industrial design; model evaluation; concept testing.

## 1. INTRODUCTION

The machining accuracy and surface quality of such parts will be the key factors that ultimately determine the performance of the equipment. Grinding is usually the last step in the processing of complex profile parts. As a new grinding technology, abrasive belt grinding has the characteristics of low grinding temperature and high grinding efficiency, and has been widely used in precision grinding of complex surface parts [1-2]. Coated abrasive belts are used in the same speed range as bonded wheels, but they are not generally dressed when the abrasive becomes dull. Abrasive belt grinding is a kind of grinding tool with special form, which needs straining device and driving wheel and to make abrasive belt strained and moved at high speed, and under certain pressure, the contact between abrasive belt and work piece surface can help to realize the whole process of grinding and machining. Belt grinding is a rough machining procedure utilized on wood and different materials. It is commonly utilized as a completing procedure in industry. A belt, covered in rough material, is kept running over the surface to be handled so as to evacuate material or create the ideal finish. [3]

A compliant belt grinding resembles an elastic grinding in its operating principle, and it offers some potentials like milling, grinding and polishing applications [4]. The abrasive belt grinding process essentially is a two-body abrasive compliant grinding processes wherein the abrasive belt is forced against the components to remove undesired topographies, such as burrs and weld seams, to achieve the required material removal and surface finish [5]. Analogous to other abrasive machining processes, many process parameters in the belt grinding impact the material removal performance, which include cutting speed, loading belt tension, the force imparted, infeed rate, workpiece topographies, polymer wheel hardness, wheel geometry and belt topography features, e.g., backing material, grain composition, and grit size [6]. Material removal in the belt grinding process is determined by force distribution in the contact area between the workpiece and the elastic contact [7]. The effect of abrasive grain size on the material removal performances of the grinding surface was studied by theoretical modeling and grinding experiments. The results indicated that a smaller abrasive grain size of the abrasive belts led to smaller microscopic contour height and surface roughness of the ground surfaces, fewer curl chips, and more spherical chips [8].

The accurate prediction of the replacement time of abrasive belts can help not only improve the product quality but also reduce the cost. According to the analysis of displacement data, a new method for the prediction of abrasive belt wear states using a multiscale convolutional neural network based on transfer learning is proposed in the paper of the authors [9]. The experimental results show that this method can accurately predict the wear status of abrasive belts, with an average prediction accuracy of 93.1%. Also, authors [10] were investigating cutting force, single grain wear height and full-size grinding mileage verification experiments were conducted. The results indicated that the established model was in reasonable agreement with the experimental outcomes, which suggests that this model could be useful

in the industry to predict the wear process of abrasive belts.
The machine we designed and fabricated is used for grinding any shape of object like circular, rectangular and polygon. In our project the work abrasive belt is used to grinding the material. The abrasive belt is rotated by single phase induction motor. Hence our project namely adjustable belt grinder.

## 2. DEVELOPING BELT GRINDER CONCEPTS

In this study two belt grinder concepts were developed. The most influential factor in concepts developing was the belt grinder frame rigidity. The frame rigidity is necessary in order to get the best grinding results. Before the concept developing the main functions of the future product was determinated such as:

- the grinder work table must have ability to rotate from 0 degree to 180 degree,
- the work table must have adjustable height,
- the grinder must have ability to accept various sizes of grinding belts (papers),
- easy change of the grinding belts (papers)
- safety of operator must be fulfilled and
- future product must have enough rigidity.

After main functions the main part of grinder was listed:

- driving unit (electric motor),
- driving pulley,
- driven pulley,
- belt tensioning mechanism,
- grinder frame and
- work table.

Based on the previous statements two concepts was developed. One concept was based mostly on square pipes, while other was based on the combination of steel plates and square steel pipes.

### 2.1. Belt Grinder based on square steel pipes

The concept based on square steel pipes was imaged to be not expensive variant of the belt grinder. The basic sketch was made, and after that the CAD model was created. The proposal of the concept based on the steel square pipes was given in Fig. 1.

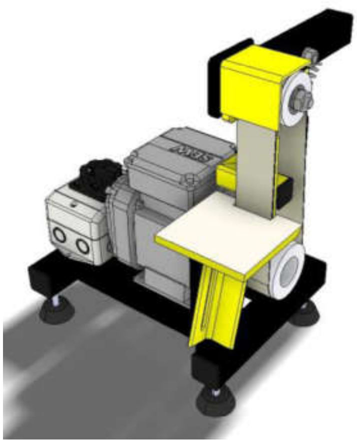

Fig.1. Belt grinder concept based on square steel pipes

The frame is designed as H letter to support the electric motor. Work table is connected to frame by using L-steel profiles, tension mechanism is based on lever which is tensioning the driven pulley by extension spring. Driven pulley has adjustable angle ability related to horizontal. The proposed concept is light in weight.

### 2.2. Belt grinder concept based on steel plates and square steel pipes

The belt grinder concept based on steel plates and square steel pipes was imaged to be a bit more expensive variant related to the previous shown concept. The basic sketch of the belt grinder was made, and after that the CAD model was developed. The proposal of the concept based on steel plates and square steel pipes was given in Fig. 2.

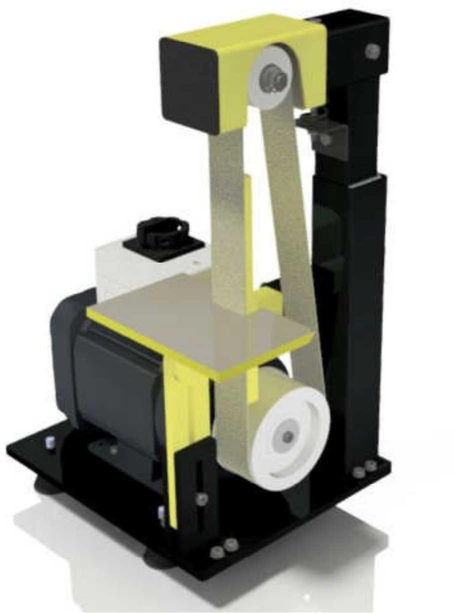

Fig.2. Belt grinder concept based steel plates and square steel pipes

The frame is designed as steel plate with adjustable holes for electric motor and machine leveling. Work table is connected to frame by steel plates cut on laser, tension mechanism is based on lever which is tensioning the driven pulley by compression spring. Driven pulley has adjustable angle ability related to horizontal. The proposed concept is no so light in weight.

## 3. EVALUATING OBTAINED SOLUTIONS

The evaluation of the both proposed solutions has been made. The comparison was made on: frame, work table, tensioning mechanism, adjusting abilities, belt changing abilities etc.

### 3.1. 3.1. Frame comparison

Frame of the solution 1 is shown in Fig. 3. The frame was done in shape of H letter and it consists of rectangular steel pipes with cross-section of 40x40x2 mm.

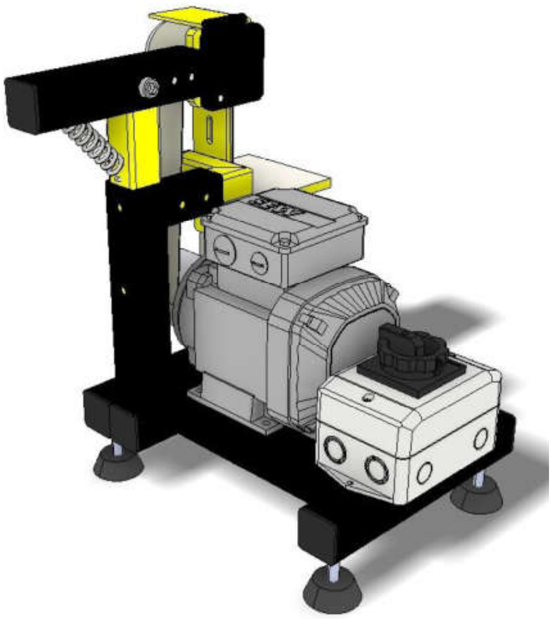

Fig.3. Frame of the solution 1

Frame of solution 2 was done from steel plate with 10 mm thickness. Steel plate was cut on laser cutting machine. Frame of solution 2 is shown in Fig 4.

Fig.4. Frame of the solution 2

The frame of the solution 2 has much better rigidity related to the frame of the solution 1. Frame of the solution 2 is much easier to be made, but because of the bigger amount of the used steel it is more expensive than solution 1.

## 3.2. Work table comparison

Work table of the solution 1 is given in Fig. 5. The work table have the abilities which are requested in section 2. Two points of worktable rotation allows work table to be used for a variety of grinding operations.

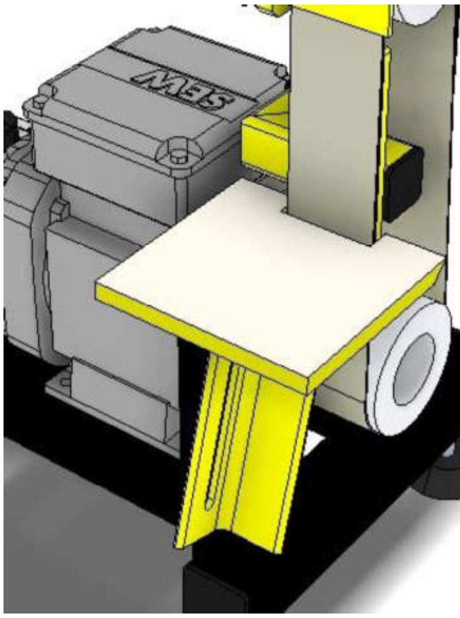

Fig.5. Work table of the solution 1

Worktable of the solution 2 is given in Fig. 6. The only difference between given worktables is in the rigidity. As worktable of the solution 1 uses L-profiles L40x40x4 which are much thinner related to the laser cut steel plates of 10 mm thickness in the solution 2.

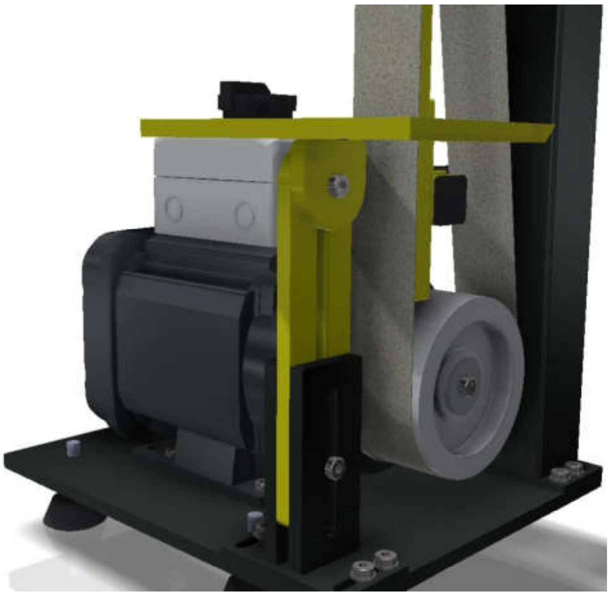

Fig.6. Work table of the solution 2

The advantage of worktable in solution 1 is a bit easier manipulating and adjusting of worktable angle because it relies on L profiles which are lighter in weight and easier for manipulation and adjustments.

## 3.3. Tensioning mechanism comparison

The tension mechanism of solution 1 is shown in Figure 7. Tension mechanism on this solution uses an extensions spring.

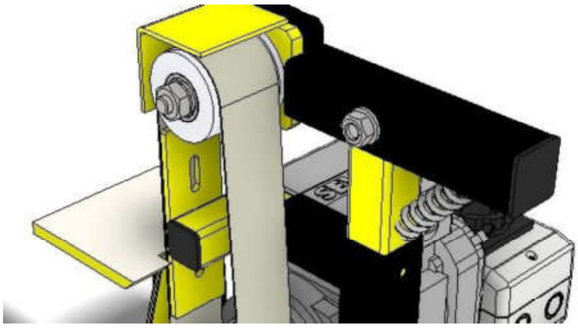

Fig.7. Tension mechanism of the solution 1

Tension mechanism of the solution 2 is given in Fig. 8. Tension mechanism of the solution 2 uses a compression spring.

Fig.8. Tension mechanism of the solution 2

Both of the belt tension solutions are acceptable and durable. The second tension solution is a bit easier for usage because a less hand power is necessary for the grinding belt changing.

### 3.4. Adjusting abilities comparison

Adjusting abilities of the solution 1 are shown in figure 9.

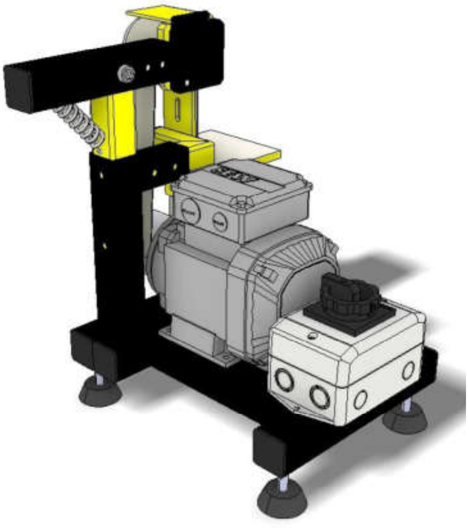

Fig.9. Adjusting abilities of the solution 1

In solution 1 the driven pulley can be adjusted by horizontal angle, the belt supporting plate can be adjusted, the height of the tension mechanism can be adjusted and worktable as well.
In Fig. 10. are shown adjusting abilities for the solution 2.

Fig.10. Adjusting abilities of the solution 2

Solution 2 has 2 advantages. Frist one is that whole vertical pillow which carries tension mechanism can move back and forward and it can use a variety of pulley sizes. The linear movement of the work table is done on the solution 2 as well.

### 3.5. Belt changing ability comparison

Belt changing ability was very nice solved on both solutions. a bit more difficult was belt changing on the solution 2 because the tension mechanism in lighter in mass and more hand power is required to push the tension mechanism down.

## 4. TESTING CHOSEN PROTOTYPE

For the prototype manufacturing the solution 2 has been selected. After manufacturing of the parts belt grinder was assembled. Assembled belt grinder is given in Figure 11-14.
After belt grinder assembling a couple of functional tests has been performed. The following test was done: changing the belt, adjusting machine for the 3 various belt types (with 3 different lengths), the operation of drill sharpening was performed and operation of preparing parts for welding.

Fig.11. Assembled belt grinder

Fig.12. Assembled belt grinder

The test for changing grinding belt went very fast and with no difficulties because the compression spring was chosen by catalogue force for belt tensioning.

Fig.13. Assembled belt grinder

Test of machine adjustment for different grinding belts length was done with some difficulties. The main difficulty was determining of tensioning mechanism height. A scale on the telescopic mechanism pipe would be very useful for implementation.

Fig.14. Assembled belt grinder

For drill sharpening the measurement of the table angle was done. Drill sharpening went without difficulties. Last test was done on preparation parts for welding in order to get chamfered edges. After chamfering edges on the belt grinder all of them was the same and uniform size so the test was successful.

## 5. CONCLUSIONS

In this paper two belt grinder concepts was developed. Both concept was developed in details with CAD models. After CAD models developing the evaluation of the obtained results was performed. Evaluation process gave advantage to the second belt grinder concept which is based on steel plates and steel square pipes. The chosen concept has much higher rigidity related to the concept which is based just on square steel pipes. After evaluation the belt grinder was manufactured and tested. Testing was performed on drill bits sharpening and welding parts edges preparation. The both tests was completed successfully. In the next step of this research the belt speed variation and control will be implemented.

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