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AUTOMATED EQUIPMENT FOR STAMPED SHEET METAL PARTS PRESS DEBURRING

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Abstract: *The paper presents the competitive development of a concept of automated equipment for sheet metal parts deburring. Deburring is perhaps the most critical post-machining operation for ensuring the functionality of the machined part, as well as the safe handling of the part. Deburring has traditionally been a manual task, but various technologies exist for reliably automating the deburring operation [1]. One such technology, called press deburring, consists of physically pressing the burr into the worked part. The paper presents the concept for an automated machine used in press deburring operations for stamped sheet metal parts. Picking the stamped parts from a stack, the machine moves the part through a series of rollers that press the burr into the part and releasing it after all the sides have been cleaned.*

Key words: *automation, sheet metal manufacturing, deburring*

1. INTRODUCTION

Deburring is perhaps the most critical post-machining operation for ensuring the functionality of a stamped machined part, as well as the safe manual handling of the part. Deburring has traditionally been a manual task, but various technologies exist for reliably automating the deburring operation [1].

LaRoux K. Gillespie states in the presentation of his book [2] that there are more than 100 internationally used methods for deburring. Out of these the manual deburring is one of the most common. This is due to the fact that the human operator can check the part to be worked and adjust the force and trajectories to be used. This is true in case of complex parts, where the edges are curved or irregular.

For automated deburring, one example can be the Trumpf Punch 3000, which can be fitted with a device that can debur stamped parts on the mentioned machine. Two types of tools can be used in performing the deburring operation on the Trumpf machine tool. A Multi-Tool, made out of three parts, for small radius and delicate geometry, and a specially profiled roller or ball tool for long edges and contours (figure 1). The roller/ball tool is to be used for carbon steel sheet metal parts up to 3.8mm in thickness and the multi tool for stainless steel and aluminum alloy sheet metal parts up to 0.2mm.

The operating principle for a rollerball tool is presented in the figure 2.

Fig. 1 Roller and MultiTool for deburring [3]

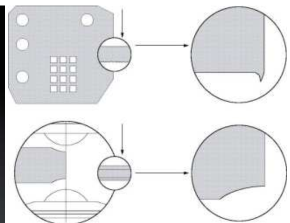


Fig. 2 Mate Rollerball Deburr™ (above: afeter stamping, below: after rollerball deburring) [3]

2. CONCEPT DEVELOPEMENT

The device was requested by a local business that has several TruPunch machine tools. The acquisition of dedicated roller or MultiTool tools for deburring isn’t cost effective for their type of activity.

Presently they use manual deburring tools and they were interested in the development of an automated machine that could perform the deburring operation without having to interfere in the stamping process or on the TruPunch machine tools normal operation routines.

Considering the range of products that the business manufactures after meetings with the upper management a set of requirements were established for the equipment.

The device or equipment should to be able to:

1) Travel automatically on three axes 2000x1000x200mm;
2) A special king of grabbing device was to be developed;
3) A deburring system that was already in the prototype phase was to be included in the machine;
4) A way for stock alignment and feed was to be developed;
5) The force acting of the part was to be controlled in real time by an embedded system.

Considering the above, the development of the concept was performed in three stages. <u>*The first stage*</u> consisted in the identification of the specifics and their importance, identifying the critical characteristics for the equipment, the required functions and the relations between these elements regarding their ability to satisfy the demanded requirements. <u>*The second stage*</u> consists of development of an own architecture, followed on in <u>*the third stage*</u>, by the detailing of the architecture identified as the most appropriate.

2.1. FIRST PHASE

Based on the literature study were identified a series of demands. Using the "Voice of the customer table" method were determined critical characteristics for the platforms and the functions which these must satisfy (figure 3). The voice of the customer table represents a process in which are identified and recorded the requirements, needs, preferences and expectations of the product, and based on these elements the product's critical characteristics.

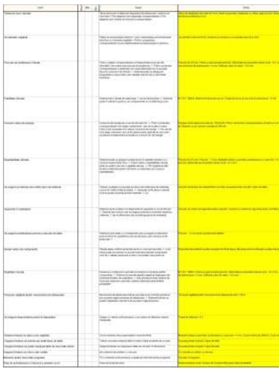


Fig. 3 Voice of the Customer Table

Fig. 4 Analitic Hyerarchy Process

Having identified the requirements, the Analytic Hierarchy Process (figure 4) was used to identify the relative importance of each requirement. The first 3 most important requirements which were identified are:

1. should store parts automatically (10.7%),
2. user safety (9.9%) and
3. adjustable lengths (9.7%).

For attaining the final results, the geometric mean method was used. The formula used is [4][5]:

$$R_i = \frac{(\Pi_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\Sigma_{i=1}^{n} (\Pi_{j}^{n} a_{ij})^{\frac{1}{n}}} \qquad (1)$$

Where:

- R_i represents the importance index of requirement "i"
- a_{ij} represents the relation between element "i" and element "j"

The House of Quality method was used for the correlations between the client's requirements and the technical quality characteristics, meaning how much contribution the improvements of the latter have on achieving the requirements.

The importance value of each characteristic is obtained with the formula [4][5]:

$$W_j = \sum_{i=1}^{n} R_i \cdot a_{ij} \qquad j=1,...,m \qquad (2)$$

where:

- 'a_{ij}' represents the relation between element "i" and element "j"
- 'R_i' represents the requirement importance index 'i', i=1,...,n,
- 'W_j' the walue weight of characteristic 'j', j=1,...,m

The relative importance value of each characteristic was obtained with the formula:

$$W_j^{rel} = \frac{W_j \cdot 100}{\sum_{t=1}^{m} W_t} \qquad j=1,...,m \tag{3}$$

In a similar fashion the requirements were correlated with the functions of the equipment, and then a correlation between the CTQs and functions revealed the relations between these two groups.

2.2. SECOND PHASE

The concept's fragments (figure 5) present several solutions, ideas regarding the embodiment of the constructive version. For each idea will be noted the associated the requirements and functions. The morphological analysis (figure 6) offers the possible solutions by combining the concept's fragments. Five fragments will form a constructive solution. In the central area will be mentioned which fragments will form the solution.

Fig. 5 The concept's fragments

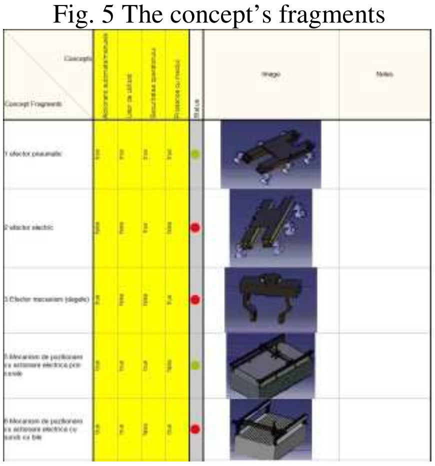
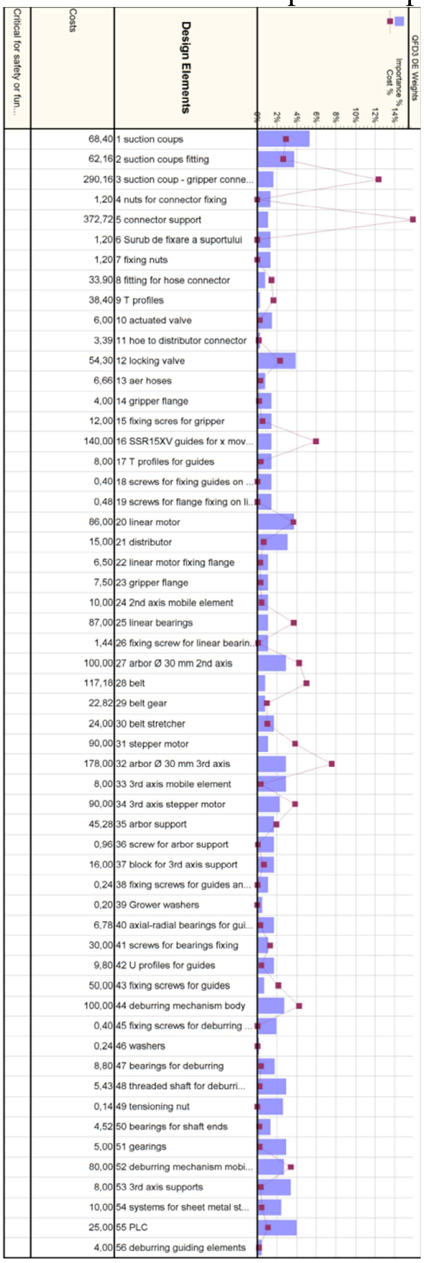


Fig. 6 The morphological analysis

2.3. PHASE THREE

Considering the identified concept, costs for each individual part are determined. The table with the target costs (figure 7) of the design elements is calculated considering the importance of the target costs of the elements. It is determined the inferior and superior limits of the target costs. The diagram on the right side of the table show in which manner the costs are within the calculated limits considering the correlations established in the previous phase.



Critical for safety or fun...	Costs	Design Elements
	68,40	1 suction coups
	62,16	2 suction coups fitting
	290,16	3 suction coup - gripper conne...
	1,20	4 nuts for connector fixing
	372,72	5 connector support
	1,20	6 Surub de fixare a suportului
	1,20	7 fixing nuts
	33,90	8 fitting for hose connector
	38,40	9 T profiles
	6,00	10 actuated valve
	3,39	11 hoe to distributor connector
	54,30	12 locking valve
	6,66	13 aer hoses
	4,00	14 gripper flange
	12,00	15 fixing scres for gripper
	140,00	16 SSR15XV guides for x mov...
	8,00	17 T profiles for guides
	0,40	18 screws for fixing guides on ...
	0,48	19 screws for flange fixing on li...
	86,00	20 linear motor
	15,00	21 distributor
	6,50	22 linear motor fixing flange
	7,50	23 gripper flange
	10,00	24 2nd axis mobile element
	87,00	25 linear bearings
	1,44	26 fixing screw for linear bearin...
	100,00	27 arbor Ø 30 mm 2nd axis
	117,18	28 belt
	22,82	29 belt gear
	24,00	30 belt stretcher
	90,00	31 stepper motor
	178,00	32 arbor Ø 30 mm 3rd axis
	8,00	33 3rd axis mobile element
	90,00	34 3rd axis stepper motor
	45,28	35 arbor support
	0,96	36 screw for arbor support
	16,00	37 block for 3rd axis support
	0,24	38 fixing screws for guides an...
	0,20	39 Grower washers
	6,78	40 axial-radial bearings for gui...
	30,00	41 screws for bearings fixing
	9,80	42 U profiles for guides
	50,00	43 fixing screws for guides
	100,00	44 deburring mechanism body
	0,40	45 fixing screws for deburring ...
	0,24	46 washers
	8,80	47 bearings for deburring
	5,43	48 threaded shaft for deburri...
	0,14	49 tensioning nut
	4,52	50 bearings for shaft ends
	5,00	51 gearings
	80,00	52 deburring mechanism mobi...
	8,00	53 3rd axis supports
	10,00	54 systems for sheet metal st...
	25,00	55 PLC
	4,00	56 deburring guiding elements

Fig. 7 Table with the target costs of the design elements

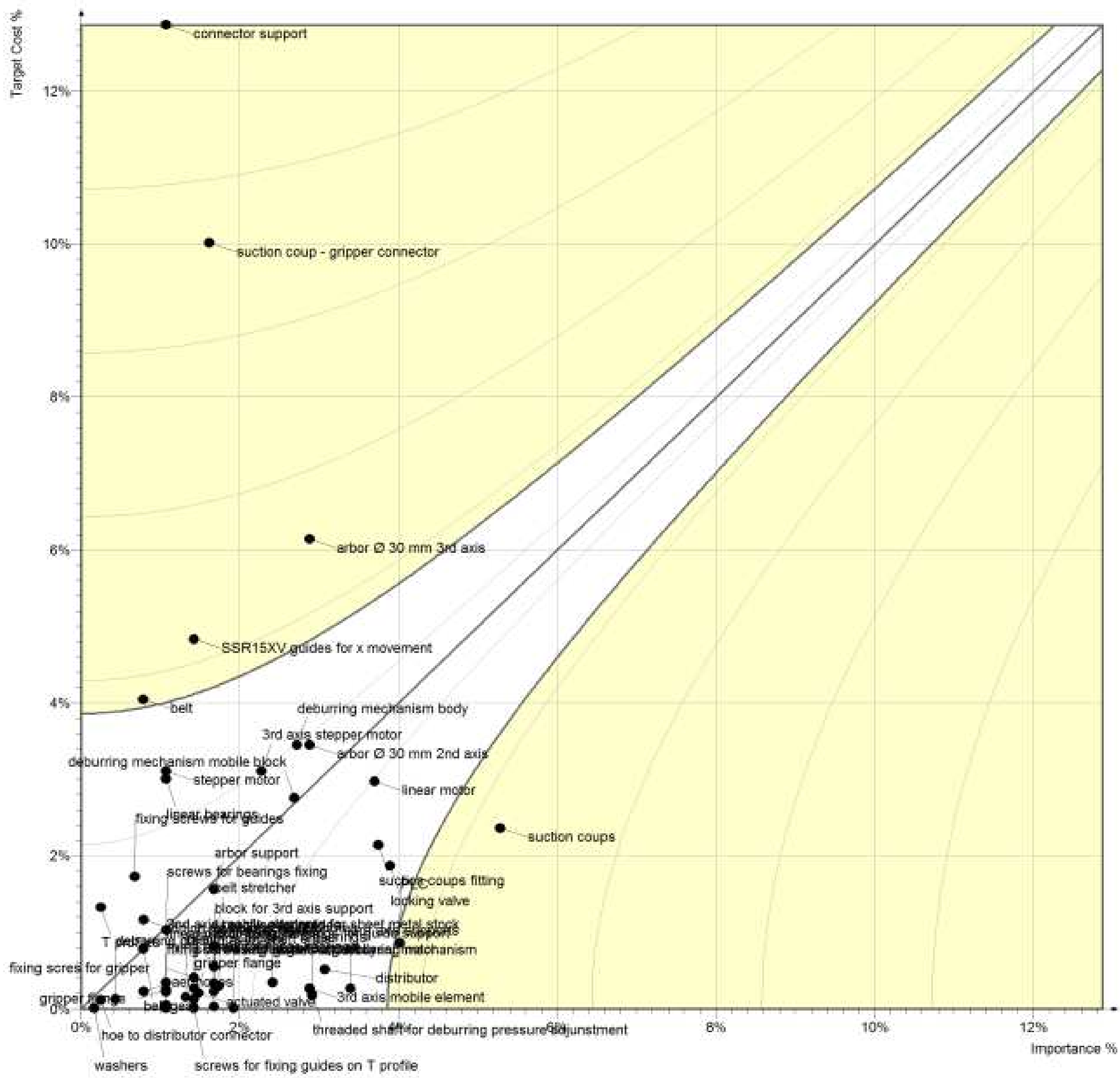


Fig. 8 The diagram of the target costs

The diagram of the target costs of the design elements (figure 8) allows a better visualization of the relative costs in relation to the importance determined for the parts.

If the elements are found on the white area of the diagram, their costs and importance for the equipment are in balance.

If they are found under the diagonal, it means that for their importance the acquisition price is lower. If the elements are located above de diagonal, this indicates the fact that their price exceeds their importance. In this case, other parts or other suppliers should be chosen.

In this case the motor drive is exceedingly costly due to use safety reasons. Also the connector supports and suction coups have a higher cost than their importance because they are specialized elements.

3. FINAL CONCEPT

To this point, the idea for the product was analyzed and transformed in various stages down to part level. The parts were modeled using Delmia software and assembled into the final concept.

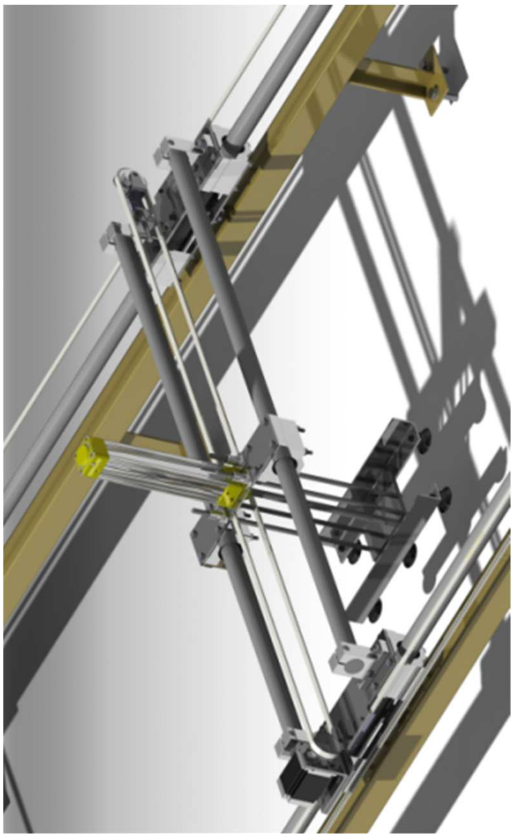


Fig. 9 View of the X, Y and Z axes

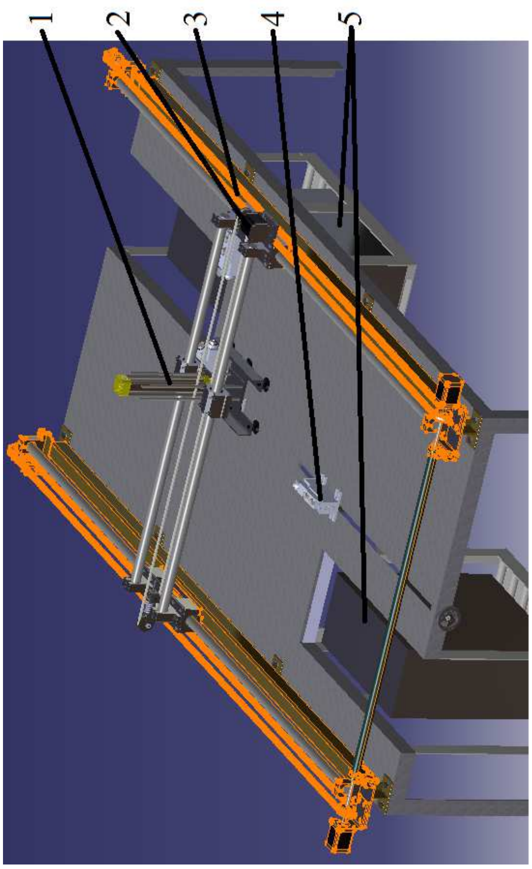


Fig. 10 Final concept of the equipment

The automatic concept that was designed (figure 9), must execute three translational motions, the motion on axes X and Y are made by translational modules, and the Z axis movement with an pneumatic actuator (figure 10-1).

On the machine's table are positioned four deburring devices (figure 10-4), two oriented on the X axis (figure 10-3) and the other two are oriented on the Y axis (figure 10-2).

As previously mentioned, there are two devices on each axis, X and Y, with one fixed devices on each axis and the other one is mobile. A screw-nut mechanism, with a blocking system on the desired position, actuates the mobile devices, allowing for a more flexible use of the equipment.

The X and Y axis movements are actuated by step-by-step motors, which are controlled through a stepper motor driver, by a PLC Arduino Mega 2560, which has a 24 V tension power source.

The PLC signal is transmitted to the CNC Drive 4 axis, which can resist up to a 4,5A current, which transmits signals to the motors, thus realizing the controlled movement on the axes.

The movements on X and Y must be accurate, because through these movements the sheet metal parts are manipulated and passed through the deburring devices.

- The movement on X axis (axis 1), is on a length of 2000 mm,
- The movement on Y axis (axis 2), has a 1000 mm race
- The translational movement on the Z axis is made by a pneumatic actuator P1D-B032MS-0200 with a 200mm race.

4. CONCLUSION

Competitive design is not a novel approach to product development. It proved useful in numerous cases. The implementation of quality specific tools like Quality Function Deployment, Analytic Hierarchy Process, benchmarks, etc. leads to a more detailed view of the concept then otherwise possible.

Using the approach presented in the article the concept can be clearly followed based on critical characteristics and functionality, giving the development team a tool that can help in properly calibrating the final products structure with the costs involved.

Unlike regular products, the development of mechatronic products presents several challenges: balancing functionality and critical characteristics, harmoniously integrating electrical, electronic and mechanical parts.

Being able to choose the appropriate components both from the functionality point of view and with respect to the critical characteristics that the equipment must have could lead to the development of a cost effective and efficient product.

The final concept presented is the first attempt at automating a deburring operation for thin sheet-metal parts. It will be manufactured and implemented in a production process for thin sheet metal parts.

5. REFERENCES

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ECHIPAMENT AUTOMAT DE DEBAVURARE PRIN PRESARE A PIESELOR DIN TABLE SUBTIRI

Abstract: *Lucrarea prezinta dezvoltarea unui concept de echipament automat pentru debavurarea pieselor stantate din table subtiri. Bebavurarea este una dintre cele mai importante operatii post-prelucrare deoarece asigura functionalitatea si manipularea in siguranta a piesei. Debavurarea este in mod traditional o operatie manuala, insa exista posibilitati de autonatizare a opratiei [1]. O astfel de tehnologie se numeste debavurare prin presare. Aceasta consta in presarea fizica a bavurii in piesa. Lucrarea prezinta un concept de masina automata utilizata pentru debavurarea prin presare a pieselor stantate. Piesele stantate sunt preluate dintr-o stiva si trecute printr-o serie de role tensionate. Astfel, bavura este presata in piesa pe toate laturile ei.*

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