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INVESTIGATION OF CORRELATION OF NOISE AND TECHNOLOGICAL-TECHNICAL FEATURES OF PROCESS ENGINEERING EQIUPMENTS LAYING EMPHASIS ON CRUSHERS

Theses of doctoral dissertation

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1. INTRODUCTION

Process engineering equipments are used in many field of industry. Their task is to get the final product with physical modifying of the feeded material. The process can be comminution, dressing, agglomeration, mixing, granding. The dissertation, taking into consideration the variety of the process engineering and its equipments, deals only with the crushers.

The crushers, depending on their type and technological features, emit noise of different degree into the environment. The annoying effect of noise can be perceived first of all next to the equipments in workplaces. The more complex an equipment is the more part of it appears as a noise source. If any kind of preparatory and maintenance facilities belonging to the equipment it becomes as noise source more complex.

There are more reasons to investigate the noise emission of machines. The most known reason is the noise protection at workplaces. The man working next to a machine is to be protected from the noise effects in order to avoid the hearing loss. The sensitivity against noise depends on the person as well. Industrial plants have measurements made during the working process to find out the noise dose that effects on workers.

Other reason to investigate the noise emission of machines is when their noise immission can be heard not only at workplaces but in farther environment in residential areas and the immission induces noise complaints. In case of exceeding the noise immission limits environmental authority imposes penalty.

Third reason to investigate the noise emission of machines is to determine the connection between the working process and the noise emission. Conclusions can be drawn from the extent of the noise emission of the machine on the working conditions of the machine, on the rubbing of the surfaces, on the adequacy of degree of filling, speed and capacity. This area is less investigated than the others. The dissertation deals with this third area.

2. SCIENTIFIC BACKGROUND, AIMS

Information about environmental noise immission of machines can be found in scientific reviews, www homepages. Similar data can be found also in reports of occupational noise measurements and environmental noise measurements.

Studying the professional literature I found the followings:
There are only few references in books, handbooks on noise emission of machines during processing period. Description of working process is very complete, but the noise emission of machines during the process is not mentioned. There are some words about noise immission in the working environment. The reason about few words from noise can be that the matter of the book is to describe the operation of the machine, investigate the developing forces.

Investigation of noise emitted by machines, equipments is general in the field of occupational and environmental noise protection.

In case of occupational noise protection data are measured at workplaces where the worker stays during the working hours. Data are suitable to find out the noise dose that workers are exposed to and avoid the health impairment.

Environmental noise measurements are performed in front of facades of houses, and are to control the noise immission compared to limits.

R. Pax performed measurements to establish connections between the operation and the noise emission of a machine. His investigations covered ball mills. He used a mathematical modelling with the application of Discrete Element Modelling techniques to model the physical grinding laws.

G. Ladányi performed measurements in 2005 to find connections between the technical features and noise emission of an impact crusher [F8]. He explored connections between capacity and noise emission and between effect of the rubbing and the noise emission.

In the examined literature the connections between the technical features and noise emission were not investigated.

Reviewing the literature it can be seen that the investigation of the technical condition of a machine, its operational features and its noise emission is a less examined field. It holds true of crushers as well. There were few measurements performed to explore their noise emission and the general publicity of measuring data is not wide-ranging.

Because of the foregoing the dissertation proposes to investigate the noise emission of crushers from new point of view to get information about connections between the technical features and noise emission and to draw conclusions that enable to estimate and control the noise of the equipment. The accessible knowledge does not give enough information what and how to do to control the noise emission of preparatory systems during the mechanical and technological planning (to choose the process and the machine, to plan the load) and how to influence the machine noise emission with the help of the characters of the operation.

3. APPLIED TESTING AND ASSESSMENT METHODOLOGY

3.1. Laboratory measurements

The first part of my research contains laboratory measurements. I chose two kind of machines. The measuring conditions were enabled.

The first investigated machine was a Prall mill, grinding by beat-impact, that can be found in the laboratory of the Miskolc Universtiy Department of Process Engineering. To perform the measurements limestone was purchased to be crushed. The sample was divided into parts and their weight was weighed in a digital scale. To determine the capacity I measured the crushing time with stopwatch. The ratio of the mass and the time gave the capacity. The material to be crushed was fed with hands into the mill.

I equipped a noise measuring system that consisted of a 2260 type Brüel & Kjær noise level meter controlled by a BZ 7206 module. The level meter is

capable to measure simultaneously more noise features this way shortened the measuring time. The level meter is also capable to storage the data. I loaded the measured data into a computer and evaluated them with the help of the software Brüel & Kjær Noise Explorer Type 7815 version 3.31. arranging the measuring data into charts.

I investigated the noise emission of the Prall mill in case of different operational conditions: free running at the beginning of the measuring series calculating the sound power level, grinding in case of different capacities, free running at the end of the measuring series also calculating the sound power level and on another occasion calculating free running and crushing sound power level.
To determine the sound power level - during the free running and also grinding measurements - I measured the sound pressure level in 5 points on the measuring surface at a distance of 0,5 m from the reference box of the mill. After that I calculated the sound power level. During the crushing I measured the third-octave band noise pressure level at a distance of 1 m from the mill and at the height of the machine axis. From the noise pressure level–time function I took characteristic the noise level of that time-period when the level was constant (i.e. I ignored the rise and decay time noise).

Measuring with different capacities and speed I asked for answer:
- how the modification of the capacity and speed influences the noise emission and sound power level and which capacity belongs to the least noisy crushing
- whether the free running sound power level of the mill changed after crushing.

The second investigated equipment-type was a jaw crusher crushing by pressure. I investigated two breakers.

The first jaw crusher is located in the Laboratory Building of the BÉM Borsod Ore Dressing Works Company. Its noise emission was measured in case of free running than in case of crushing three materials – ore-sinter, brick and magnesite brick – later free running again. The capacity was determined the same way as earlier. I used the same measuring system as at the Prall mill.
I stored and evaluated the measured data as at the Prall mill.

In this case I investigated:
- how crushing of materials with different quality and hardness influence the noise emission of the breaker,
- how the free running noise emission of the breaker changes.

The other investigated jaw crusher is located in the Laboratory of the Miskolc University Department of Process Engineering. I determined the noise power level at free running and at three different capacity during limestone crushing.

I asked for answer how the sound power level changes during crushing in case of three capacities and compared to free running power level.

3.2. Measurements in working conditions

In the second part of the dissertation I collected noise data and performed measurements in working conditions:
- I methodized and evaluated the sound pressure data of measurements, performed in mines and in mineral processing plants, next to different type of crushers and mills, completed by the health authority and myself as well. I got estimable data about 21 crushers.
- The analysis of data was carried out as a function of the following factors:
  1) method of the load (beat, impact, pressure; crushing on one and two surfaces)
  2) speed of the load
  3) capacity and capacity groups
  4) crushing grain size (fine-, intermediate-, preliminary crushing)
  5) different materials to be crushed and grinded
  6) crusher types (jaw crusher, impact crusher etc.)
  7) rubbing of the crushing surfaces and other machine elements

4. RESULTS OF RESEARCH WORK

Sound pressure level and sound power level of an equipment depends on the method of the load (beat, impact, pressure, crushing or grinding

on one and two surfaces), speed of the load, capacity, crushing or grinding grain size (fine grinding, intermediate-, preliminary crushing), properties of the material to be crushed or grinded, crusher types (jaw crusher, impact crusher etc), construction of the machine, state of the machine (rubbing of the crushing surfaces and other machine elements):

$L_p = f(k_1, v, Q, k_2, k_3, k_4, k_5)$

where:

k_1 = factor depending on the method of load

v = speed of load

Q = capacity

k_2 = factor depending on grain size

k_3 = factor depending on material to be crushed or grinded

k_4 = factor depending on machine type

k_5 = factor depending on machine construction

1. 1. Noise data of a machine must be explained whether they sound pressure or sound power level are. Noise data must be completed with the name of the crushed/grinded material, the operating conditions, where the measurements were performed (in laboratory or in situ), which measuring method was used (precision, engineering, survey method). The most accurate information is if also the used standard is reported. In case of measuring sound pressure level the position of the microphone must be reported.

2. Noise level basically depends on the method of the load.

2.1. Regarding the method of the load if capacity is under 100 t/h beating is the noisiest, pressing is less noisy and impact is the least noisy comminution. Regarding the speed between 30 – 65 m/s pressing is the noisiest, beating is less noisy and impact is the least noisy.

2.2. Comminution two surfaces is noisier than comminution on one surface (Figure 1.)

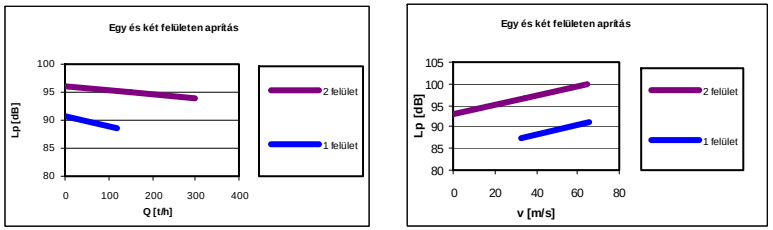

Figure 1. Sound pressure levels of comminution on one and two surfaces

3. Speed also influences the noise emission. Increase of speed, taking into consideration all machines, induces increasing sound pressure level trend in case of all comminution method and comminution field (Figure 2.).

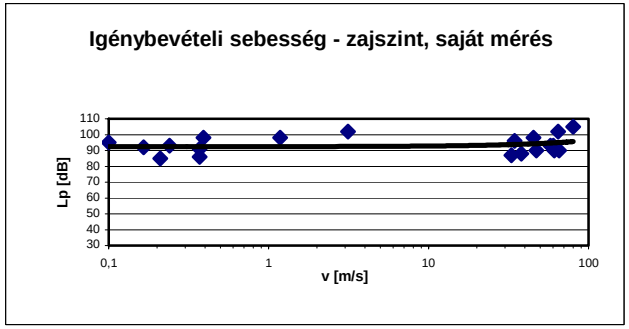

Fig. 2. Sound pressure level as a function of speed

4. Working method of the machine influences the noise emission. Increase of capacity (Q):

4.1. Generally draws down decrease of sound pressure level trend (Figure 3.)

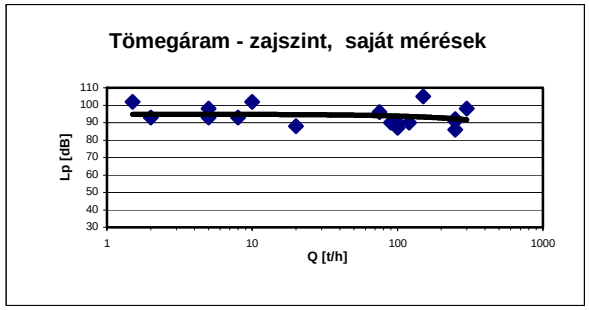

Fig. 3. Sound pressure level as a function of capacity

4.2. Induces increasing sound pressure level trend in case of intermediate and preliminary crushing, in 1-100 t/h capacity range (in laboratorial and working conditions as well).

4.3. Induces increasing sound pressure level trend in case of jaw crushers (in laboratorial and working conditions as well), crushing limestone and andesite and in case of Prall mill in laboratory.

5. The sound pressure level is approximate constant value as a function of product of capacity and speed in relation to all machines.

6. Taking as a base the grain size of the end-product between 25 and 100 t/h, the intermediate crushing is the noisiest, the fine grinding shows decreasing, the preliminary crushing shows increasing noise level trend as a function of increasing capacity.
Increasing speed induces steeply increasing noise level trend of preliminary crushing, induces decreasing noise level trend of fine grinding, induces little increasing noise level trend of intermediate crushing. Between 10 and 50 m/s speed fine grinding is noisier than intermediate crushing.

7. The noise emission also depends on the material to be crushed:

7.1. Noise emission of materials to be comminuted with difficulty (Bond index > 15) is higher than the one of materials to be comminuted easily (Bond index < 12).

7.2. Crushing zeolite and andesite increase of speed induces decrease of noise level. Crushing zeolite increase of capacity induces also decrease of noise level.

8. Under 80 t/h capacity noise emission of hammer crushers is higher than one of impact crushers and jaw crushers. In case of capacity over 80 t/h jaw crushers are the noisiest. In case of low speed jaw crushers are the noisiest and their noise emission increases steeply as a function of increasing speed. Over 30 m/s speed hammer crushers are noisier than impact crushers.

9. Construction of a machine influences its noise emission. Rubbing of the crushing surfaces (in case of the investigated impact crusher) did not induce increasing sound power level. Dislocation of sheating and machine elements increases the sound power level steeply (BÉM jaw breaker).

5. APPLYING THE RESULTS

The gained connections (for example sound pressure level - capacity $L_p(Q)$, sound pressure - speed $L_p(v)$) will be utilizable for mines and other firms, that crush and grind materials, to estimate the noise effect in the surroundings to a first approximation and to guess the noise immission on the workers in the work places and in the near environment of the firm, additionally to choose the method of crushing to become more prosperous to reduce the noise emission. Enlargement of number of measuring data, collecting and evaluating data continuously, accuracy of estimation can be improved continually.

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