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RELEVANT ASPECTS WHEN DEVELOPING A NEW CUSTOMIZED PRODUCT – MARBLE AND GRANITE CNC BEVELLING MACHINE

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Abstract: *Machining edges of marble and granite blocks is commonly required in, both, domestic and construction applications. The severe conditions involved by this process ask for rigid, reliable and productive machine-tools. Relevant aspects dealing with product specifications, modeling and engineering of a customized beveling machine are pointed out by this paper. The CNC equipment is the one Isel automation systems are equipped with. The software used for modeling is SolidWorks, while the machining software required is isy-CAM.*

Key words: *specification, customized product, modeling, modules, beveling, CNC machine.*

1. INTRODUCTION

Marble and granite are very tough materials with lot of applications, due to their special properties. They have a nice look and a good resistance to severe (corrosive, aggressive etc.) factors, in time.

Both materials are used in various fields but, most of all, in construction (building, pavement, etc.), monuments industry and decoration (ornaments).

Rough form of marble and granite is that of blocks. By disk heading or milling, slabs and tiles are obtained, so that it can be easier to handle, machine and use them. That is why and how, for further application, machining edges is many times required.

A widely used procedure is that of polishing / beveling by a diamond based grinding wheel whose profile is identical to that of the beveled edge.

Another procedure is that of kynematically determining edge profile, the grinding wheel being of disk shape.

There are [3 and 4] beveling machines designed and produced by famous international companies (see Fig. 1) but their major disadvantage is that of the very high price. These kind of machines, are "huge" requiring a large space and, as for the CNC aspects, the data offered by producer are not relevant but, rather "poor".

Fig. 1. Automatic polishing machine (www.arc-rom.ro).

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2. PRODUCT SEPCIFICATIONS

Product specifications represent [6] the complete description of what the product has to do / it is used for. So, by specifications, the needs or intentions of group of people are transferred towards another group of people.

The specification process deals with all the activities involved in defining the specifications associated to certain customer's requirement.

It can be defined as the process of analyzing customer's needs, of designing and engineering the customized product [1 and 2] and of specifying the activities for supplying, manufacturing, assembling, delivery and service.

Considering the customized product whose developing aspects are presented by this paper, the specifications are the ones that follow.

- Marble and granite slabs' dimensions, meaning:
  - length – maximum 2500 mm;
  - width – minimum 250 mm, maximum 1 000 mm;
  - thickness – minimum 20 mm, maximum 100 mm.
- Shape of the edges to be machined, meaning:
  - rounded (10 to 50 mm radius),
  - rectangle or multiple facets (0º to 180º angle) – see, as example, Fig. 2.
- Ability to compensate the wear of diamond based grinding wheel.
- Highly automated and CNC controlled operation – with Isel® components [5].

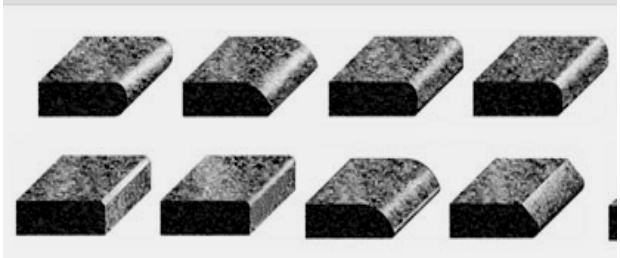


Fig. 2. Different shapes of marble and granite slobs' edges (www.arc-rom.ro).

3. MODELING OF BEVELLING MACHINE'S COMPONENTS

3.1. Working principle

Machining (beveling / polishing) marble and granite slobs / tiles' edges requires diamond grinding wheels.

This process can be done with very high machining speed and, consequently, very high rotational speed, about 15 000 rev/min. Also, the feed speed is of high values, from 1 to 3 m/min and the abrasive tool's granulation should be a fine one.

In order to complete the process, there should be eight machining phases, one rough and the rest of seven being finishing, with granulation from 50 to 300.

Also, there is a large amount of dust that needs to be exhausted / removed because it damages the wheel and scratches the machined surface. That is why a jet of pressurized water should "come" to machining zone [7].

Most of the times, the beveled edge is obtained by copying the tool's profile – see Fig. 3.

There are many disadvantages of this procedure, the most important ones being that of:

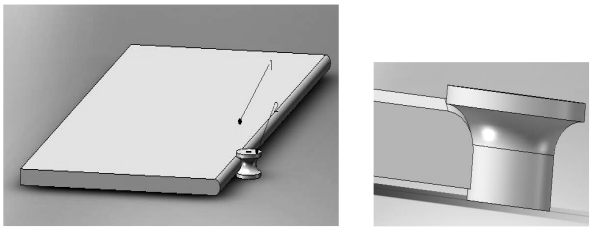
- an intense wear of the abrasive tool when, first, gets in contact with slobs' thin edges - see Fig. 4.
- need to change the tool when the edge profile changes – during the finishing machining phases;
- many abrasive tools to be needed – with different granulation and no material's particles loaded.

All the above mentioned facts, lead to the idea of beveled edges different generation procedure.

So, the edge's profile should not be copied but, kynematically generated by the same abrasive wheel – for, at least, one piece of slob / tile to be machined.

The grinding wheel shape should be that of a disk whose machining surface is the flat (plane) one.

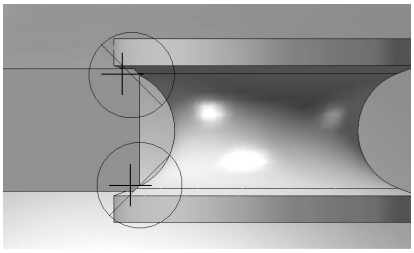
A schematic representation of this working principle can be seen in Fig. 5.



a. working principle b. detail

1 – marble or granite slob
2 – abrasive tool

Fig. 3. Bevelling by profiled abrasive tool.



noticed the severe tool's wear when first in contact with slob's edges

Fig. 4. Zones of intensive wear for profiled abrasive tool.

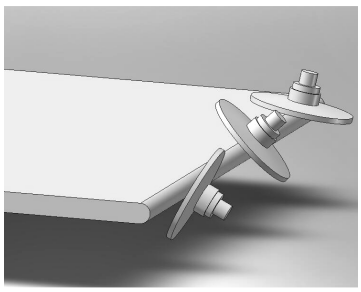


Fig. 5. Kynematically generation of bevelled edges.

3.2. Component elements characteristics

The beveling machine is a customized product and that is why it should be designed as module based structure. There are four main modules, as:

- module of support elements;
- module of guiding and high rigidity elements;
- module of the machining head – main sub-assembly;
- module of automation and CNC elements.

Modeling of machine's component elements has been carried out with SolidWorks software and was based on the "entry data" mentioned by product specifications.

Automation and CNC commands are ensured by Isel-automation components [5] .

It means, there is the isy-CAM software, with its two main parts – isy-CAM CAD (for 2D and 3D parts' designing) and isy-CAM CAM (for machine coded data).

The real components – meaning machine plateau, guiding profiles, rolling screws, etc – are mainly aluminum alloys and ensure the reliability, flexibility and most of all rigidity needed for machining so hard materials.

The servomotors have an encoder and are produced by Isel® Corporation.

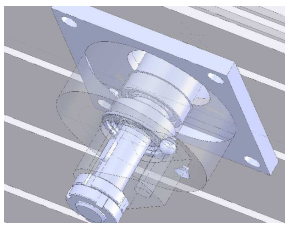
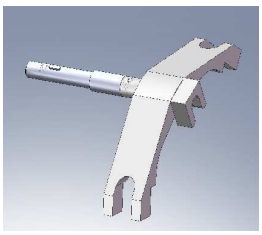
Based on all the above mentioned, it should be summarized that some of beveling machine's important characteristics, are the following ones:

- plateau dimensions: $3\,000 \times 1\,200 \times 850$ [mm];
- longitudinal axis (Y) : $3\,000 \times 450$ with active length of 2 500 [mm];
- vertical axis (A) : $4\,000 \times 150$ with active length of 350 [mm];
- horizontal axis (B): 350×150 with active length of 300 [mm];
- rotational axis (X): 180º in revolution;
- translation axis (Z): 150×77 with active length of 100 [mm];
- trough for water recovering;
- system for re-circulating and recovery of the water required by proper machining process;
- machining head – incorporating a small hydraulic turbine;
- diamond abrasive wheel – 100 mm diameter;
- five axes CNC controller, incorporated hardware.

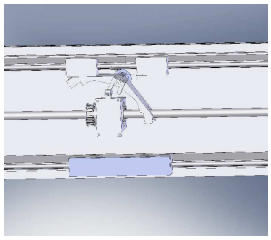
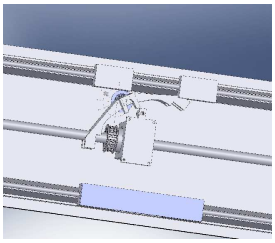
3.3. Component elements modeling

All bevelling machine's components have been modelled – with SolidWorks software but, only the relevant aspects will de presented forward.

So, the main elements and modules whose dimensions and geometry were modelled are shown in Figs. 6, 7 and 8.

a. elements for reversing the axial movement

b. assembled elements

Fig. 6. Modeling of the guidance module.

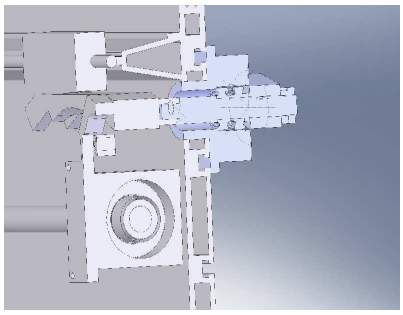
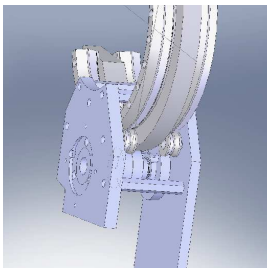
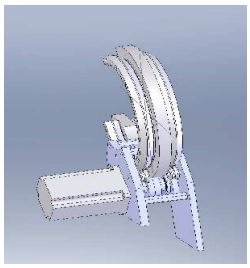
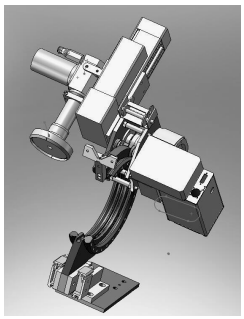
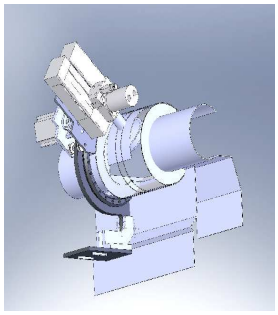


Fig. 7. Modeling of Isel® component elements for rigidity and guidance.

a. elements for rotational guiding and action

b. assembled elements

Fig. 8. Modeling of the main module –machining head.

There should be stated, once more, that even the basic principle of how the beveling machine works it is not completely original (see www. arc-com.ro) the design of all CNC machine's component elements is new, innovative and it is mainly developed on Isel® catalogue components. Also, the CNC system is specially developed for the specific software isy-CAM. That was because one of the author used to work for one of its companies.

So, images of the CNC beveling machine – both drawing and model (without connection to computer), are presented in Fig. 9.

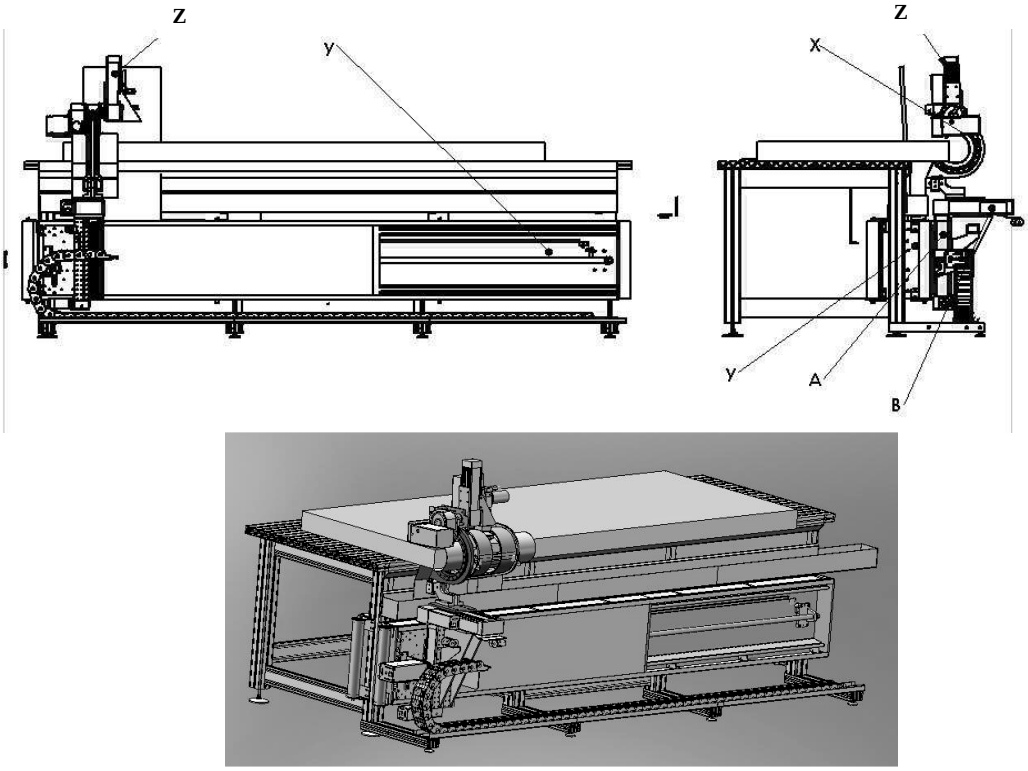


Fig. 9. Beveling machine – drawing and model.

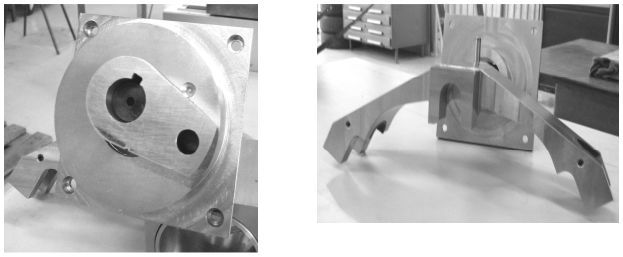
4. ENGINEERED BEVELING MACHINE

As it is a customized product, result of a specific customer requirement, the CNC bevelling machine had to be done, meaning all component elements had to be completely designed, modelled, manufactured assembled and, finally, the whole product, tested.

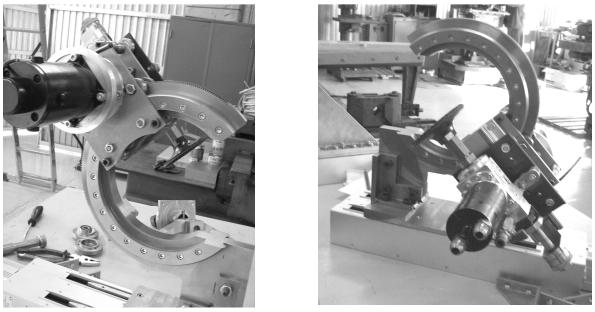
It has to be noticed that, right before manufacturing, simulations have been done.

So strain and stress states of the main components could be studied. Also, interference analyses were performed and so, eventually designing errors could be corrected before elements manufacturing.

Some of machine's modules / elements, presented above as modelled, can be seen as real, engineered, in Fig. 10, while an image of an "early" prototype is noticed in Fig. 11.



a. elements for reversing the axial movement



b. elements of the machining head

Fig. 10. Engineered real component elements.

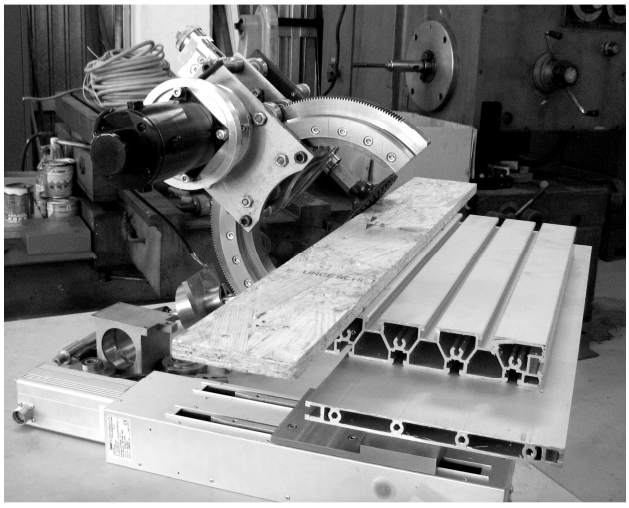


Fig. 11. CNC beveling machine – real prototype.

5. CONCLUSIONS

There are many filed where marble and granite are used and most of the times, bevelling of their slob / tile edges is required.

The worldwide producers do offer the machines suited for this operation kind but, they are very expensive, need a huge space for positioning and, that is why do not "fit" the Romanian consumers' needs.

When the customized product is CNC bevelling machine, specifications are very important and do represent the bases for designing and engineering its component elements.

The design and models of machine's component elements are presented by this paper. Also, simulations of some elements' behaviour (loaded similar to real machining conditions) and of their interference have proven to be of great help, before starting the manufacturing process of these elements.

Major part of components, as well as the CNC system involved, are produced / offered by Isel® Company.

Once the sub-assemblies obtained, they were al "fitted" together and the CNC bevelling machine could be tested.

Further research should be done in order to improve machine's cooling system, as well as its "connection and interaction with the CNC equipment.

It is worth to consider the possibility of "extending" the machining ability for interior slob / tile's edges.

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