12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

METODOLOGY PROCESSING AND EVALUATION OF MACHINERY FAMILY FOR DE-COILING METAL SHEET

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ABSTRACT
This paper uses the construction method for the synthesis of machinery for metal-sheet de-coiling. This family covers the whole market demand for such equipment. Equipment has been divided into two larger groups, further dividing into several classes, which have developed to the level of working on similar principles and having a large number of identical parts. The general function of the equipment (iron-sheet processing) is divided into 20 (twenty) partial functions and each partial function has found its own solution. All versions have been checked for their technical and economic usefulness. The designing process has taken into account technical and economic requirements provided on the Requirements' List, including validation of dimensions, selection of materials and processing technology, and calculation of main forces driving the machinery. Finally, modeling has been presented as a process of shape creation. The resulting spatial model (3D), designed in Autodesk Inventor 5 software, represents the computer description of the equipment shape.
Keywords: Construction methodology, general function, evaluation, modeling.

1. INTRODUCTION

Iron-sheet de-coiling equipment may be used for iron-sheet de-coiling even in manual iron-sheet processing. Depending on processing and size of the coil, equipment may vary in their construction. The most important parameters of a coil in selecting the equipment construction are: the internal diameter (d), external diameter (D), width of coil (B) and mass. The largest dimensions of iron-sheet coils, which may be ordered from metal foundries, depend on equipment functions of iron-sheet coiling possibilities of the equipment, starting at an internal diameter of 420 mm up to 850 mm, while the width cannot be greater than 2050 mm.

1.1. Methodology of processing

One of the key conditions for an accurate solution to the assignment, and a successful realization of the construction process is accurate and clear definition of the assignment. With the requirements made by the user, the constructor has to work directly in resolving such requirements. In relation to this, one must have:

- A clear and accurate presentation of the assignment,
- Solution of the assignment must be in accordance with technical, economic, financial and temporal possibilities,
- Solution possibilities must be in a proper ratio with the technical condition,
- Recognition of several requirements in their relation with the general condition of the market,

The list of requirements may include: basic requirements (function, capacity), alternatives (energy spending, easy maintenance), minimal – desires (position of the driving machine).

1.2. Equipment system functional structures

The functional structure of the system is unknown, and it is viewed as a black box, which develops processes driving to a desirable transformation of input parameters into the output. Hence, the general function of this system is rotation of the coil to de-coil the iron sheets.

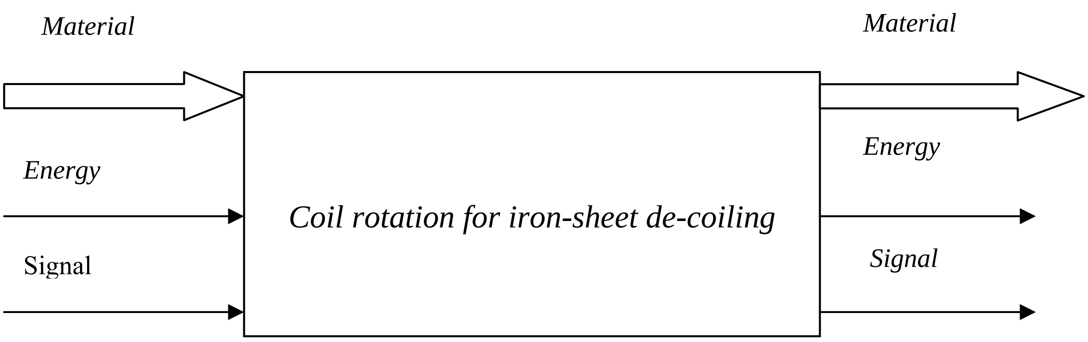


Figure 1. The general function of equipment

2. MACHINE FAMILY CLASSES

Equipment has been divided for in classes of **small serial production** and **industrial production**, which assign more attention on the speed of coil replacement.
Each equipment has three most important sizes: **a greater coil width, a larger mass of the coil** and **the range of internal diameter of the coil**. The division of equipment into groups of different coil width ranges is shown by Table 1.

Table 1. Division of equipment by coil internal diameter range

Group	I	II	II	IV
Coil internal diameter range (mm)	380-520	490-620	600-760	740-860

Table 2. Division of equipment by width and mass of coil

roup	I	II	II	
Width (mm)	1000	1550	2050	
Mass (kg)	7000	12000	21000	industrial production
Mass (kg)	2000	5000	12000	small serial production

The division of equipment by width and mass of coil, and division by mass of coil for industrial production and small serial production are shown on table 2.
The basic division of this family is in industrial production classes and small serial production classes. An overview of these classes is provided by table 3.

Table 3. Family of equipment for industrial production and small serial production

	Industrial production				Small serial production				
Width (mm)	Load (kg) 7000	12000	21000	Classes	Load (kg) 2000	5000	7000	12000	Classes
380-520	1000	1000	1000		1000	1000	1000	1000	
	1550	1550	1550	K1.3	1550	1550	1550	1550	K2.3
	2050	2050	2050		2050	2050	2050	2050	
490-760	1000	1000	1000		1000	1000	1000	1000	
	1550	1550	1550		1550	1550	1550	1550	
	2050	2050	2050	K1.2	2050	2050	2050	2050	K2.2
600-760	1000	1000	1000		1000	1000	1000	1000	
	1550	1550	1550		1550	1550	1550	1550	
	2050	2050	2050		2050	2050	2050	2050	
740-860	1000	1000	1000		1000	1000	1000	1000	
	1550	1550	1550	K1.1	1550	1550	1550	1550	K2.1
	2050	2050	2050		2050	2050	2050	2050	

The sign is made of the letter "K" and two numbers. The first number shows the category of the class, while the second number shows the sorting number of the class. **This division was made in an intuitive manner.**

2.1. Evaluation and decision

For finding the most adequate solution in the best version, evaluation is required in two parameter, technical and economic terms.

The technical and economic usefulness, namely general usefulness graph is presented in an S chart. Technical usefulness x_j is presented in the abscissa, while the economic one in the y_j, axis. The usefulness curve in a construction solution is defined at S_j.

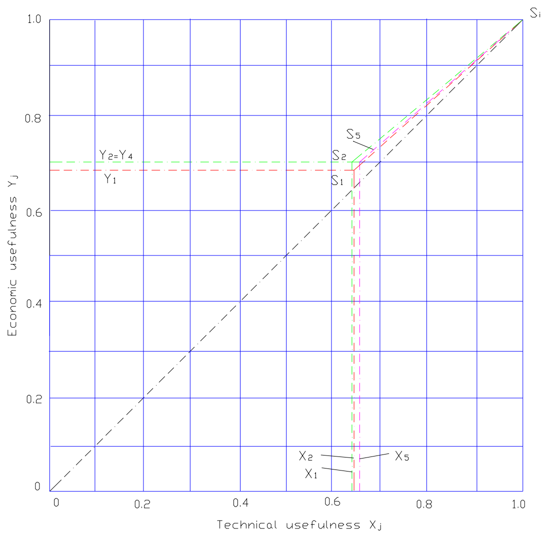


Figure 2. S-Chart

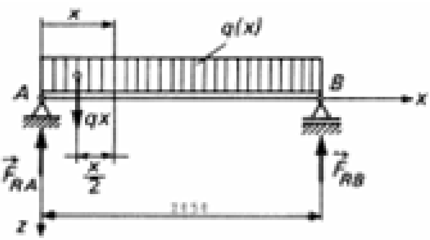
Pursuant to the list of requirements and a review of different versions in various classes, and ultimately following technical and economic assessment, and calculations, the final result is that the equipment shall be compliant to conditions and requirements of processing in the version V5. the maximum continuous load q_{max} is.

$$q_{\max} = \frac{\sigma_{lej} \cdot \left((D_b^3 \cdot \pi)/32 - (5 \cdot D_b^2)/2 - 45663.7/D_b\right)}{(lx/2) - x^2/2} = 283{,}7\ N/mm^2 \quad ; \qquad m_{max}=59.2\ \text{t}$$

Calculations show that the version V5 achieves the greatest load in both categories.

3. DESIGNING

Designing is part of the construction process, in which the conceptual solution through technical and economic assessment is shaped into a construction. In the designing stage, validation of dimensions, selection of materials and processing technology are important parameters. In accordance with the list of requirements, it is necessary to build an iron-sheet de-coiling equipment, with a coil of these dimensions:



Internal diameter d_{min}= 380 mm, maximal external diameter of the coil d_{max}= 520 mm, maximal coil diameter of the coil D_{max}=1900 mm, minimal width B_{min}=375 mm and maximal width B_{max}=600 mm in the coil, thickness of iron-sheet t=0.8-2.5 mm, and density $\rho_c = 7850\ kg/m^3$.

Forces burdening the equipment are the weight of the coil and the weight of upper parts of the equipment.

Volume of coil $V_b = 1.63\ m^3$, coil mass $m_b = 12795.5\ kg$, weight of coil $G_b = 12.57 \cdot 10^4\ N$,

Equipment weight $G_{s1} = 1000\ N$ and gross weight $G_p = G_b + G_{p1} = 12.67 \cdot 10^4\ N$.

Parameters of the main axes: $D_b = 190\ mm$, $d_b = 62\ mm$, $a_b = 20\ mm$, cross-section inertia momentum $I_X = 52179323.31\ mm^4$, resistance momentum $W_X = 549256.034\ mm^3$, bending strain $\sigma_f = 38.6854\ N/mm^2$, and construction steel material Č.0460 $\sigma_{flej} = 220\ N/mm^2 > \sigma = 38.6854\ N/mm^2$,

3.1. Calculations of bearing construction

Forces in construction are set by method of partial elements

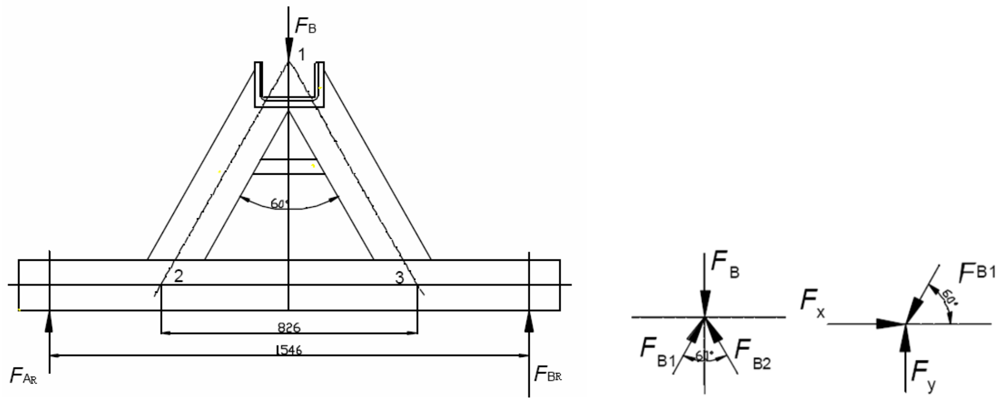


Fig. 3. Forces in the podium construction

Partial elements 1

$$F_{B1} = F_{B2} = \frac{F_B}{2 \cdot \cos 30°} = 37256\ N$$

Partial elements 2

$$F_X = F_{B1} \cdot \cos 30° = 32265\ N$$

3.2. Velocity of iron-sheet de-coiling

Coil velocity – speed of iron-sheet de-coiling is: V = 0,2-0,4 m/s

- Minimal velocity for the largest coil diameter

$$\omega_{min1} = \frac{2 \cdot V_1}{D_{max}} = 0.21052\ s^{-1}\ ,\ n_{\min 1} = 2{,}011\ \min^{-1}\ ,\ \omega_{\min 2} = \frac{2 \cdot V_2}{D_{\max}} = 0.421\ s^{-1}\ ,\ n_{\min 2} = 4{,}02\ \min^{-1}$$

- Maximal velocity for the smallest coil diameter

$$\omega_{\max 1} = \frac{2 \cdot V_1}{d_{\min}} = 1{,}053\ s^{-1},\ \ n_{\max 1} = 10{,}07\ \min^{-1},\ \ \omega_{\max 2} = \frac{2 \cdot V_2}{d_{\min}} = 2{,}105\ s^{-1},\ n_{\max 2} = 20{,}06\ \min^{-1}$$

4. ANALYSIS OF RESULTS

A large number of versions have been addressed, by dividing the general function into partial functions, and providing respective solutions to each partial function. Also, it is important to underline that by using methodological construction, the possibility of wasting good solutions in an evaluation has been eliminated.

All versions have been checked for their technical and economic usefulness, which means that evaluation has selected the usefulness of the solution provided, and based on evaluation, the best version was selected to fulfill all requirements at the best manner possible.

5. CONCLUSION

This paper synthesizes the family of machines for iron-sheet de-coiling. Provision of this equipment covers the demand of producers interested about the appearance of this equipment in the market. Equipment was divided into two larger groups, further dividing them into several classes, within which equipment works in generally similar principles, and has a large number of identical parts.

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