STUDY OF STABILITY OF 2K-52MU CUTTING-LOADING MACHINE ON TR-5 CONVEYER IN FACES WITH INDIVIDUAL SUPPORT

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Abstract: Besides the problem of adapting 2K-52MU machine to the TR-5 scraper conveyer, the study of stability of the machine on conveyer was required, in faces with individual supports. To this end stability coefficients of the machine were determined in cutting and loading coal on the conveyer, and even in blocking the drum at the face. The study was made for maximum 250 kN traction force and variation of the inclination of the face in the range of 0 and 300 for three cases of machine movement towards the face.

Keywords: correlating, cutting and loading machine, scraper conveyer

INTRODUCTION

To adapt the existing equipments in view of refurnishing the faces, we should be familiar with the construction and characteristics of the equipments used and how to correlate those with the coal extraction mining method, the geological-mining conditions specific to the exploited layer and with respecting the occupational health and safety standards.

Fig. 1. Extraction method of the longwall with individual support and machine cut
By the implementation of a refurbishing program of a longwall in Lonea Mine during the fourth trimester of the year 2013, the classical extraction method with a productivity of 6.8 ton/job, was replaced with longwall method with individual support and cut with the machine with an estimated productivity of 12 tons/job.

**CORRELATION OF THE EQUIPMENTS**

To see how the equipments were correlated, an analysis of the framework method of longwall method with cutting the coal with the machine was performed [5]. Fig. 1 shows the work stages for a face of maximum 3.2m high and 1.8 high cut with the machine, thus: I – machine in the butt pocket; II – cutting the first slice; III – manual execution of the seat to mount the articulated beam; IV – advance of the machine in the butt pocket and mounting the fourth prop; V – cutting the second slice. VI – manual clearing of the face and advance of the machine in the pocket butt; VII – moving the back prop under the first beam; VIII – ripping the prop and the back beam.

From the above, it results that an economic efficiency analysis should be made regarding the correlation of the longwall height with the cutting height of the machine, with the geological-mining conditions and the occupational safety standards. In this analysis, the price of the machine should be taken into consideration, which was recovered from cassation, scrap iron – Euro 2500, rehabilitated and put to use with maximum Euro 5000. The technical characteristics of the 2K-52MU machine were not correlated with those of the TR-5 scraper conveyer, especially considering that the latter had not been devised for longwalls, and they were designed and manufactured by different companies in different countries. The two equipments are however compatible, at least from the following points of view [1], [5]:

- more than half of the theoretical capacity of cutting of the machine, which is not reached in practice due to the correlation of the heading speed with the geological-mining conditions, can be supported by the scraper conveyer;
- dimensionally, the machine can be mounted on the conveyer by adopting suitable modifications, adapting the TR-5 stations to TR-6 chutes by using TR-7A laterals and by modifying the machine shoes, without diminishing their resistance characteristics;
- the conveyer’s robust construction withstands the machine weight of approximately 12 …14 ton;
- the design of the scraper conveyer allows the coal loading by the auger drum in good conditions;

The main non-correlation of the of the two equipments lies in the fact that the driving and turning stations of the TR-5 scraper conveyers re not provided with fixing plates/hooks for the linking device of the end of the traction chain end of the machine.

**STUDY OF MACHINE STABILITY ON THE CONVEYER**

Starting from the maximum transportation capacity of the TR-5 scraper conveyer of 4.1 ton/min, and knowing the width of the slice that has been cut of 0.63m and its thickness of 1.9 m, the maximum heading speed of 2.45 m/min was determined.
Knowing the design characteristics of the machine’s auger drum (diameter, number of cutting lines, number of bits per face and corner on a cutting line, the width of the cutting edge of a CMR3 bit) and the 42.7 rpm rotation of the drum, the average depth of the cut was determined, made by a 0.029 m face bit, and maximum 0.045 m [2], [4].

With the help of these data, the cutting forces on the auger drum of the machine were calculated, of 18.9 kN for the drum cutting on the roof and in compact seam, and 10.78 kN for the drum cutting the floor for 0.7 m high.

The variation of the machine’s heading force, in kN, and the power required at the electric driving motor, in kW, function of the inclination angle of the longwall, when it is inclined towards the main gallery where the driving station is found, is shown in Fig. 2, where [5]: Facq – heading force in cutting towards the turning station, in the range of 84.1 - 161.6 kN; Facaq – advance force in cutting towards the driving station, in the range of 84.1 și -4.5 kN; Pmotq – necessary force at the electric driving motor in cutting towards the turning station, in the range of 125.76 - 130.15 kW; Pmsaq – necessary power at the electric driving motor in cutting towards the driving station, in the range of 125.76 - 120.75 kW.

Knowing the technological forces acting on the machine, its design dimensions and how it is positioned on the conveyer, shown in Fig. 3, the stability of the 2K-52MY machine was verified, by developing a simplified calculation model for stability, shown in Fig. 4. In Fig. 1 it is noticed that in cutting towards the main gallery, towards the driving station, at angles larger than 25°, the heading force is compensated by the component of the machine’s weight, which was 118.66 kN and a machine-conveyer friction coefficient of 0.25.
Fig. 3. Design dimensions of 2K-52MY machine and its position of the conveyer.
It results that for the machine’s heading, 4 … 7% of the motor power is consumed, and the greatest part, 90 … 95%, for cutting the coal. The motor power was estimated for a spare coefficient of 1.25. In the case of the simplified calculation model of the 2K-52MY machine stability on the conveyer, Fig. 4, points 1 and 2 represent the center of the support skid of the machine on the longwall side lateral of the conveyer, and points 3 and 4 represent the captive guiding of the machine on the back lateral of the conveyer [5]. The technological forces on the auger drum of the machine are represented for two cases, noted with index 1 when it moves towards the driving station, and with index 2, when moving towards the returning station, with:

- $F_{ts}$, $F_{tj}$ – cutting force on the upper drum, at the roof, or down, on the floor;
- $F_{as}$, $F_{aj}$ – force opposing to the machine movement up on the drum, at the roof, and down on the floor;
- $F_{rs}$, $F_{rj}$ – machine’s rejection force by the face on the upper drum, at the roof, or down on the floor.

To determine the weight centre of the machine, 3D modeling of the machine’s component parts and their assembling was performed, shown in Fig. 5 [3].

Thus, for a 12095,82 kg weight of the machine, the coordinates of the weight centre were determined, and the reference system is found in the assembling plan of the feeding mechanism with the motor, in the horizontal central plane of the motor and on the outside of the feeding mechanism on the longwall side, for three possible working cases, when the front drum cuts up on the roof:

a) when the machine moves towards the driving station, the position shown;
b) when the machine moves towards the returning station;
c) when the machine moves with both drums down to clear the longwall.
Fig. 5. 3D model of 2K-52MY machine with positions of the weight centre for three working cases
With the help of these data, the reactions in the leaning points of the machine on the empty running conveyor were determined, thus in the trials performed in the Mechanical Workshop in Lonea Mining Plant, the results were, per total for the three cases, high values on the skids on the longwall side, 90.4 kN and 28.4 kN on the back guides, and the repartition difference on the skids is 40.8 kN in point 1 and 49.6 kN in point 2, and 17.6 kN in point 3 and 10.6 kN in point 4, respectively. These differences between the reactions on the longwall side and back are not more than 25%, as it is recommended in the literature of specialty. The greater load on the skids on the face side, which was highlighted at the machine movement on the conveyor at the functioning trials at the surface, are lower during the cutting of coal, due to the technological forces acting on the machine. The maximum contact pressure between the skid and the conveyer lateral is 3.76 N/mm$^2$, very near the admissible pressure at the guides of machine-tools, of 4 N/mm$^2$.

![Figure 6. Variation of stability coefficients function of the longwall inclination angle, case 1](image)

![Figure 7. Variation module of stability coefficients function of the longwall inclination angle, case 2](image)

Variation module of stability coefficients function of the longwall inclination angle, case 2

Four lines determined by the support points, whose variation depending on the angle of the longwall inclination is shown in Fig. 6, where:

- $C_{s14q}$ – stability coefficient according to line 1-4, with values in the range of 2.95 and 2.48;
- $C_{s23q}$ – stability coefficient according to line 2-3, with values in the range of 4.61 and 6.95;
- $C_{s12q}$ – stability coefficient according to line 1-2, with values in the range of 5.98 and 5.5;
- $C_{s34q}$ – stability coefficient according to line 3-4, with values in the range 2.95 and 2.62;
- $C_{s14bq}$ – stability coefficient according to line 1-4 when the upper drum is blocked and the traction force reaches maximum 250 kN, with values in the range of 1.53 and 1.51;
- $C_{s23bq}$ – stability coefficient according to line 2-3 when the lower drum is blocked and the traction force reaches maximum 250 kN, with value in the range of 1.67 and 1.24.

Verification of the stability of 2K-52MY machine on the conveyer, during cutting towards the return station, case 2, was made by calculation of the stability coefficients according to the four lines determined by the support points, whose variation, depending on the longwall inclination angle, is shown in Fig. 7, where:
\( C_{s14q} \) – stability coefficient according to line 1-4, with values in the range of 3.0 and 2.12;
\( C_{s23q} \) – stability coefficient according to line 2-3, with values in the range of 5.27 and 3.34;
\( C_{s12q} \) – stability coefficient according to line 1-2, with values in the range of 5.98 and 5.5;
\( C_{s34q} \) – stability coefficient according to line 3-4, with values in the range of 2.95 and 2.62;
\( C_{s14bq} \) – stability coefficient according to line 1-4, when the lower drum is blocked and the traction force reaches maximum 250 kN, with values in the range of 1.24 and 1.22;
\( C_{s23bq} \) – stability coefficient according to line 2-3 when the upper drum is blocked and the traction force reaches maximum 250 kN, with values in the range of 1.21 and 1.0.

**Fig. 8. Variation of stability coefficients depending on the longwall inclination, case 3**

Verification of the 2K-52MY machine stability on the conveyor during loading the coal that has been cut towards the returning station, case 3, was made by the calculation of the stability coefficients according to the four lines determined by the leaning points, whose variation, depending on the longwall inclination angle is shown in Fig. 8, where:
\( C_{s14q} \) – stability coefficient according to line 1-4, with values in the range of 2.94 and 1.93;
\( C_{s23q} \) – stability coefficient according to line 2-3, with values in the range of 36.7 and 7.56;
\( C_{s12q} \) – stability coefficient according to line 1-2, with values in the range of 12.64 and 11.03;
\( C_{s34q} \) – stability coefficient according to line 3-4, with values in the range of 19.2 and 16.78;
\( C_{s14bq} \) – stability coefficient according to line 1-4 when the lower drum is blocked and the traction force reaches maximum 250 kN, with values in the range of 1.25 and 1.2; \( C_{s23bq} \) – stability coefficient according to line 2-3 when the lower drum is blocked and the traction force reaches maximum 250 kN, with values in the range of 50 - 14.34.
CONCLUSIONS

The study of 2K-52MY machine stability on the conveyer showed that all the stability coefficients have values higher than 1.2 as it is limited in the literature of specialty, even in the case of blocking of a drum in the longwall, due to sterile intercalation and haulage of the machine with maximum force of 250 kN, except for the movement during cutting towards the return station, case 2, when in the event of the upper drum being blocked, the stability coefficient according to line 2-3, has smaller values than 1.2 [5]. It is seen that in the two cases of machine movement during cutting, case 1 and 2, when a drum is blocked due to sterile intercalations, or due to other causes (wear or lack of bits for the cutting part) the stability coefficients values reduce greatly, and great reactions result horizontally on the machine’s captive guides, of up to 100 kN, in case 1, much greater than the friction force between the conveyer and the longwall floor, leading to tear of the conveyer and even to breaking the articulations between the chutes and the back laterals, since the conveyer chutes are not supported in the longwall as in the case of mechanized support. To avoid the situations presented above, of conveyer tear horizontally, the following measures of exploitation for the equipments are recommended:

- at the beginning of each shift or whenever required, the sterile intercalations should be visually checked and localized, all along the longwall, and their derocking should be done with the hammer; after cutting a slice with the machine, the condition of the bits is checked of the cutting parts and the worn and broken ones are replaced and the missing ones are completed;
- cutting a slice with the machine in the longwall is made by moving the machine towards the turning station of the conveyer, case 2, when the reactions on the machine’s captive guides are not greater than 50 kN, this value being half of the one in case 1;
- reduction of the pressure value of the advance mechanism from 160 bar to 120 bar, which reduces the maximum traction force from 250 kN to 187 kN, and the reactions horizontally from 50 kN to 37.5 kN, by 25%, respectively.

REFERENCES
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