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VENTILATION OF WELDING COLLECTION SHOPS

N. Z. Bitcolov
Research Institute of Sea Transport Hygiene
St. Peterburg, Russia

A.T. Olishevskiy, A.I. Agoshkov and S.N. Strizheusov
Far-Eastern Politechnic Institute
Vladivostok, Russia

SUMMARY

Specially developed method was used for carrying on analysis of physical and chemical properties (chemical composition, fraction distribution and others) of aerosols for welding in the shop space. As well, the nature of those properties changes due to the shop height is analyzed.

With the purpose of improving sanitary conditions of work at a working zone, decreasing ventilation air expenditure, and, correspondently, reducing operation expenses on ventilation a new method of ventilation of large volume shops by means of laminated streams, forcing out all contaminations into the upper zone of a premise.

Construction in the form of automatically regulated air heat screen is designed. It protects the technologic gate openings from penetration of cold air masses into welding collection shop.

The results of the research and development done can be applied in the fields of industries, having welding shops of large sizes, particularly in severe climatic conditions.

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INTRODUCTION

Multispanned welding collection shops of shipbuilding enterprises have considerable sizes. They are characterized with their specific production character (a variety of welding types and welding materials, availability of large-sized sections to be welded, works on welding being done on non-fixed working places and at different heights); intensification of welding processes and consequently, with the excretion of considerable amount of highly toxic substances into the shop atmosphere. To dilute and take out welding aerosols out of the working zone it is necessary to supply large volumes of air by means of general ventilation system, and considerable energy expenditure is required here, particularly within the cold season. In addition, in welding collection shops technological openings are available and they influence greatly on distribution of air temperature fields at the working zone. Thus, if to take into account the above difficulties concerning insurance of normal atmosphere parameters at the working zone, it will be very important to think about theoretical and experimental studies of optional schemes for ventilation and efficient equipment for air cleaning. As well, it is necessary to work out some measures to prevent the passage of cold air into the working zone. To solve that problem is impossible without preliminary investigation of the quantity and quality of the toxic substance composition not only in the working zone, but at different heights of the shop too. These measures give a possibility to study carefully the dynamic of aerodispersive systems, to select efficient methods of air input and outlet (distribution).

WELDING AEROSOL PROPERTIES

To pick out welding aerosol probes at different shop heights due to the base of working zone a special technique has been developed. This technique allows to determine perfectly disperse and chemical composition of aerosols. The idea is that on the cross-beam of bridge-girder crane the equipments to take probes were installed; they were connected with filter basement for filter to be fixed by means of hoses. The crane lowered filter basements with filters. The lengths of hoses should ensure simultaneous selection of air probes at definite heights of the shop. The chemical and dispersive composition of welding aerosols, releasing at the process of welding, is known to depend, mainly, on composition of welding materials and to less extent on composition of steels welded, as well as, on welding regimes [1].

The electrodes of chrome-nickel and manganese group as well as ones of fluor-calcium type were mainly (85-90%) used in the investigated welding-collection shops (volume ranges from 500 to 700,000m^3). For automatic and semi-automatic welding highly alloyed steel wires with considerable content of chrome, nickel and manganese are used. Determination of quantity of toxic substances in the welding-collection shop air was carried out by liquid chromophotography [2].

The data obtained are given in table 1.

Height of Taking Probes, m / Aerosol Components	1,5	5	9	13	18
Ni	1,96-2,5	1,52-2,1	1,38-1,67	0,9-2,29	2,02-2,1
$Cr O_3$	3,78-4,6	1,97-2,62	1,42-2,28	1,16-3,62	0,995-1,05
Mn	4,1-5,7	3,12-3,87	2,19-5,12	1,93-5,2	2,08-2,12
Fe_2O_3	27,8-65,1	22,6-36,8	19,5-32,6	18,9-50,3	27,9-29,1

Fig.1. Content of Ni, Cr, Mn, Fe in % at different height.

Analysis of data (given in table 1) showed that the toxic substances in the working zone air exceeds acceptable level of concentration: chrome - 3.4 times, manganese - 1.2 times, nickel and ferro (iron) - 1.09 and 1.06 times correspondently. The average content (in %) of nickel, chrome, manganese and ferro in welding aerosols at different heights of shop is: Ni - 1.4÷2.29%; Cr - 1.02÷4.1%; Mn - 2.1÷4.92%; Fe - 28.5÷37.7%. To study the disperse composition of welding aerosol the method of optical microscopy was accepted. But there are no exact characteristics of the conditions when one can get preparation of the optimal "thickness". That is why time for taking probes was determined experimentally, taking into account the fact, that at optimal probe the number of dusts must not be more than 8÷10 on the square of 18×18 mcm[3]. The basic statements of mathematical statistics were used to process the results of disperse analysis [4]. The average diameter $\bar{\delta}$ was determined by formula

$$\bar{\delta} = \frac{\sum \bar{\delta}_i n_i}{\sum n}, \quad (1)$$

where δ_i is the average size at interval; n_i is the number of particles at interval. The meaning $\bar{\delta}$ does not show the whole characteristic of the particle parameters because it does not reveal the degrees of its homogeneity. The average quadratic declination $\sigma(\delta)$ is an important indication supplementing an average arithmetical diameter δ and characterizing homogeneity of diameters and it is expressed by formula

$$\sigma(\delta) = k\sqrt{\sum(\delta_i - \bar{\delta})^2 n_i / \sum n}, \quad (2)$$

where k is coefficient correcting the result of calculation according to the number of done independent measurements:

$$k = \sqrt{n/(n-1)}. \quad (3)$$

Along with it, to evaluate the state of dispersion the variation coefficient ψ is more convinient, which is often called the degree of dispersion, that is a qualitative indication, characterizing the homogeneity of aerosol particles:

$$\psi = \sigma(\delta)/\bar{\delta}. \quad (4)$$

In table 2 results of dispersive analysis of the welding aerosol at shop height of 1.5 (working zone), 5, 9, 13 and 18 meters are given.

Shop height, m	Average arithmetical diameter of particles $\bar{\delta}$, mcm	Average quadratic declination $\sigma(\delta)$, mcm × 10^{-2}	Coefficient of variation ψ
1,5	0,30	4,46	0,15
5,0	0,28	4,09	0,15
9,0	0,27	3,87	0,14
13,0	0,26	3,65	0,14
18,0	0,23	2,70	0,12

Fig.2. Results of dispersive analysis of welding aerosol.

Analysis of the results showed that the welding aerosol is practically monodispersive system (variation coefficient $\psi \leqslant 0.15$). The average arithmetical diameter of the welding aerosol particles varies from 0.23 to 0.3 mcm according to the shop heights. In table 3 a dispersive composition of the welding aerosol formed in welding of highly alloyed steels is presented.

Size of fractions, mcm	0 ÷ 0,3	0,3 ÷ 0,6	0,6 ÷ 1,2	1,2 ÷ 2,4	2,4 ÷ 4,8	4,8 ÷ 9,6	9,6 and more
Content of particles in %	75,1	17,1	5,40	1,70	0,44	0,2	0,06

Fig.3. Dispersive composition of the welding aerosol.

From the data obtained and presented in the table 3 it follows that the welding aerosol is fine disperse system. There is 97,6% of particle sized less than 1.2 mcm and 99.3% with the size less than 2.4 mcm. In fig.4 differencial curves express distribution of particles according to the number of functions n(δ) and characterizing the portion of particles with the size ranging from ($\delta \div \delta + d\delta$). The diagram square limited with the distribution curve, axis of the absciss and two ordinates δ_1 and δ_2 shows clearly the portion of particles with the sizes between δ_1 and δ_2. Fig.5 shows the results of dispersive analysis on form of integral curves, every point of which shows a relative content of particles with the size more or less than the given one. It is very convinient to use integral curves for making calculations in designing of dusters and in evaluating the effectiveness of their work. As one can see in fig.5 the disperse composition of welding aerosol at shop heights varies unessentially: there were 96.2% of particles with the size up to 1,2mcm at the working zones (1.5m), at the heights 9 and 18 m up to 98.3 and 98.1% respectively. It should be noted that distribution of the welding aerosol follows normal law, and percentage ratio of welding aerosol fractions keeps the same at different shop heights [5].

VENTILATION OF WELDING COLLECTION SHOPS

With the purpose of improving sanitary conditions of work at the working zone, decreasing ventilation air expenditure, and, correspondently, reducing operation expenses on ventilation a new method of ventilation of large volume shops by means of laminated streams was proposed (Fig.6).

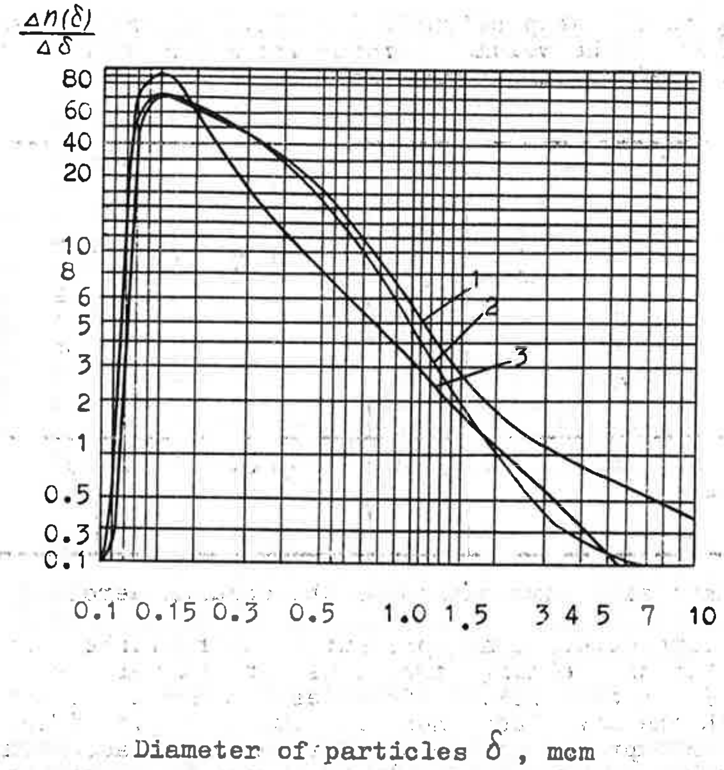

Fig.4. Differential curves of distribution of the welding aerosol particles due to the numbers:
1- for height of 1.5 m (working zone); 2 - for height of 9 m; 3 - for height of 18 m.

The method of premise ventilation 1, relatively divided 2 into the working zone 3 and the upper section of premise 4, is realized in the following way. Preheated in calorifer 5 the air flow by means of ventilator 6 through airpipes 7, located at the lower border 8 of the working zone (probably at underfloor room) is forced in the form of vertical laminated currents up to the working zone and they remove the released toxic substances into the upper zone of the premise. At the upper zone contaminated air is brought to circular motion by directing currents from the air distribution system 9 and because of the air rarity, created by ventilator 10 through the sucking in branch pipe 11 is intensively removed from the premise. It should be noted that convection currents above heat release system increases the effectiveness of such ventilation method, in addition to it, an ascending circulating current prevents contaminations from coming back into a working zone. Contaminated air being removed after preliminary filtration can be used again in supercharging ventilators for operation within the recirculation ventilation scheme [6]. The method suggested to ven-

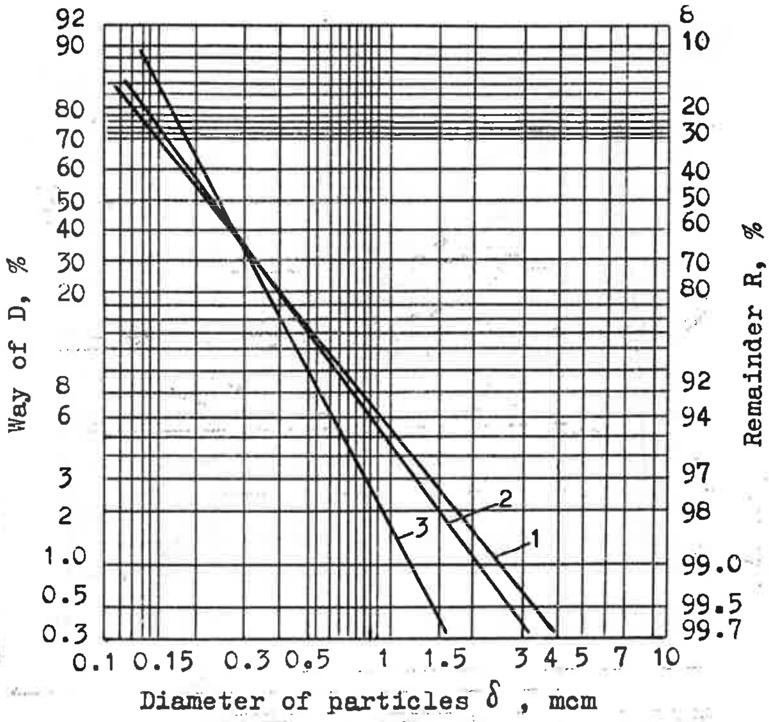

Fig.5. Integral curves of distribution of welding aerosol particles for heights of: 1-1.5 m; 2-9 m; 3-18 m.

tilate the welding collection shops with the help of laminated streams is developed on the analysis of the chemical and disperse composition data of welding aerosol in view of its distribution at different shop heights.

AIR HEAT SCREEN

Investigations of the passage of cold air masses within the cold season through technological gate opening with the square of 250 m² showed that substantial reduction of the air temperature differs within the range of 30 m from the technological opening, the shop square being 60%. Substantial supercooling of working zone, even at momentary opening of technological gates, requires some technical solutions to maintain normal working conditions at the working zone. Air heat screen construction with automatic regulation of air consumption has been developed. The construction is designed to protect technological gate openings from penetration of cold air masses into the welding collection shop in their openings, and it reduces considerably the energy consumption on heating and ventilation. The air heat screen consists of three air distribution boxes, two of them being made in the form of diffusors 2, 3, the less platforms of which are connected with the forcing airpipe 4 by flexible airpipes 5,

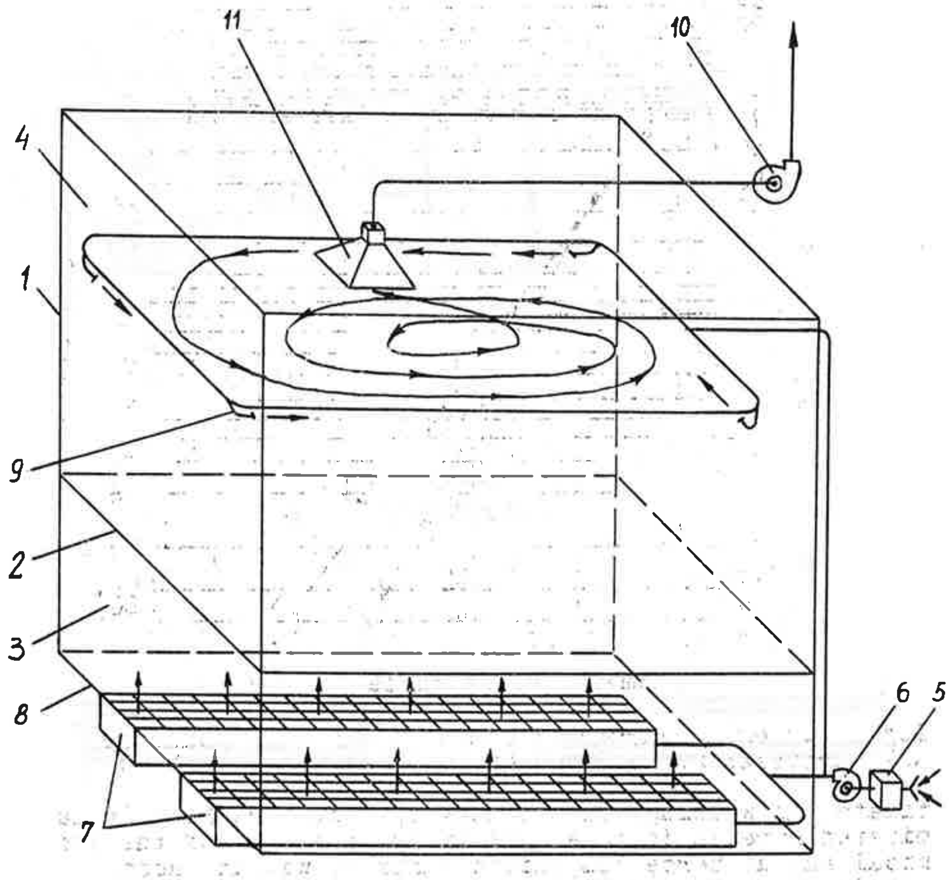

Fig.6. A new method of ventilation by means of laminated streams.

changing their length and installed at the empty gate folds 1. The airpipe of constant static pressure 6 is place at underfloor room, just right under gate folds and has air outlet openings 7 and 8. The air distribution by lateral boxes is realized through air outlet openings 9, placed at the built-ends of the gate folds which in gate contact (corresponding closed gates) are overlapped with packing 10 respectively. In fig.7 we can see that the air outlets 7 at gate closing are overlapped with the gate folds, and the screen is produced with non-overlapped section 8 of lower distribution opening with minimum air consumption. The heated air stream mixed with the cold air tends to get to the upper zone of premise and prevents penetrating of cold masses into the working zone of the premise. The construction of air heat screen proposed allows to install it right at the width of opening being open. In this case, the air heated in air stove 11 and supplied to the screen is distributed between lateral and lower boxes. With increasing the width of the

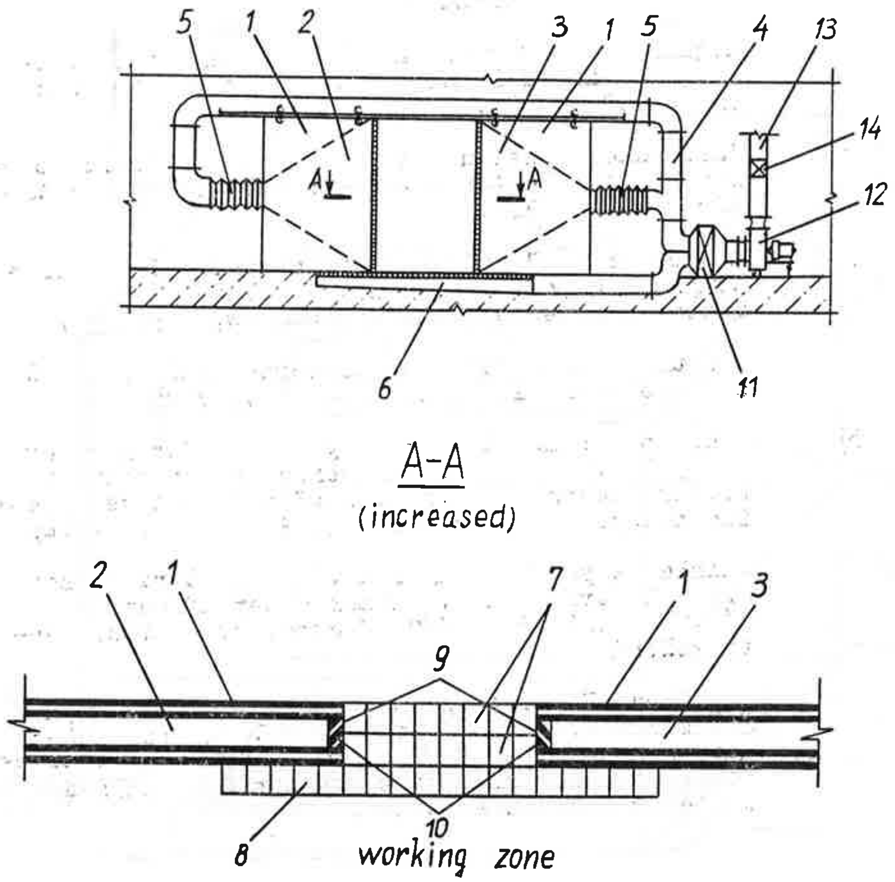

Fig.7. Air heat screen construction with automatic regulation of air consumption.

working opening, the air screen consumption increases respectively. Ventilator of variable capacity 12, as well as the air taking in to the screen from the upper zone of premise by means of sucking air pipe 13 and availability of cleaning filter 14 secures economy of the air heat screen operation proposed [7].

CONCLUSION

The researches carried out allow to improve the sanitary conditions of air medium at the shop, to select the optimum complex of duster arrangements, to increase economic efficiency of ventilation systems and to find application in different branches of industry, having large volume welding shops, particularly, in severe climatic conditions.

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