Central Mining Institute,
Experimental Mine „Barbara”

GŁÓWNY INSTYTUT GÓRNICTWA

Mining speed control in the coal panels with high coal output concentration

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Factors which made this subject interesting for us:

- Increase of methane release into **exploitation areas**, which is result of both: increasing output concentration and location of the coal panels in deeper - more saturated coal beds.
- The conditions of higher coal output and methane content of exploited coal seams, when the cutting speed of coal shearer is being constantly increased - it was certain message to elaborate shearer coal cutting speed control system – providing safe longwall coal extraction.

In consequence : International project „PICTO" is focused on elaboration of the tool enabling control of longwall shearer speed having fulfilled methane hazard safety conditions

Methane release into environment of the longwall:

- **Share of the methane released from the exploited coal seam, in average in Upper Silesian Coal Basin coal mines reaches 20-40% from total volume of released methane into environment of the longwalls, the remaining 60-80% it is methane migrating into gob from the relaxed undermined and overmined coal seams.**
- **Length of the longwall has major impact on methane release development into the gob (first of all) and into the environment of the longwall itself (secondly), which is shown on Fig. 1.**

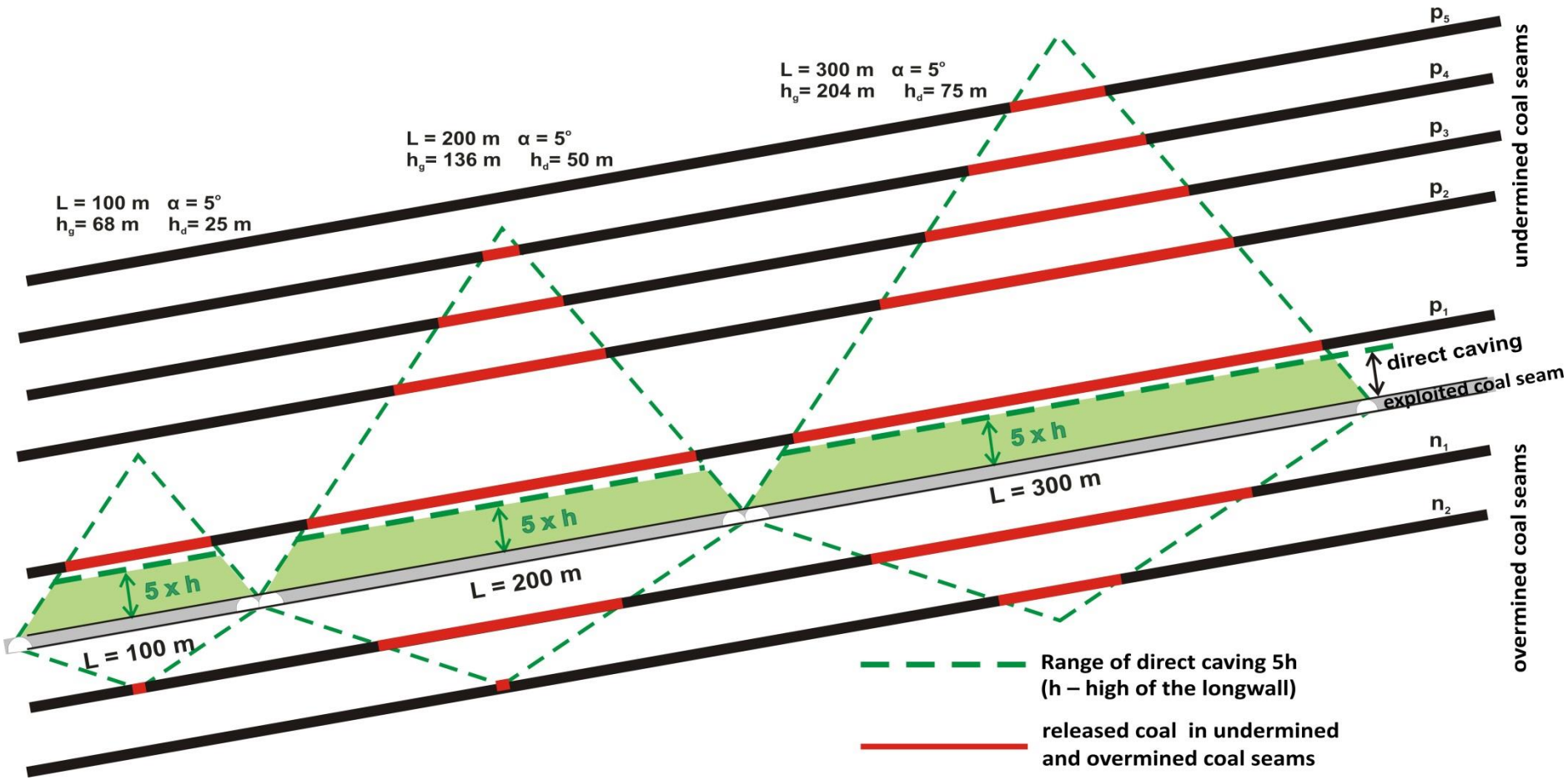

Fig. 1. Vertical cross-section through the zone of stress relaxation and degassification of the longwalls with different lengths: Ls = 100 m, Ls = 200 m, Ls = 300 m and inclination angle α = 10

In Polish hard coal mines in practice there are three methods of coal panels ventilation being used:

- **„U” type along coal solid, it involves about 75% all coal panels (fig. 2),**
- **„Y” with removing exhaust air along gob behind the exploitation front, it consitutes in average about 20% all coal panels (fig. 3),**
- **„short Y” with two ventilation roadways, it consitutes in average about 5% all coal panels (fig. 4)**

Volume of methane released directly to the environment of longwall in principal comes from two sources: exploited coal seam **mainly when extracting it and from the gob, due to degassification of relaxed undermined and overmined coal seams.** Methane flow coming out from the gob into the environment of the longwall ventilated with „U" type system along coal solid causes potential high methane hazard, both in the longwall itself as well as in the ventilation workings.

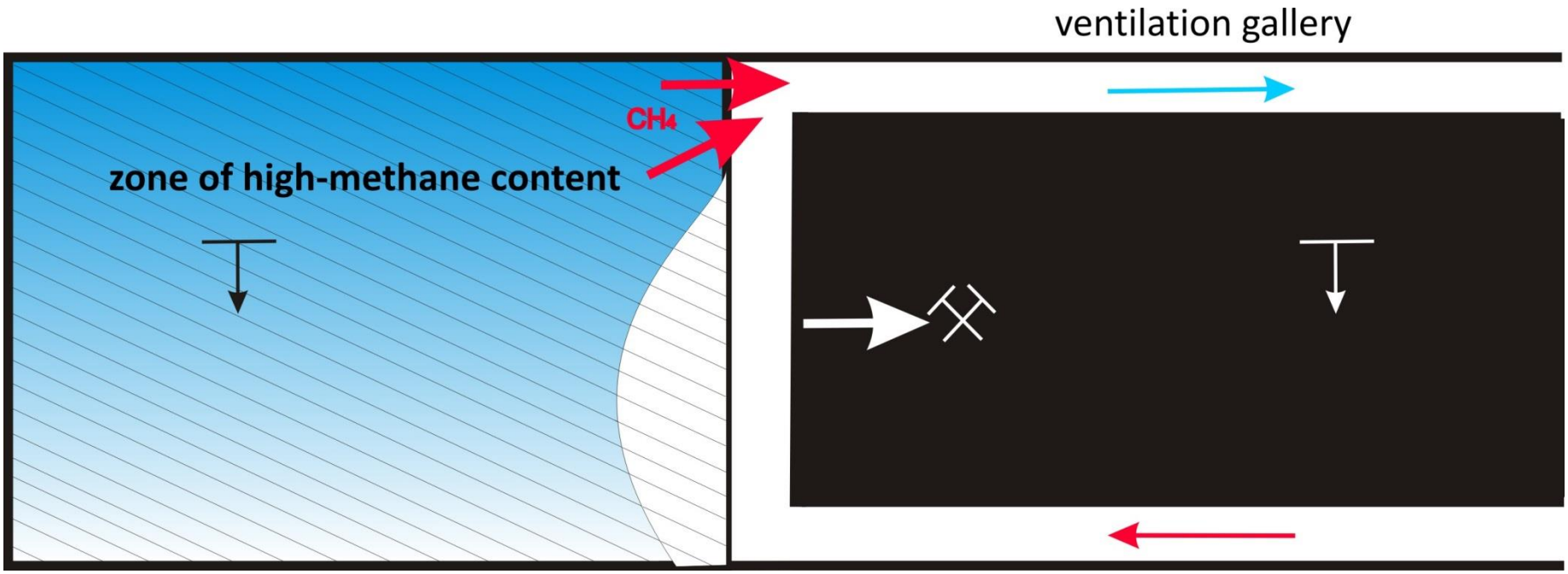

Fig.2. Development of methane zone in the longwall gob using longitudinal exploitation system, using „U" type ventilation system along coal solid

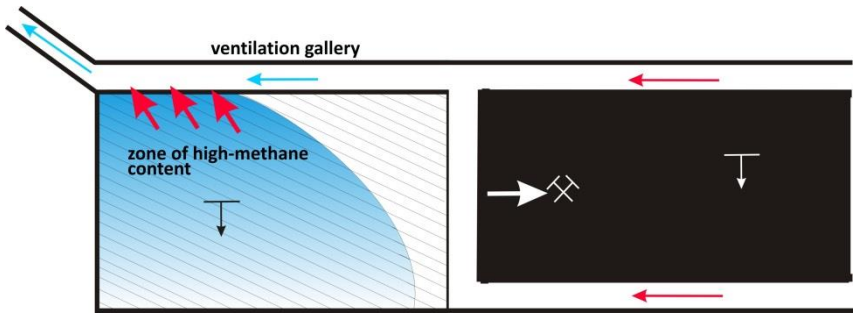

Fig.3. Development of methane zone in the longwall gob using longitudinal exploitation system, with „Y" type ventilation extracting exhausted air along the gob.

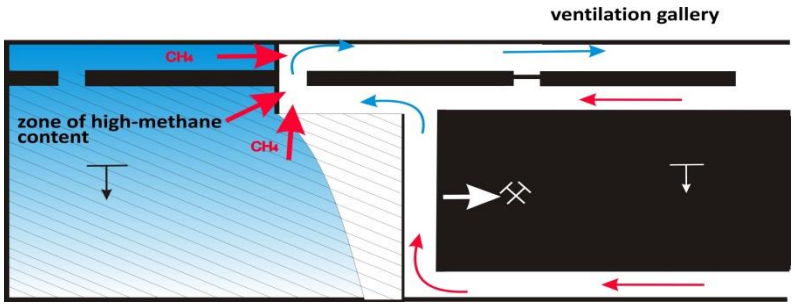

Fig .4. Development of methane zone in the longwall gob using longitudinal exploitation system using two parallel ventilation roadways

When using „Y" or „short Y" type ventilation systems methane release from gob directly into **the longwall working practically does not exist** .

Increase of coal output concentration in the coal panels ventilated with „Y" or „short Y" causes methane release from exploited coal seam directly into longwall environment, besides **from the seams closeby from exploited coal seam.**

Volume of methane released into the longwall environment from the exploited coal seam depends on the volume of exploited coal in time and its methane content.

Volume of methane released in time unit is proportional to the volume of extracted coal and its methane content.

Methane release into the environment of the longwall while coal mining

Volume of methane stream release, when mining in the time unit is proportional to the volume of extracted coal and its methane content – developing methane stream release directly from the exploited coal seam into the longwall working.

$$\dot{V}_{CH_4}^{1\,skr} = \frac{L_s \cdot m_e \cdot z \cdot \gamma \cdot M_0 \cdot \eta_s}{100 \cdot t} \qquad (1)$$

Coal volume after one shearer cut

Methane volume released from one shearer's cut

Where:
L_s – length of longwall, m,
m_e – high of longwall, m,
z – cut depth, m,
ɣ - coal density, Mg/m^3,
M_0 – value of primary methane content of exploited coal seam, m^3CH_4/Mg_{daf}
η_s – degassification degree, %,
t – duration of single coal shearer cut, min.

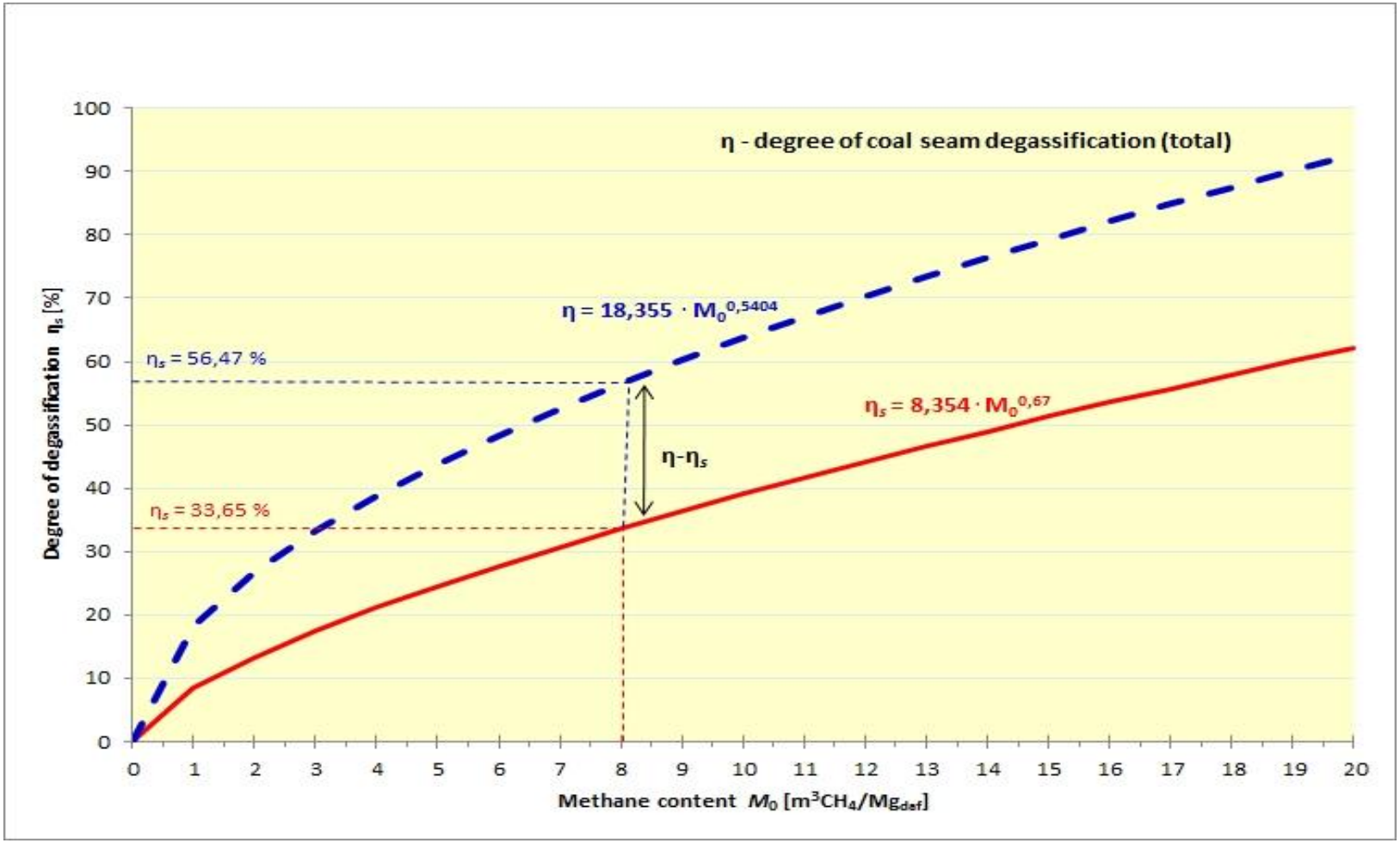

Fig. 5. Degassification degree η_s of the exploited coal seam when mining it with coal shearer depending on its primary methane content M_0

Function interrelation of the coal seam degassification degree when extracting it from its primary methane content

$$\eta_s = 8{,}354 \cdot M_0^{0{,}67} \qquad (2)$$

can be expressed by the formula (2) and graphically (fig. 5) . It does not take into account however methane released due to degassification of the coal seam being exploited directly ahead of the coal face and its migration through the roof layers into the longwall gob.

Based on the example of the longwall with the length L_s = 280 m, high m_e = 3 m, shearer cut z = 0,8 m, located in the coal seam with methane content M_0 = 8 m^3CH_4/Mg_{daf} for different one cutting cycle duration times: t = 60 min, 80 min, 100 min, 120 min, 140 min and 280 min, the values of forecasted methane emissions for individual cycle durations were calculated.

The formula (2) was used to calculate degassifying degree η_s of the exploited coal seam with methane content of 8 m^3CH_4/Mg_{daf} , which is 33.65% what is shown on fig.5.

Calculated, forecasted methane volume releses into longwall environment, depending on average coal shearer speed and single cutting cycles durations „t" are presented in table 1

Table 1. Forecasted methane volume calculated into time unit of 1 min for different time durations of single coal shearer cuts

#	Time duration of single coal shearer cut	Operational (average) speed of the shearer for longwall length Ls = 280 m	Degree of coal degassification η_s	Forecasted methane release/emissions
	[min]	[m/min]	[%]	[m^3CH_4/min]
	2	3	4	5
1.	60	4,66	27,75	22,62
2.	80	3,50	27,75	16,97
3.	100	2,80	27,75	13,58
4.	120	2,33	27,75	11,31
5.	140	2,0	27,75	9,70
6.	280	1,0	27,75	4,85

In the conditions of using coal panel venitilation systems „Y” (fig. 3) or „short Y” (fig. 4), the volume of methane emissions, getting directly into longwall working would mainly come from the coal mined with the shearer .

The resources coming from the European Research Fund for Coal and Steel and from Polish Ministry of Science allowed us to start international project with acronyme **PICTO.** Its final product will be elaboration of the coal shearer speed control based on the online recordings of methane content measurements by methane sensors located along the individual longwalls’ length.

Elaborated under PICTO project coal shearer speed control system will be related to „Y” and „short Y” coal panel venitilation systems

Presented in column 5 of table 1 forecasted volumes of released methane depending on coal shearer cutting/mining speed which has direct impact on single cut duration allow for preparing methane-ventilation balance in the mined coal panel.

Necessary air volume required in the longwall is calculated based on the following formula (3):

$$Q_{śc} = \frac{100\,(\dot{V}_{CH_4} + \dot{V}_D)}{C_{m-dop}} \text{ , m}^3\text{/min} \quad (3)$$

Where:

$C_{m\text{-}dop}$ – admissible methane content at the outlet from the longwall, % (it was assumed 2%),

$\dot{V}_{CH_4}$ – volumetric methane stream released into longwall environment, depending on shearer mining speed m^3CH_4/min,

$\dot{V}_D$ – volumeric methane stream delivered to the longwall with fresh air, m^3CH_4/min,

is calculated with formula (4):

$$\dot{V}_D = 0,01 \cdot \%\, CH_4 \cdot Q_{pow} \text{ , m}^3\text{CH}_4\text{/min} \quad (4)$$

Where:

Q_{pow} – air flow delivered to the longwall, m^3/min,

% CH_4 – percentage methane content in the air delivered to the longwall.

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Three values of $\dot{V}_D$ were assumed , i.e. methane volumes delivered to the longwall with fresh air

Table 2. Necessary air outflows in the longwall depending on mining speed and methane release

#	Time duration of single coal shearer cut	Average operational speed of the coal shearer for longwall length L = 280 m	Necessary air outflow in the longwall $Q_{śc}$ in m³/min for $\dot{V}_D$		
			$\dot{V}_D$ = 2 m³CH_4	$\dot{V}_D$ = 4 m³CH_4	$\dot{V}_D$ = 6 m³CH_4
	1	2	3	4	5
1	60	4,66	1231	1331	1431
2	80	3,5	948	1049	1099
3	100	2,8	779	876	979
4	120	2,33	666	766	866
5	140	2,0	585	685	785
6	280	1,0	343	443	543

Conclusions

1. Due to significant increase of methane concentration in the environment of operating longwalls in high coal output concentration regime there is rational justification for elaboration of coal shearer speed control system.

2. Elaboration of the tool which would be system of coal shearer speed control based on automatic methane concentration sensors measurement will have direct and significant impact on safety conditions in the exploited coal panels.

3. Application of coal shearer speed control system justify and enable its implementation into mining practice, especially in the longwalls using „Y” or „short Y” ventilation systems.

Thank you for your attention

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