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PROBLEMS WITH APPLICATION OF BELT CONVEYORS IN EXTERIOR TRANSPORT IN NON-METALLIC MINERAL MINES

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Abstract: *Non-metallic raw materials are transported on different distances what is in connection (depense) of kind and price of raw material. The biggest distances between mines and consumers are typical of transport of rare and precious nonmetals (phosphates, certain types of decorative stone, borates, magnesite, talc, various salts etc.) and can amount to several thousand kilometers. However, the biggest production is that of technical stone, clay, sand, gravel and other building material. These raw materials do not cost too much, this means that these materials are carried over shorter distances - up to 100km.*

Key words: *belt conveyor, non-metallic mineral*

1 TRANSPORT OF NON-METALLIC RAW MATERIALS THROUGH THE ENVIRONMENT

Currently, over 60 various non-metallic mineral raw materials are exploited all over the world and some of these are very important for the development of whole industries. Non-metallic mineral raw materials are exploited on many deposits, but most of them are exploited from deposits which in geological terms are defined as small and medium ones.

The biggest production is that of technical stone, clay, sand, gravel and other building material. These raw materials do not cost too much, and thus the cost of transport is low as well. This means that these materials are carried over shorter distances, up to 100km. The exception is water (river) transport which allows transport of building material for over several hundred kilometers.

The biggest distances between mines and consumers are typical of transport of rare and precious nonmetals (phosphates, certain types of decorative stone, borates etc.) and can amount to several thousand kilometers.

For transport of non-metallic mineral raw materials to consumers all types of transport can be used. From mines to nearby plants for primary processing of the most common modes of transport are belt conveyors, overhead cableways and trucks. For longer distances, in addition to the already mentioned ones, rail is also used, to a smaller extent hydraulic transport and river transport, while sea transport by ships is characteristic for longest distances.

Belt conveyors are more and more used in external transport of non-metallic mineral raw materials. These are mostly classical conveyors, with the belt width of 800 to 2000 mm, often equipped with a protective cover to prevent air pollution. The use of pipe conveyors has increased of late, as a result of smaller pollution, ability to manage curves on horizontal level and steeper inclines.

Transport systems all over the world are developing in accordance with technology developments. The emphasis is placed on efficient, economic and eco-friendly systems which ought to be reliable and safe for use. By covering ever longer distances and minimizing the number of reload points, raw materials arrive at their destinations in the shortest possible time, with less possibility of unplanned delays, which means that reliability level of a system increases with a reduced number of reload points.

Here are a few examples of transport of non-metallic raw materials in the world:

The longest conveyor belt in the world is constructed in Western Sahara and it is used to transport phosphate ore from Bu Craa Mine (Morocco) to the Atlantic coast, where the ore is transferred to ships

for further transport. The length of the conveyor is 100km and its capacity is 200t/h.

The longest conveyor is definitely the conveyor used to carry limestone from a mine in India to a cement plant in Bangladesh. This conveyor is ca. 17km long, which means that the belt is 35km long and 800mm wide, while its capacity is 960t/h.

As it may be seen from the examples above, transport boundaries are being extended daily. Technological parameters of transport such as transport distance, route properties, operating conditions (low and high temperatures), capacities, etc. are continually improved. In order to keep the line of technological development rising, it is necessary that it should strictly adhere to environmental criteria.

2 TRANSPORT OF NON-METALLIC RAW MATERIALS IN SERBIA

Non-metallic mineral deposits on the territory of Serbia are numerous and varied. Their economic importance is increasing due to a widening range of their use in industry, building construction, agriculture… The biggest part of these resources is used in construction industry as raw materials (sand, gravel, limestone and other types of stone, gypsum, clay, marl), but they are also used in other industries (chemical, food processing etc.). In addition to raw materials used in production of construction materials, currently of biggest economic importance are: ceramics and fireproof clay, quartz sand and sandstone, magnesite, quartz materials, kaolin, calcite, limestone (as an industrial raw material), gypsum and anhydrite and pozzolanic ash. Lithium and boron resources in the Adriatic basin, which are still under research, also have a big potential.

Considering that the values of various non-metallic raw materials range widely, transport distances also considerably vary. Average values of external transport of non-metallic raw materials are given in the table below:

Type of mineral raw material	Average transport distance in km
Stone	10,5
Sand and gravel	3,8
Clay	3,2
Other nonmetals	18,3

Exploitation of technical stone used in road construction is most extensive, and amounts to 8 million m3 per annum. There are 170 deposits of non-metallic raw materials in Serbia currently in operation. Technical stone is excavated as near as possible to infrastructural corridors which are under construction. That is why quarries are opened, expanded, relocated and closed so often.

The second most exploited non-metallic raw material is clay. Annual production amounts to 150.000 m3. Clay is also a cheap raw material the price of which does not support long-distance transport.

Production of decorative stone is 1000 tons per year. As a relatively expensive material, it is transported over somewhat longer distances to cutting and shaping plants. Transport distances for decorative stone vary and range up to several hundred kilometers.

Transport of cement industry raw materials mostly takes place close to mines. Marl, limestone and gypsum are brought to cement plants.

Clay, as a cheap material, is usually excavated close to ceramics factories. The longest distance in clay transport is from Cekmin Mine to brick and tile plant in Leskovac and amounts to 20km.

3 THE EFFECTS OF THE MINERAL RAW MATERIAL CHARACTERISTICS TO TRANSPORT EFFICIENCY

It is an accepted practice to use continuous belt conveyor whenever possible, as costs of this type of transport are very low. Rail comes second in terms of economy, but both these modes of transport require even terrain and small inclines.

Belt conveyors are used very often in exterior transport of non-metallic mineral raw materials. This means of minerals transport is widely used and it it used ever more year by year and it becomes a successful alternative to other means of transport. The reason for the upgrade of technology and economic parameters and upgrade of design elements which are closely related and interdependent contributes to the upgrade of performance of belt conveyors. Each modification of technology asks for investments in the beginning and thereby, transport price is increased. However, these modifications influence the final price of the material that is transported since successful upgrade results in savings and decrease in the transport price.

Technical characteristics of the transported material which directly influence the transport technology are the following:

- volume
- abrasiveness
- filling angle
- humidity, adhesiveness, hydroscopic feature
- granulometric contents.

The volume directly influences the lifetime of the belt conveyor. In case of great specific weight, the load per unit is increased, the pressure to the main layer of the belt conveyor is more intensive, resulting in higher pressure when the conveyor goes over the rollers as well as with greater deflection between the rollers.

Abrasiveness of the material is directly reflected in wearing out of the main layer of the belt conveyor. Special belt conveyors with protected main layer which is resistant to highly abrasive materials such as stone-line material, siliceous earth sand, etc are used for these highly abrasive materials.

Humidity of the material, especially tiny fractions of clay-like materials which may swell and stick to the belt is an additional burden for the conveyor operations due to an increased voltage on cleaning devices.

Granulometric contents of the materal determines the width of the conveyor and therefore it is necessary to have stone-crushers for solid stone materials – different stone crushers so as the granulometric contents could be acceptable.

Maximum dimension of a piece that can be transported by continual conveyance, without scattering of material, depends on the width of the supporting body B and can be determined on the basis of the following conditions:

$$d_{max} \leq \frac{B - b}{n}$$

Parameters b and n are given in the next table:

Conveyor type	b	n
Belt conveyor	200	2
Drag chain conveyor	0	2.5 - 3
Drag two-chain conveyor	0	2 - 2.5
Chain link conveyor	200	1.7

When belt conveyors are used, it is recommended to have the transport route with as few horizontal curves as possible which are handled by setting locations for emptying the material from one belt to another. Material is wasted on these locations and the belt layer is worn out intensively with an increassed emission of dust, resulting in reduced belt speed.

Increase in the dustiness in contact of the material with the atmosphere occurs especially in the stage of motion and at increased drafts in general. The dustiness degree depends on many factors; however, the exposure surfaces, the degree of size reduction and of humidity of transported loads are considered as the most important ones.

The exposure degree in continual conveyance systems depends on the width of a freely created profile of the material on the conveyor F_t and the conveyor length L:

$$\xi = \frac{F_k}{F_k \times L \times \gamma_n}, \; m^2/t$$

In belt conveyance systems, this surface can be roughly determined using the following expression:

$$F_k \approx \frac{L \times b_1 (2\cos\beta + 1)}{\cos\delta_k}, \; m^2$$

where:

b_1 – length of the conveyor middle roller, and

β - incline of side rollers.

In general, the dust emission from point dust sources can be presented in the following form:

$$G_i = \frac{1}{k} l \psi^2 (c_l - c_o) v_v, \; m/s,$$

And for line sources:

$$G_i = \frac{1}{k} l \psi (c_l - c_o) v_v, \; m/s,$$

where:

k – coefficient of which the value depends on air drafts, type of the dust source and its position, and it widely ranges from 1.5 to 5.6,

l – distance between measurement points and the dust source, m,

ψ - parameter reflecting the atmosphere turbulence at the point of dust source and it depends on the wind speed. Its value, for the wind speeds higher than 1 m/s, can be determined through the following formula:

$\psi = 0{,}05\ v_v + 0{,}22$

c_l – dust concentration at the measurement point, (mg/m^3)

c_o – dust condensation in the air before the emergence of the dust source on the conveyance system (mg/m^3)

v_v – speed of air drafts (wind) (m/s)

Other parameters influencing environment (noise, vibrations, pollution caused by waste oils and lubricants, land demeaning due to the route construction, etc.) are much more favourable with this means of transport than with other types.

12 CONCLUSIONS

Transport, being a segment of the exploitation of mineral raw materials, cannot exist independently. The final product of the transport is the raw material with a price increased by the transport price from one place to another. Therefore, it is impossible to upgrade transport operations without making analysis of the correlateion between the material which is transported and specific technical parameters of transport, transport route characteristics, i.e. mutual dependence between the material, transport and environment.

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