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POWER CONSUMPTION INVESTIGATION IN DISC REFINER AT WASTE PAPER TREATMENT

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Abstract

In the paper there was presented investigation methodology of power consumption by disc refiner which worked on an industrial scale. In the article there was presented the structure of qualitative and energetic model, which described beating process of waste-paper stock in disc refiner. The author has chosen the basic parameters of this process, which can be obtained during investigations on an industrial scale.

Keywords: *disc refiner, beating process, waste paper*

1. Introduction

In the production of paper, the beating of waste paper stock is the most important process. The most typical refiners in papermaking are the conventional double disc refiners [1, 2, 4]. Working idea of these devices was presented on the Fig. 1. On the scheme, there was presented working knife disc of the refiner and flow system of stock by refiner.

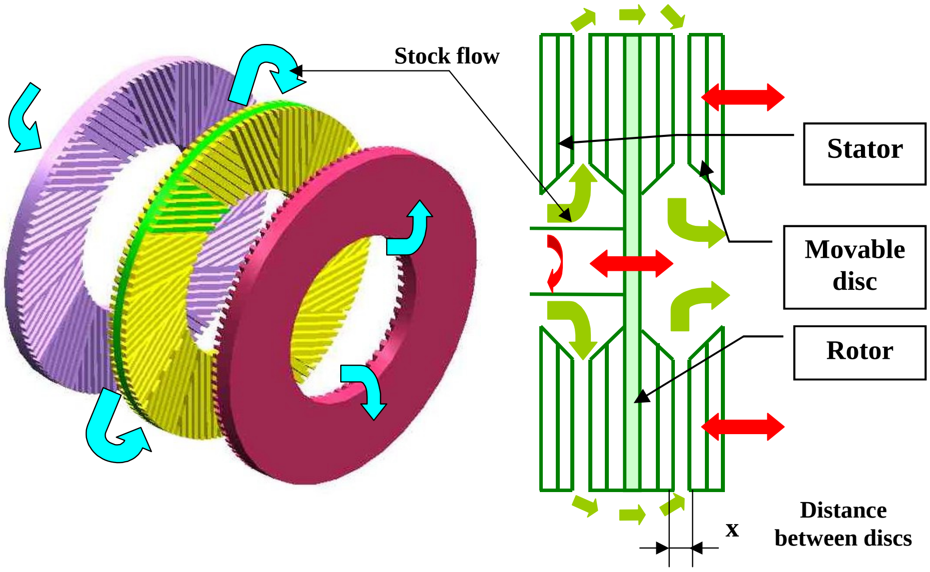

Fig. 1. Typical dimensions of the refining zone [3]

Modern industrial disc refiners are based mainly on a narrow gape treatment of the paper making fibers. In order to achieve the desirable refining effects in waste paper refining the gape between the rotor and stator bars varies in the range 10-400 μm (fig. 2). The average gape of 100 μm corresponds to the thickness of 2-5 swollen fibers or 10-20 collapsed fibers.

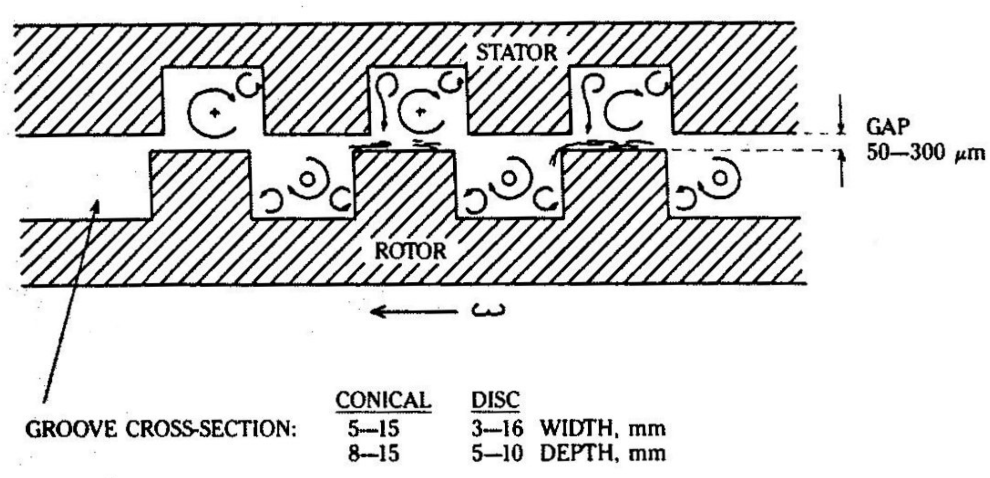

Fig. 2. Typical dimensions of the refining zone [1, 2]

Beating process, like in any other complex technological process, depends on many factors which we can divide into construction and system factors (connected with beating system and with its equipment) and technological factors. To the first group of factors belong: using refining system (periodic, continuous), number of refining devices and their division into units (refining, proper beating, post refining), system of refiners connections and chests and characteristics of the used devices (kind, type, rotary speed, refining elements etc). We cannot change these factors during the exploitation of refiner or these changes would be complicated in practical realization.

Into the most essential parameters of the second group (technological) we can accept [1, 3, 6]:

- properties of waste paper stock before refining,
- flow intensity by refiner,
- distance between disc,
- stock consistency,
- stock temperature.

In this article, technological factors connected with the work of single disc refiner were described. The author undertook an attempt to build a qualitative and energetic model. This model will describe the treatment of waste paper stock in a disc refiner. Below there is presented the description of most factors affecting the refining process.

2. Identification of beating process parameters

The beating of waste paper stock is a complex process. The most important variables were shown diagrammatically in Fig. 3. In this scheme there are presented factors, which influence the beating process in disc refiners. As one can see, it is necessary to introduce indispensable simplifications to the practical description of qualitative and energetic model of beating process.

In Fig. 4 there were specified only these variables which most often change during waste paper treatment in disc refiners. Additional reductions result from stand test in an industrial scale.

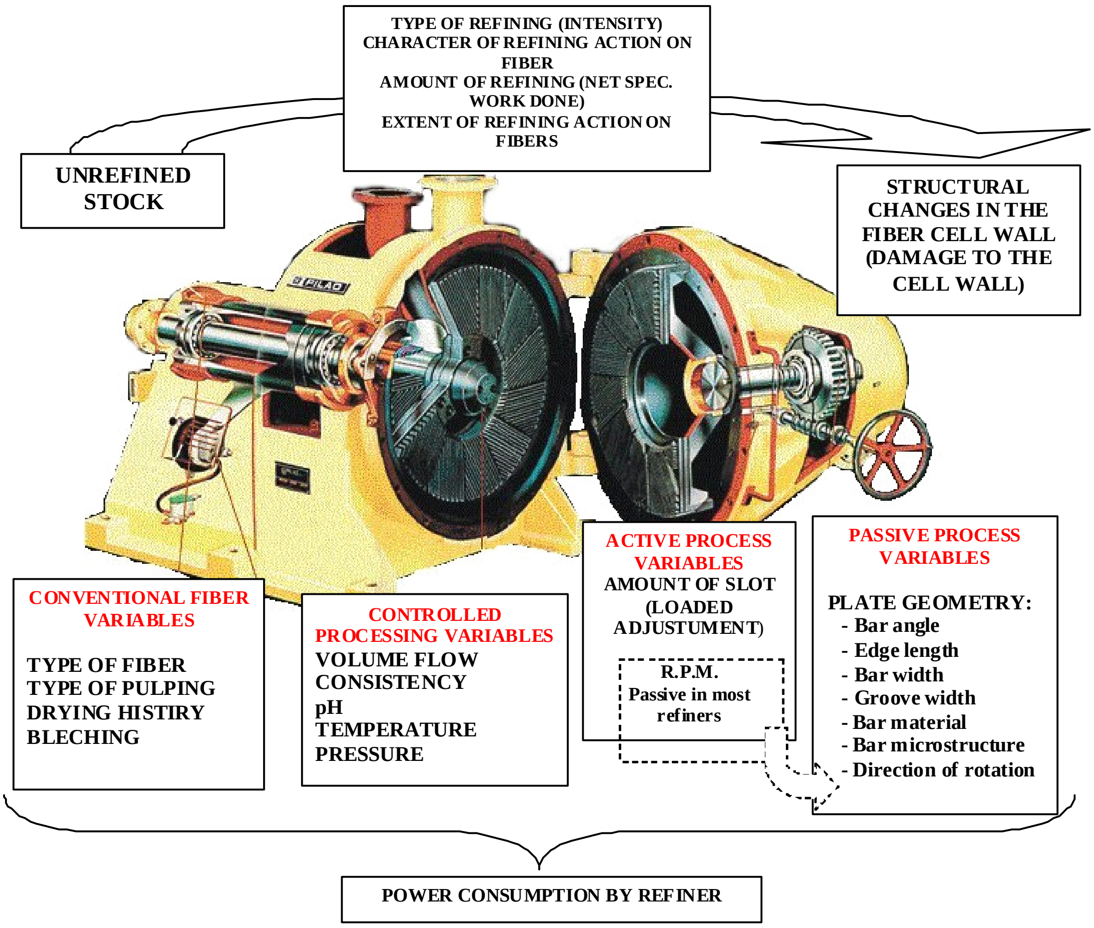

Fig. 3. Qualitative model for the refining process - The most important variables [1, 2, 3]

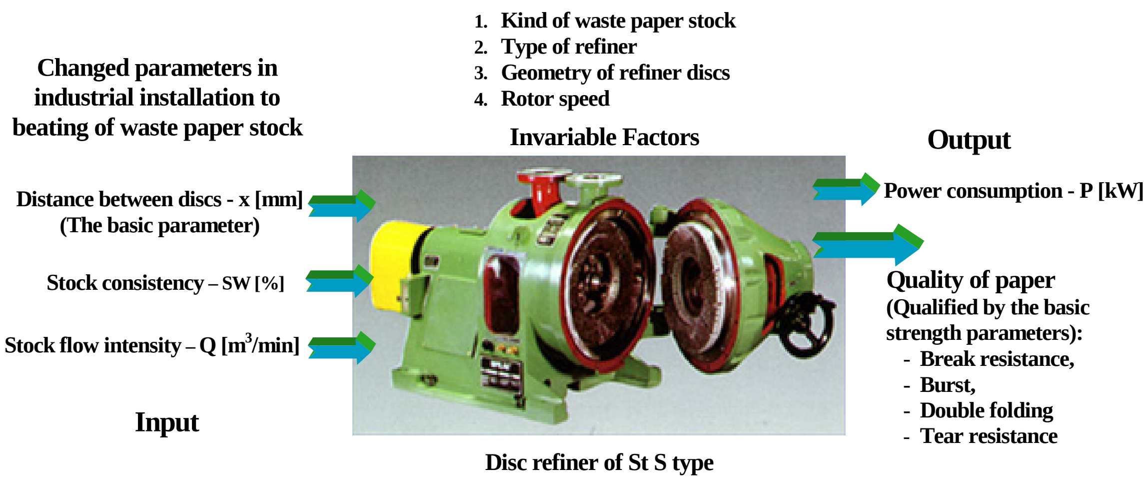

Fig 4. Investigated disc refiner with fundamental variables [3, 6, 7]

3. Description of machine model – disc refiner as paper stock treatment system and distribution of total power

In Fig. 5 there was presented the model of machine identification as treatment system of waste paper stock and energy. In this scheme the machine was presented as the object of investigations. In this figure there are two inputs: 1) delivered total energy N_c, volume of which depends in this system on slot-gape size; 2) waste paper stock, which has definite properties. At the exit there are symptoms in the form of obtained efficiency of the process, quality of obtained stock and energy consumed on the processes connected with refining. Additionally, in this scheme there were illustrated thermal losses and other processes which we can observe in the refiner: vibrations and noise. The other processes will be used during the verification of the phenomena and changes which take place during refining (slot size correlation with noise and strength properties).

Description of parameters which we can see on the Fig 5:

x - Gape (slot size) - variable - distance between discs;

M_w - Semi-finished product: waste paper stock led to the refiner (its parameters: flow intensity and quality are constants);

M_{wy} - Stock which had specified characterization (parameters before the refiner) transformed in the refiner. Parameters before the refiner affecting the received paper - quality J;

S_c - Losses of refining thermal process - negligibly small;

J - Quality of paper which is verified by selected strength parameters of the received paper.

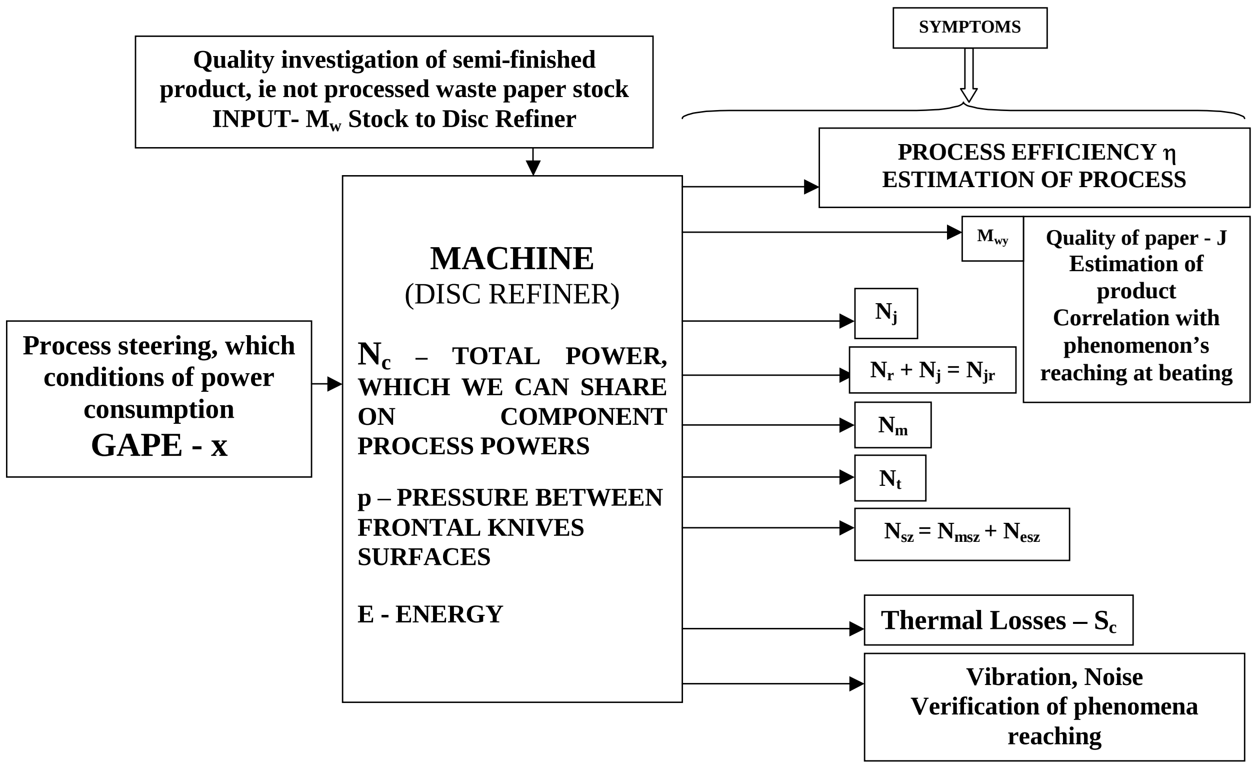

Fig. 5. Model of machine identification as treatment system of waste paper stock and energy [3, 4]

Process powers were qualified by theoretical analyses of the refining process [4, 5]. These powers are as follows:

N_c - Total power consumption which depends on x – distance between disc, refiner construction and stock kind. This power is measured on engine shaft which drives the refiner;

N_j - Power consumed on idle run without stock, for slot size greater than 0.2 mm;

$N_{jr} = N_j + N_r$ - Power consumed on refining with power consumed on idle run (with stock), for slot size x > 0.2 mm;

$N_r = (N_j + N_r)\text{-}N_j$ - Power consumed on refining, $N_{jr} - N_j = N_r$;

N_m - Power consumed on beating;

N_t - Power consumed on fibers cutting;

N_e - Power consumed on metallic friction (friction between frontal surfaces of knives);

N_{sz} - Power consumed on mixed friction (mixed friction consist of metallic friction and friction which is connected with beating process): $N_{sz} = N_{msz} + N_{esz}$;
N_{msz} - Power consumed on beating which is a part of power consumed on mixed friction;
N_{esz} - Power consumed on metallic friction which is a part of power consumed on mixed friction.

Accepted distribution of process powers in relation to the slot size x was presented in Fig. 6. This figure is an example chart obtained during investigations. On the base of investigations, there were obtained curves A-B-C-D-E (for different dryness). The other curves (refining, proper beating, cutting, metallic and mixed friction) were obtained on the basis of mathematical analysis. The character of these powers' changes was described in earlier works [3, 4, 5, 6].

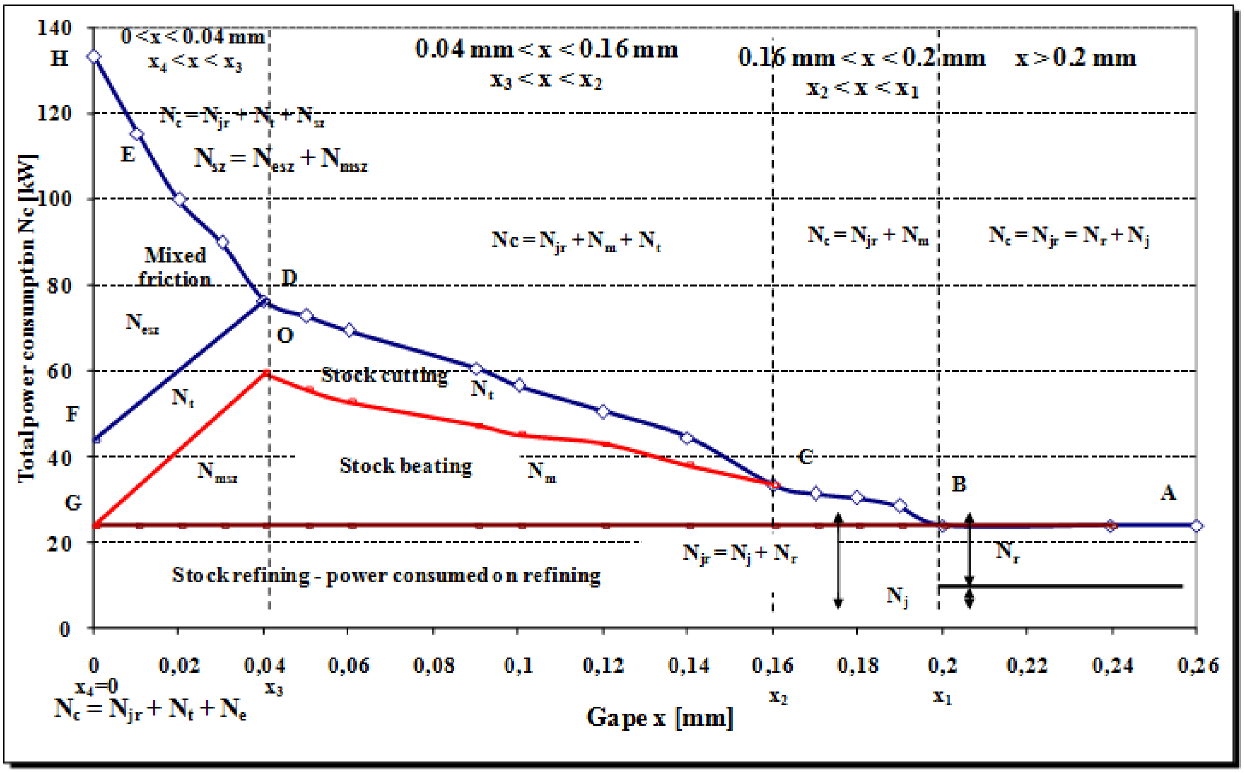

Fig. 6. Chart of total power consumption (A-B-C-D-E-H) in function of distance between discs for disc refiner with regard of proposed composition process powers distribution

4. Conclusion

This paper is an attempt to build qualitative and energetic model of disc refiner work for the distance between discs as a main variable. In the paper there was described the procedure of determining the methodology of investigations. Adjustment gape is most essential from the point of view of quality of obtained paper stock and volume of power consumption by the refiner. In the gape function there was also carried out the description and analysis of process powers which can be defined during the beating of waste paper stock.

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