

# Research regarding to behavior on advanced plastic from rolling mills equipment

M Ardelean<sup>1</sup>, E Ardelean<sup>1</sup>, E Popa<sup>1</sup>, A Josan<sup>1</sup> and A Socalici<sup>1</sup>

<sup>1</sup>Politehnica University of Timisoara, Department of Engineering and Management, 5 Revolution Street, 331128 Hunedoara, Romania

E-mail: [marius.ardelean@fih.upt.ro](mailto:marius.ardelean@fih.upt.ro)

**Abstract.** New advanced plastic can be used in construction of different equipment's from some industries; due to mechanical properties closer to nonferrous materials. In steel industries uses of this materials are limited because working temperature is too low, related to nonferrous or ferrous material.

In this paper is presented some researches related to replacement of bronze material with advanced plastic in construction of antifriction bearings. For replaces of this material with engineering plastic product, it was calculated analytical and using simulation, forces in node of braking mechanism. Using these loads, it was make simulation regarding behavior of static loads with finite element software. Based on these researches, this bearing can be made from engineering plastic product, in same qualitative and technical condition, and this is a way to reduce maintenance and exploitation cost.

## 1. Introduction

For the design of cooling bed cannot be specified uniform principles, the construction of this equipment depends primarily on the rolling speed and schedule of rolling, it is also influenced by local conditions such as, for example, the length and width of the hall. How much will become a greater cooling area, the greater will be the cooling capacity. The cooling capacity  $C$ , of the cooling bed is related to the productivity of the rolling mill  $Q$  and cooling time  $t_r$  according to the equation, [1]:

$$C = q \cdot t_r \quad (t) \quad (1)$$

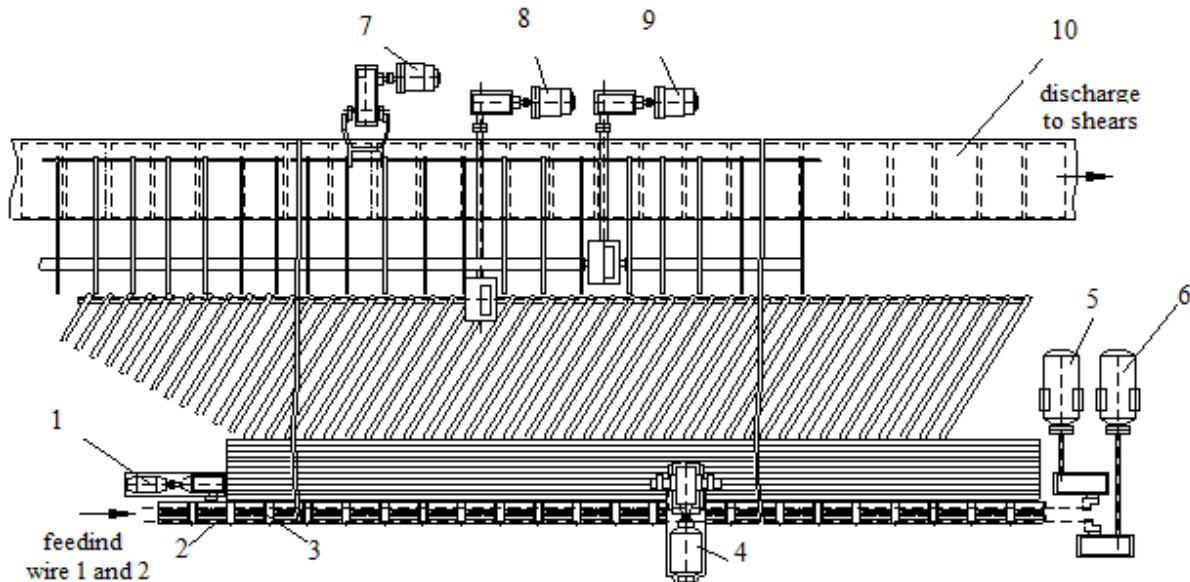
The value of  $t_r$  from the equation result of the laminate heat disposal to the environment, mainly through radiation. Temperature of the material to leaving the cooling bed shall be in general under the 150°C. When, after cooling, the material is directed in the main production flow, the temperature should not exceed 100°C.

The cooling bed from small profiles rolling mills, is one of the most complicate constructive-functional cooling beds, first of all because it is composed from several mechanisms and all must be correlated in operation. The location of the main mechanisms components of the small section cooling bed rolling mill is shown in Figure 1.

Kinematic analysis of mechanisms aims to determine the positions, speeds and accelerations of mechanism elements (angles of position, angular velocity and accelerations for elements in rotation and displacements, linear velocities and accelerations for items in translation) by the angle position of the driving element for rotation or linear movement for the translational motion of drive element [2].



Kinetostatic analysis is made for structural mechanism groups, considered statically determined, and start from more distant structural element to driving element, that containing effector element. The purpose of this analysis is to determine the kinematic couplers loads, forces and moments [1], [2], [5].

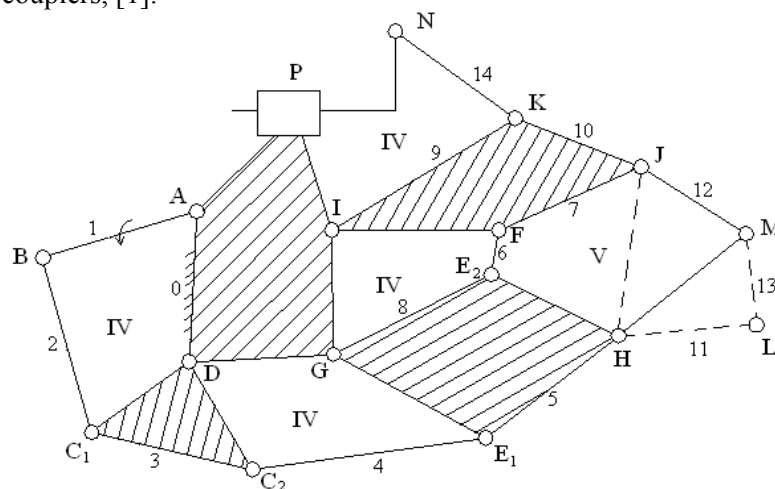


**Figure 1.** The location of the cooling bed mechanisms

1- separating mechanism; 2,3-supply roller conveyor; 4-the walking drive mechanism with rack; 5,6- brake mechanisms of the wires 1 and 2; 7,9-discharge mechanism; 8- inclined roller drive mechanism; 9- evacuation roller conveyor

## 2. Presentation of the studied mechanism

Structure diagram of a brake mechanism for the wire 1 is shown in Figure 2. The figure shows that the mechanism contains a rank V, two elements of rank IV, an element of rank III and eight elements of ranks II, which form five closed deformable contours including four class IV and one class V. Joints C and E are double couplers, [1].



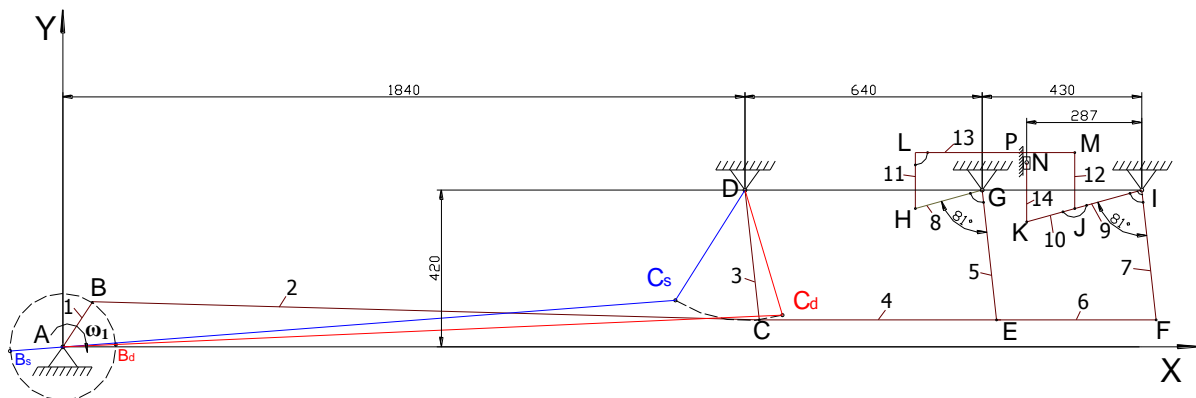
**Figure 2.** Structure diagram of a brake mechanism

Kinematic scheme of the mechanism is shown in Figure 3. The mechanism is based on a plan reference system, with origin in fixed joint A with its OX axis oriented in a direction parallel to direction of fixed couplers D, G, I.

The mechanism is plan, consists of 11 movable cinematic elements and 15 rotation grade cinematic couplers (forming rectangles A, B, C, D; dyad C, E, G; dyad E, F, I, dyad H (L) MJ; dyad K, NN) and a translational coupling in P, [3].

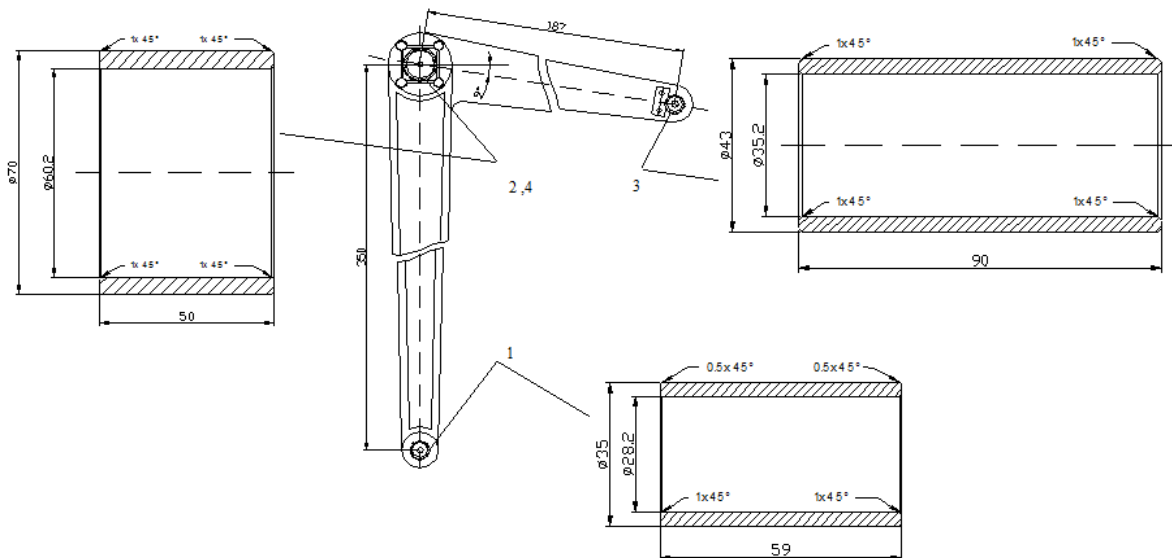
Family plane mechanisms are mechanisms  $f = 3$ , degree of mobility for planar mechanisms is calculated with relation:

$$M_3 = 3 \cdot n - 2 \cdot C_5 - C_4 = 3 \cdot 11 - 2 \cdot 16 - 0 = 1 \quad (2)$$



**Figure 3.** Kinematic scheme of the mechanism

Studied subassembly is part of the braking mechanism of the booth wire, and is shown in Figure 4. Also is presented drawings of three types of bushings used in construction of this subassembly.



**Figure 4.** Subassembly of the braking mechanism

For the bushings 1, 2 and 3 maximum loads shall be increased by a factor of safety ( $c=1.2$ ). Are determined the loads that will make simulation in finite element analysis software Ansys, [4], [5].

$$F_{1\max} = F_1 \cdot c = 162.864 \cdot 1.2 = 162.864 \text{ N}$$

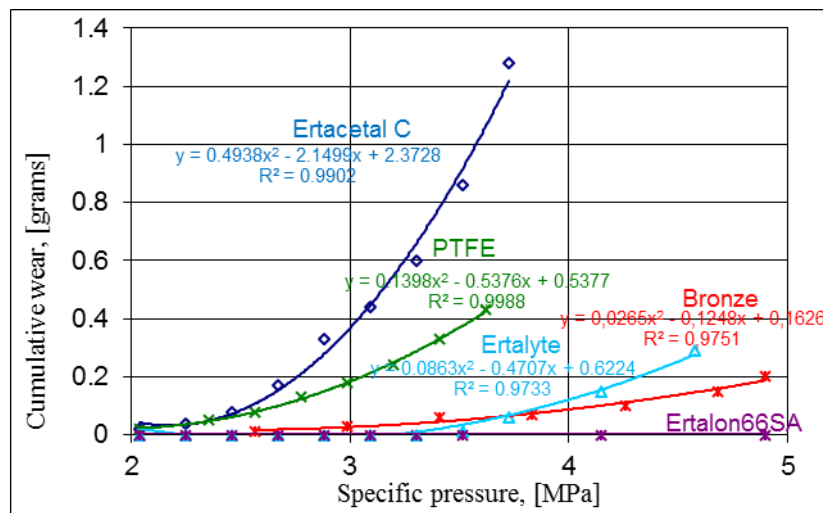
$$F_{2\max} = F_2 \cdot c = 530.69 \cdot 1.2 = 318.414 \text{ N} \quad (3)$$

$$F_{3\max} = F_3 \cdot c = 289.197 \cdot 1.2 = 304.197 \text{ N}$$

### 3. Simulation and experiments

Based on the results of wear testing (Figure 5), will be presented in this section simulation results to static behavior, focusing on the materials ERTALON 66SA and ERTALYTE, which had the best behavior to wear in the test circumstances, [2], [6], [7], [8], [9].

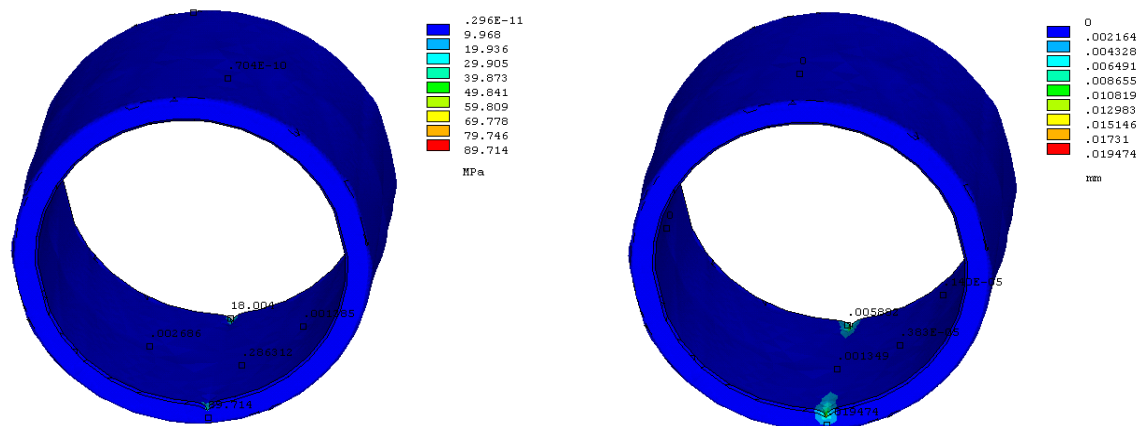
In figure is presented comparative values of cumulative wear according to the specified pressure for all studied materials, including bronze. In conclusion, the plastic composite ERTALON 66SA performs better than bronze in these test conditions. ERTALYTE perform well at low and medium loads when not wear at all. It is observed in this case a tendency to buckling that leads to an increase of wear. The material ERTACETAL C presents the worst behavior and is observed an accelerated wear, particularly with increasing load, [1].



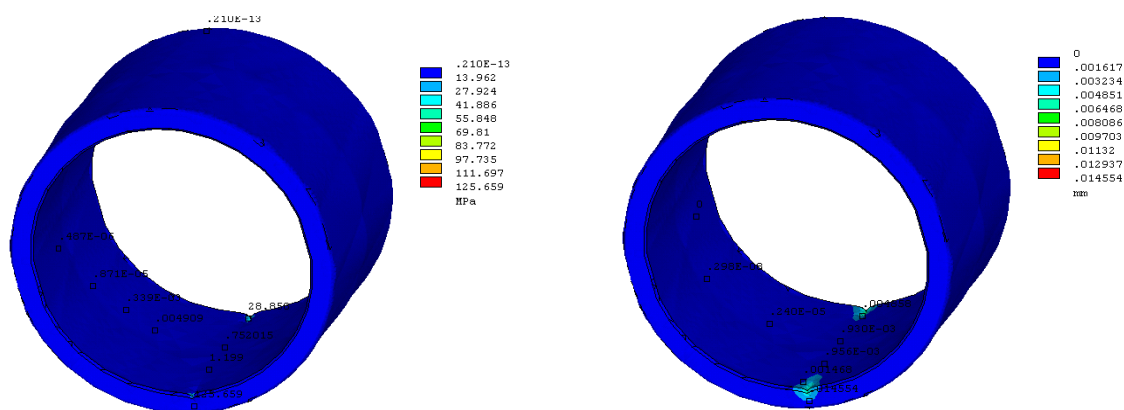
**Figure 5.** Cumulative wear according to the specific pressure - comparative values

Are established two variants cases of extreme loading, corresponding to a uniform force distribution on the contact surface, or force acting along the contact line – Figure 6 to 9. The loads are applied through the force transfer surfaces or network lines (nodes). From the loading analysis notes that bushing 2 is more loaded and in the following will study only this bushing.

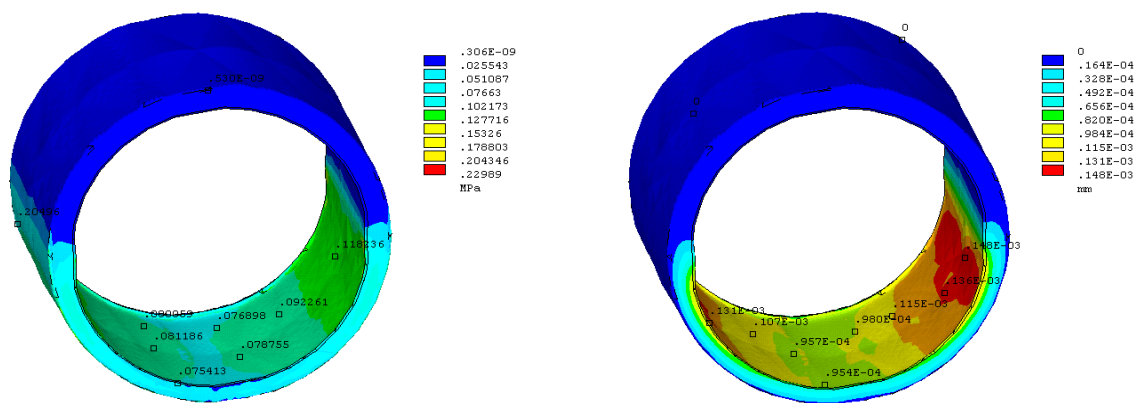
This version represents an extreme load case that would come when it would be extremely worn bushing and replace it as necessary anyway. Based on the presented simulations ERTALON 66 SA is loaded to yield stress (max. 89.714MPa) request to corresponding maximum deformation of 0.019mm.



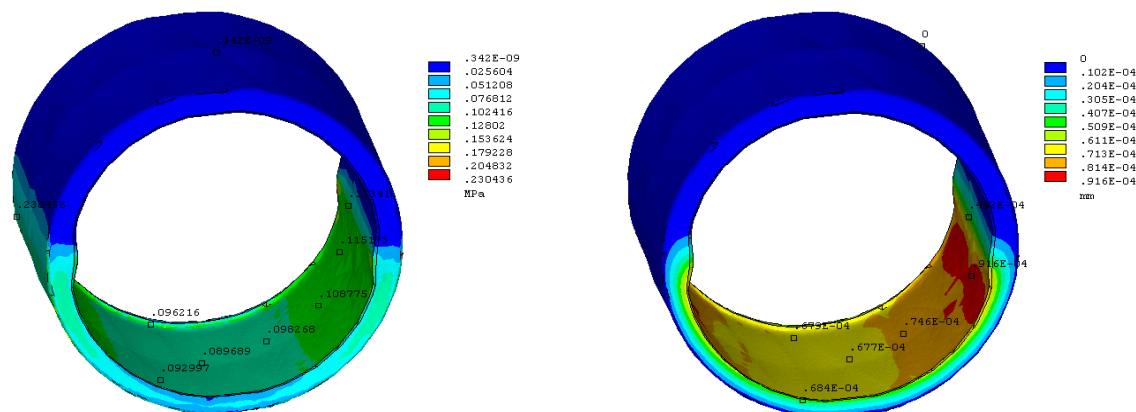
**Figure 6.** Equivalent stresses and strains at loading of bushing 2, line cases, for Ertalon 66SA



**Figure 7.** Equivalent stresses and strains at loading of bushing 2, line cases, for Ertalyte



**Figure 8.** Equivalent stresses and strains at loading of bushing 2, surfaces cases, for Ertalon 66SA



**Figure 9.** Equivalent stresses and strains at loading of bushing 2, surfaces cases, for Ertalyte

The figures are shown both maximum equivalent stresses and deformations and also stresses and equivalent deformations values at different point's inner or outer bushing.

On this basis we can say that the material ERTALON 66SA is closest to the desired exploitation behavior. ERTALYTE compared ERTALON 66SA behaves weaker showing load more than the yield point of approximately 30%, leading to an accelerated bushing degradation. Maximum equivalent stress were 0.229MPa for material ERTALON 66SA.

#### 4. Conclusion

Using the simulation results in the two versions of load, in conjunction with wear test performed on plastics materials can say that studied bushings may be made of technical plastic material ERTALON 66SA that can replace in optimal condition bronze currently used in the construction of these bearing and at low cost prices. It can be used ERTALYTE (as replacement material) but with worse results than ERTALON 66SA.

Also it can be concluded that in the construction of bushings can be used the same types of materials with the observation that the using of ERTALYTE could be do under conditions of poor lubrication with good results of operating equipment. It should be noted that these bushes can operate at high temperatures (for short time approx. 90-110°C) and even under poor lubrication.

Compared with bronze (which has a purchase price of around 12...14€/kg) these plastic composite materials have a much lower price (about 7...7.5€/ kg for bars and approximately 12... 13€/kg for tubes). Low costs in conjunction with lower density compared to the bronze, 7 times ( $1.14\text{g/cm}^3$  for plastics and  $8.65\text{g/cm}^3$  for bronze) leads to significant financial savings. So if processing costs are the same, the economy resulting from the use of plastics is around 0.2 ...4€ / bushing to its size.

#### References

- [1] Ardelean M and Zamfir V 2008 *The Equipment of Cooling Beds Section Mills. Constructive and Functional Analysis*, Mirton, Timisoara, Romania
- [2] Starcevic J, Pohrt R and Popov V L 2015 *Plastic Properties of Polytetrafluoroethylene (PTFE) under Conditions of High Pressure and Shear*, Wear, Lausanne, Switzerland
- [3] Ardelean M, Ardelean E, Hepuț T and Socalici A 2009 *Simulation Results Regarding to Cinematic Parameters of Mechanical Systems*, 13th WSEAS International Conference On Systems: Recent Advances In Systems, Book Series: Mathematics and Computers in Science and Engineering, Rodos, Greece, July 22-24, pp 254-259
- [4] Kljajin M, Pisičić K, Keček D and Bolarić D 2014 Comparison of Kinematic Analysis Methods at One Demonstration Mechanism, *Technical Gazette* **21**(3) 657-664
- [5] Ardelean M, Hepuț T, Ardelean E, Socalici A and Vilceanu L 2008 New Methods and Analysis

- Functioning Techniques for Cooling Bed Tool of the Profile Laminators, *Metalurgia International* **XIII**(5) 48-53
- [6] Demirci MT and Duzcukoglu H 2014 Wear behaviors of Polytetrafluoroethylene and Glass Fiber Reinforced Polyamide 66 Journal Bearings, *Materials & Design* **57** 560-567
- [7] Ardelean E, Ardelean M, Hepuț T and Socalici A 2008 *Aspects Regarding to Dimensioning of Shape Cooling Bed*, International Symposium about Forming and Design in Mechanical Engineering KOD 2008, Novi Sad, Serbia, April 15-16, pp 233-236
- [8] Glasscock D, Walter A, Kozielski G and Martens M 2008 *High Performance Polyamides Fulfill Demanding Requirements for Automotive Thermal Management Components*. DuPont Engineering Polymers, available: [www.plastics.dupont.com](http://www.plastics.dupont.com)
- [9] Kutz M 2015 *Mechanical Engineers' Handbook, Materials and Engineering Mechanics*, Fourth Edition, John Wiley & Sons, Hoboken, NJ USA