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Reduction of Toxic Components Released by Motor Vehicles in Quarries

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ABSTRACT: When the open mines go down deeper into the ground the velocity of air streams becomes lower and the air exchange around the work places gets worse thus polluting the atmosphere with hazardous gases and dust. And furthermore, the ore quarries use dump trucks which discharge large quantities of toxic components into the atmosphere. To reduce the toxicity of the exhaust gases of the dump trucks there have been developed and introduced into production gamma catalytic neutralize«, complying with the type *of* the vehicle, its engine power and operating conditions.The dump trucks BcIAZ operating in MEDET Open Ore Mine have different lifting capacity and use the catalytic neutralizer H-2. It is charged by means of a catalyst based on cobalt and copper oxides laid in thin layers on small porous aluminum oxide spheres. During the road tests it has been established that the reduction of the toxic components in the exhaust gases is close to that of catalysts made one the basis of platinum. The catalytic neutralizer H-2 has excellent noise silencing characteristics as well as low aerodynamic resistance and the lack of precious metals make it inexpensive and readily available.

1 INTRODUCTION

Open pit mines use powerful high production technical facilities permitting the increase of their maximum allowable depth. With the increase of mining depth the velocity of the air streams decreases resulting in air exchange deterioration and pollution of the mine atmosphere with hazardous components. The content of hazardous components in open mines atmosphere produced by diesel internal combustion engines can be reduced to a certain extent by adjustment of the engine combustion system and mode of operation. A major measure to fight the harmful substances contained in the exhaust gases of the diesel engines is the employment of various neutralize« - liquid and platinum based. The liquid neutralizes are not sensitive to the carbon oxide and the necessity of periodical carbon black cleaning from the inside, their unsuitability for low environment temperatures as well as their considerable dimensions makes them rarely applied.

The studies made so far have shown that for the time being the most efficient way for exhaust gases toxicity reduction is their catalytic name-free burning up. The results of the tests of catalytic platinum-based neutralizers have shown both their lower sensitivity to nitrogen oxides prevailing in the exhaust gases from diesel engines and a higher price and that made it necessary to develop and implement a new range of neutralizers with a catalyst based on cobalt and copper oxides.

When they contact the catalyst the toxic components of the exhaust gases released by diesel engines burn up forming carbon dioxide and water, thus limiting the hazards in the mine atmosphere.

2 DESIGN FEATURES OF THE NEUTRALIZER

An example of a catalytic neutralizer of exhaust gases subject of the invention is shown in Figure 1. The catalytic neutralizer comprises a housing I including a heat insulating material 2, placed between cylinders 3 and 4; a reactor 5, the inside space 15 of which is formed by perforated outside and inside cylinders 6 and 7; streamline separator 8 and a back cover 9. The inside space of the reactor 15 is filled with catalyst granules 10. The reactor is filled with catalyst granules through the plugged opening 11 on the back cover 9. The catalytic neutralizer has also a pipe 12 with tapered outlet for feeding the exhaust gases and an inlet enclosure 16 for directing the exhaust gases to the reactor. The perforated inside cylinder 7 has a non-perforated end which serves as a pipe discharging the exhaust gases to the atmosphere. On the inside surface of cylinder 4 at a distance of 1/3 of its length there are two circle rings 13 directing the movement

of the exhaust gases to the reactor 5. The front cover 17 has a plugged opening 14. The streamline separator 8 is loosely accommodated in the cylinder 4 and the linear expansion of the individual elements of the reactor 5 due to heat load do not affect the catalytic neutralizer.

Based on the patented design there has been developed and implemented the production of H-2 catalytic neutralizer for dump trucks BCJIA3 of 27 tons capacity and KOM-1 and KOM-2 catalytic neutralize« for fork-lift trucks.

H-2 neutralizer is installed horizontally, KOM-I and KOM-2 are installed vertically. The reactor is heat insulated in order to maintain a higher temperature m the neutralizer for ensuring a more intensive oxidation process and avoiding overheating of the truck units. The heat insulation consists of swollen pearlite sand with heat conduction X = 0.46-0.7 W/ m "K.

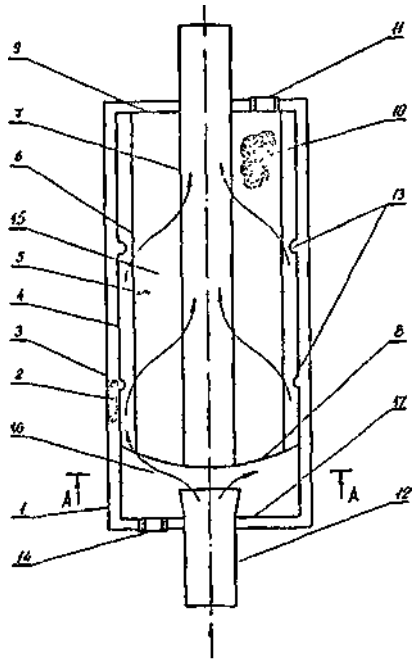


Figure 1. Vertical section of H-2 catalytic neutralizer

3 PRINCIPLE OF ACTION

The catalytic neutralizer acts in the following way: the engine exhaust gases are fed by pipe 12 and are evenly distributed in the streamline separator 8 and guided by the circle rings enter the reactor through the perforated outside cylinder 6. When the exhaust gases contact the catalyst grains the hydrocarbons, carbon oxide and carbon black oxidize, burn up and turn into non-toxic products discharged to the atmosphere through pipe 7. The tapered outlet of pipe 12 and the streamline separator 8 ensure regular and more effective passage of the gases through the reactor.

In case of inclined or vertical installation of the neutralizer the catalyst grains that have incidentally fallen off collect in the enclosure 16 and are removed through plugged opening 14.

The design developed can be used in different internal combustion engines having characteristics corresponding to the neutralizer activity.

3.1 Composition and properties of the catalyst

The proposed design of the catalytic neutralizer complies with the application of a catalyst developed by the Institute of General and Inorganic Chemistry at the Bulgarian Academy of Sciences and patented under No 21437. It has been developed on the basis of cobalt and copper oxides applied on a thin layer of porous carrier having a heat resistant surface. The starting temperature of the catalytic action is 200"C (cold start). The maximum efficiency of purification is achieved at a temperature of 30()"C. The catalyst is resistant to catalytic toxins such as sulphur dioxide ($S0_2$).

4 TEST METHODS

H-2 catalytic neutralizer was subjected to road performance test in Medet Open Ore Mine. The aim of the tests was to determine the reliability of the neutralizer and its efficiency under operating conditions.

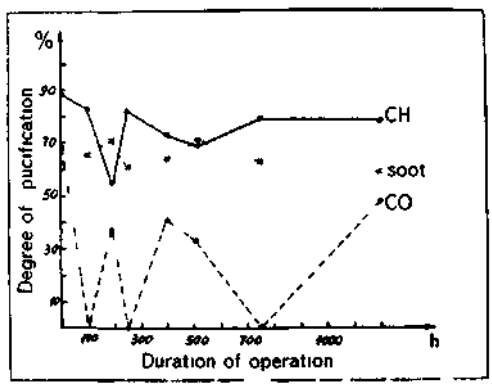
For the test purposes the exhaust systems of two dump trucks 6ejiA3-540 were each equipped with two H-2 neutralizes on the left and right cylinder group, respectively. The measurements included taking of gas samples with the truck moving in first gear, at maximum engine load of 1700 rpm, with a load of about 30 tons in the coach, at road slope of 10%, upstream and downstream the catalytic neutralizer.

The inlet and outlet temperature of the exhaust gases as well as soot content were measured. The gas samples were taken to measure the content of carbon oxide (CO), hydrocarbons and nitrogen oxides. The temperature was measured with the aid of thermocouple of copper-constantan and millivoltmeter. The soot content was measured with the Polish sootmeter D-400. Ten measurements were carried out and the soot content was determined as an average arithmetical value taking into consideration only those measurements with deviations up to +/- 10%. The CO content was measured by a gas analyzer Meihak , Germany while the hydrocarbons concentration was determined with Chrom-4 gas Chromatograph. The content of nitrogen oxides content was measured with "Toxiwarn", Deegger, Germany

5 TEST RESULTS

Figuie 3 shows the dependence ot the purification elficiency ot the catalytic neutraliser on the duiation of its activity As it can be seen throughout the complete test iun H-2 neutralize) shows high activity
The degree hydiocarbons îcmoval is about 80% In lespect ot CO it shows high activity as well, but the content ot this component in the exhaust gases at noimal diesel engine control is relatively low, Theiefore when the inlet CO content gets lower than 0 2% the neutiahzer activity becomes zero

Since the chaiacteiistics ot the catalytic neutralizes offered in the international market do not indicate the reduction of nitrogen oxides Figuie 3 docs not show such data about H-2 neutrahzer But, however the tests earned out demonstiated that as a result ol the leduction aiea formed in the H-2 ieactor the content ot nitiogen oxides is paitially reduced too by about 20-25%



Figuie 2 Dependence of the punlication efficiency ot the catalytic

Table I gives comparative data in teims ol punfication el fluency ot different types of catalytic neutralizes otteied on the woild mai ket and the Bulganan H-2 neutiahzer

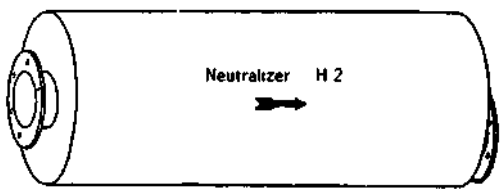
All neutralizers offered aie based on piecious metals such as platinum or palladium the catalyst ot which is passive in lespect ot nitiogen oxides

As can be seen in Table 1 H-2 neutralizer has almost the same activity as the otheis Only H-2 and Engelhard are the most efficient in iespect ot hydiocaibons At the expense ol the lelativeiy low activity in iespect ot CO it has the highest degree of soot removal
The concentration ot CO in the diesel engines is small i e tiom 0 01 to 0 5 vol % and consequently the degiee ot puiification is quite good taking into consideration the small share of CO in the total

Table I Efficiency of Diffeient Catalytic Neutralizers

Component	Degi ee of i emoval vol <7c			
	Bulgana H 2	USA Engel haul	Gei many Helens 20	Russia H Kfl 241
Hydiocaibons	XO	80	6S	70
C il bon oxide	45	X5	90	75
Soot	60	20	45	
Nitiogen oxides	20			

exhaust gases toxicity In the exhaust gases the hydrocaibons soot and nitiogen oxides are considered to be the most toxic They aie piesent in the highest concentrations, too Thcretoie, the efficiency of a ceitain catalytic neutializei tor diesel engines is assessed by the extent ot removal ot those components



Figuie 3 Geneial view ot H-2 Neutralize!

Technical characteiistics ot H-2 catalytic neutralizei

1 Dimensions mm	
Length	822
Housing diameter	
300	
2 Weight ot charged neutralizer kg	35
3 Weight ot catalyst, kg	11
4 Weight ol heat insulation mateiial kg	I
5 Aerodynamic resistance at noimal engine operation mode mmHg	25
6 Durability, km	
- after initial charging	20 000
- after second charging	40 000
7 Degree ot exhaust gases purification, vol %	
- Hydiocarbons	80
- Cai bon oxide	45
- Soot	60
- Nitrogen oxides	20
8 Engine powei kW	175

6 CONCLUSION

The results of the H-2 tests show that it complies with the current requirements for diesel engine exhaust gases purification.

It is easy to install, does not affect the operation of dump trucks, its activity is secure and requires no special maintenance.

The fact that this catalyst is not based on precious metals oxides makes it inexpensive and readily available. The rechargeability of H-2 neutralizer is an additional asset to its economic protltability and implementation.

Moreover, H-2, KOM-1 and KOM-2 have excellent noise supression capabilities and thus the need of installing noise damping pots on the trucks is non-existent.

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