ENERGY SAVING INPUT-EXHAUST DEVICES FOR THE EXTRACT OF HARMFUL SUBSTANCES OF TECHNOLOGICAL PROCESSES

Nikolay Maystrenko
Postgraduate of the Odessa national polytechnic university
Engineer of a 1 category of laboratory of adjusting of service of ventilation of energy repair subdivision
Zaporozhskaya NPP, Ukraine

LIST OF CONDITIONAL DENOTATIONS, CHARACTERS, UNITS, REDUCTIONS AND TERMS
Dc - is conditional diameter;
MW - is megawatt;
NPP - is a nuclear power plant;
VVER-1000 – water-water power reactor by electric power 1000 MW;
KYUM - is coefficient of the use of the set power;
KMS i- s coefficient of local resistance;
SNyP - are building norms and rules;
A miniwhirlwind is a whirlwind, the maximal linear size of which makes a few decimetres, no more than one meter;
«Mixer» ventilation is ventilation proper to the chart «from above – upwards», at which and the serve of supply air is produced in a working area in the form of penetrable streams from above and of air of containing the harmful matters or surplus warmth execute the delete from an overhead area;
«Supplant» ventilation is ventilation proper to the chart «from below – upwards», at which the serve of supply air is produced directly in a working area, and the delete of air of containing the harmful matters or surplus warmth is executed from an overhead area.

INTRODUCTION
In modern terms more actual and claimed there are energy saving technologies and technologies allowing working out ecological problems.

Ventilation, accordant [1], is foreseen for providing of the meteorological terms and cleanness of air set by sanitary and technological norms in the apartments of buildings and buildings.

Dysnai - 2008
The International Youth Nuclear Symposium

The systems of ventilation depending on setting subdivide on: general exchange, local, conditioning, air curtains.

Ventilation allows deciding the row of important tasks: to provide balance of heat, delete of harmful matters from air of apartments and, if necessary, dispersion of the harmful troop landings, cleaning of air and gases from a dust, etc.


Modern venting technologies: equipment and of principles charts of ventilation – to a great extent in the development stopped at the level of 60 – 70 years of past century, and perfection takes place mainly at technological level.

On occasion, for example for general exchange ventilation, additional efficiency can obtain by the change of principle chart of organization of ventilation in the apartment. So, for example, «mixer» ventilation most traditional for the device of the domestic general exchange systems is replaced on «supplant», at which is achieved a positive energy saving effect is decline of expense of air on a few ten percents [5]. But realization of such decision in majority case is impossible from a restrictive condition – implementation of requirements of comfort of receipt of supply air in the working area of dwelling of people in obedience to the S NyP norms [1].

Before appearance of whirlwind technologies development of ventilation was forward. The analysis shows that whirlwind technologies are able to provide a energy saving effect in ventilation.

The indicated whirlwind technologies are especially perspective for the circulation charts of organization of ventilation of cooling (heating) and filtration of air. For such charts creation of ventilation without channels is possible. The function of channels network in such charts is executed by a whirlwind. Preliminary researches of author of miniwhirlwinds – whirlwinds, the maximal linear size of which does not excel a 1 meter – shows on high power efficiency of organized himself of underlying structure of such whirlwinds are the losses of energy are minimum. Generally known, that exactly aerodynamic resistance of network of channels gives considerable, as a rule, more than half of value of complete pressure of ventilator constituent. Thus, translation of ventilation on whirlwind without channels technologies will allow to apply the ventilators of less pressure and to those to reduce energy consumption.

Major and middle industrial concerns are the most perspective and economic claimed places of the use of whirlwind without channels technologies.

Such major concern NPP with power unit of the type VVER-1000 can exemplify. Thousand ventilators of a different type and power consume plenty of electric power of produced NPP, multiplying consumption of electric power on own needs and reducing the general making and the same coefficient of the use of the set power – KYUM is basic integral index of efficiency of the use of power unit.
Presently KYUM power units of NPP makes 4…5 %. At nominal electric power of power unit 1000 MW, consumption of electric power of NPP on own needs comparably with consumption of middle city with the population in a few set of thousand habitants. The decline of consumption of electric power is substantial reserve of the KYUM increase and vacation of commodity products of NPP in the electric networks of grid of Ukraine.

For example, consumption of electric power by ventilation (without taking into account systems of conditioning) of NPP the largest in Europe – Zaporozhian, makes 8 MW and decline of the indicated value in two-three times gives a considerable economic effect.

Energy saving at the ventilation based on whirlwind technologies is provided due to multiple (sometimes, on an order, in 10 times) diminishment of charges of air. For example, decline of expense of air in 5 times, allows to decrease pressure of ventilator in 25 times, and, as a result, decrease power of ventilator in 125 times.

Use of whirlwind technologies for local ventilation in processes localizations and catching of harmful matters from a technological or working area, which the indicated matters are secreted in, allows to get such values of descriptions of the local sucking which can not be provided by none of the known technologies. Thus, some descriptions have the such quantitative changes which ground to speak about the high-quality changes.

It should be noted that in local ventilation whirlwind technologies are most perspective at soldering and welding.

**REVIEW OF NORMATIVE DOCUMENTS AND EXISTENT TECHNOLOGIES FOR FORMING OF REQUIREMENTS TO LOCAL VENTILATION**

In a modern world with his giant industrial growth, plenty of harmful productions, promoted requirements of ecology and labour protection of workers of such productions, the local sucking of ventilation all in a greater measure are technically and economic the effective mean of decision of problems.

In obedience to 3.3 [6], workplaces it is necessary to equip by the local drawing devices providing the rate of movement of air directly in place of soldering no less than 0,6 m/s, regardless of construction of reception of air.

This value of rate of movement of air directly in place of soldering is indicated in Rules of labour protection operating in Russia [7].

Extractions from [6], including in part of rate of movement of air in place of soldering entered in a normative document [8].
In Ukraine except for an operating normative document [6] there are department norms [9], in which that value of rate of movement of air is indicated in place of soldering.

In Byelorussia operates [10], in which that value of rate of movement of air is indicated in place of soldering.

Because a lead is the extraordinarily hazardous substance (class 1), at soldering is selected in the most dangerous kind – aerosols (size from 0.7 to 7 mkm) and at inhalation of steams and aerosols with lead a lead can be taken in almost fully, the rationed rate of movement of air directly in place of soldering is grounded and must be executed.

Most complication at creation of the local sucking is represented by creation of such their constructions which will provide most action in the distance is ability of the local sucking to create and support the rationed speed on maximally possible distance from the suction opening. The smooth is thus desirable, near to linear dependence, change of speed of the sucked blast in, at the least values of parameters providing this process of suction, for example, such as expense of the sucked air in, diameter of the suction union coupling, etc.

Except for the indicated basic parameters, the local sucking must satisfy to the row of no less important requirements of such as: efficiency of catching of the local sucking in the conditions of practical application, instead of in the ideal terms of stand tests; low level of noise of created by the local sucking; comfort of his exploitation.

Practice of implementation of soldering and welding works in the conditions of repair at the place of location of the repaired equipment, for example, terms of NPP, specifies on desirable property of mobility of the local sucking and equipment of providing his functioning.

For local drawing ventilation at soldering of the «Sovplym, «Ekoyurus-Vento», «Elstat» firms» et al offer the devices with the following technical descriptions:

- expense of air – 125…200  m³/h;
- diameter of the union coupling – 75 and 100 mm.

Thus, in obedience to the Torgovnykov [4] formula, for the round and square openings relative speed of suction at \( x > 0.5d_0 \)

\[
\frac{v_x}{v_0} = k \frac{c}{(d_0/x)^2}
\]

(1)

where, \( v_x \) is speed of air in the distance \( x \) on the axis of the suction union coupling by the diameter of \( d_0 \), m/s;

\( v_0 \) is speed of entrance of air on the axis of \( x \) in the suction union coupling by the diameter of \( d_0 \), m/s;
\textbf{knc} is coefficient, taking into account character of flow line of stream to opening, equal for the fully opened sucking with the round or square opening 0,06.

In obedience to a formula (1), for providing of rate of movement of air 0,6 m/s in the place of soldering the union coupling of device which sucking the air must be not further 66…84 mm from the sting of soldering iron. Some increase of distance from the device to the place of soldering (in 1,4 times) can be given on him by setting of reflector.

The same result is given by the Talyev formula [11]

\begin{equation}
\frac{v_x}{v_0} = \frac{1}{2} \left(1 - \frac{x}{1 + x^2}\right)^{0.5}
\end{equation}

where, \(x\) is relative distance on the axis of the suction union coupling from the entrance in him to the point, in which determine speed of \(v_x\), here, \(x = \frac{X}{R}\);

where, \(X\) is distance on the axis of the suction union coupling from the entrance in him to the point, in which determine speed of \(v_x\), m;

\(R\) is radius of the suction union coupling, m.

In practice the sucking devices by a diameter 75 and 100 mm are nearer 200…250 mm from the place of soldering can not be set, otherwise they interfere with work. Thus, the requirements of normative documents in part of rate of movement of air directly in place of soldering are not executed.

Calculations are shown, that for providing of distance 200 mm from the sucking device to the place of soldering the expense of air is needed no less 1000 m\(^3\)/h and diameter of the suction union coupling (for providing of acceptable level of noise) no less than 180 mm, that unreality.

The developments of the last years conducted on Ukraine allowed to the author to create the device – local sucking, possessing the indicated so contradictory properties, functioning of which is based on whirlwind technology, having the differences of process of suction and effect of localization of area of selection of harmful matters important for the practical use substantial, of principles.

The desired descriptions of the local sucking conflict with physics of process of suction in the ordinary, traditional understanding is delete of air by means of suction through channel. The numberless amount of the theoretical and research advanced studies is devoted to description of this process.

We will remind one of substantive provisions of theoretical ground of process of suction: dependence of speed of air in the point of space from distance to the suction union coupling is reverse quadratic.

As a result of such dependence are extraordinary difficulties on providing of higher indicated action.
Till recently, action of practically all local sucking was based on traditional suction of air through the union coupling located in the distance as possible less from the source of selection of harmful matters.

Summarizing the analysis of structural features of the created and exploited local sucking on providing of them action, it is possible to select two-three directions of the conducted and widely realized developments. At first, is implementation of cut under a corner, ordinary from 30 to 45 degrees, suction union coupling for the receipt of his entrance section in the form of ellipse. Secondly, is implementation of the suction union coupling of greater size, as a rule, through transition. Thirdly, is combination of the first two structural features.

Experience of exploitation of the local sucking of traditional chart of suction shows that, for example, the local sucking from the working areas of shareholders allow to provide the rationed speed of the deleted air 0,6 m/s from distance, approximately, 1,0-1,2 Dc suction union coupling, that at the values to Dc 80 mm and Dc 100 mm allows to work only with shallow details and in the very limited space. In addition, soldering in such terms is accompanied by the following negative effect: during work with shallow details soldering irons of small and middle power (25 – 40 W), which at approaching to the suction union coupling from the quickly multiplied rate of movement of air cool down below than minimum working temperatures, are usually used, that does the process of soldering unhigh-quality or in general impossible. Actually, the suitable for soldering is an area from 80 to 100 % distances, which the rationed speed of the deleted air is provided on.

The indicated difficulties of providing of effective work of local ventilation in especially harmful productions were decided by creation of drawing closets of a different construction, i.e. by creation of mechanical barriers for distribution and organization of delete of harmful matters.

Drawing closets, providing necessary efficiency of local ventilation, have the row of the substantial failings. These failings are: specific discomfort which feels working in a drawing closet from a barrier being before him (this glass is ordinary); the large occupied space in the apartment, which, actually, is involved only during work in a drawing closet; considerably megascopic expense of the deleted air by comparison to possibilities of the local sucking of based on whirlwind technology.

Analysis of physics of processes of suction of air, different constructions of the local sucking, experience of exploitation and model researches was shown, that the traditional chart of the local sucking did not have a prospect for development of constructions of devices proper to the modern stage of development of science and technique.

As a result of analysis and comparison of dignities and lacks of existent technologies of ventilation it is possible to do a conclusion that only whirlwind technology is able...
to provide the receipts of all necessary spectrum of descriptions of the local sucking on principles of energy saving:

- minimum values of charges of air and as a result minimum values of complete pressure of ventilator and his electric power are the so-called parameters providing functioning,
- maximum values of action suction stream at saving in the working area of area of speed of stream sufficient for operative space of worker and smooth change in an operative volume,
- efficiency of the reliable catching of harmful matters,
- minimum value of speed of current of air in the places of his contact with a worker, limited from above by the normative values,
- comfort of the practical use in the real terms.

During realization of whirlwind technologies the maximal use of the wide-spread and known equipment or his elements is desirable: ventilators, electric motors, driving wheels and other

**INCREASE OF EFFICIENCY OF LOCAL VENTILATION WITH THE USE OF TECHNOLOGY OF «TORNADO»**

The known whirlwind technologies are described by a next of principle chart.

Supply-drawing device, in which clean air is given and which air containing the harmful matters is deleted from, by a ventilator – at a circulation chart, or ventilators, serves as the generator of miniwhirlwind. Thus the delete of air with the harmful matters is produced from central part of whirlwind, and serve of clean air – in peripheral to part whirlwind in an involute kind, i.e. the streams of supplied air have the vector of speed $V$ with projections on three directions: axial – $V_a$, radial – $V_r$, tangential – $V_T$.

Remote air or is thrown out in an atmosphere, his preliminary filtration is here possible, or, at the circulation chart of ventilation, after obligatory filtration the cleared air is given as supply, which localizes working or technological space with the harmful matters.

The supply-drawing device is the feature of technology of «Tornado», in which a whirlwind is formed by supplied air in running part of device without the use of what or whirlwind makers, blades and that similar elements.

About the basic element of technology a formula says (patent of Ukraine on an useful model № 18770 from 15.11.2006 «supply-drawing device of «Tornado»), «supply-drawing device, which contains a cylindrical corps with the suction union coupling coaxially set in him, and union coupling of supply air and whirlwind maker of supply air, which differs to those that whirlwind maker is executed as the spiral area of supply
The supply-drawing device of «Tornado» will realize whirlwind technology and basis of functioning of device makes whirlwind.

A suction blast has the form of pear, the arbitrary spatial location of which can be.

Basic primary destiny of device of «Tornado» is the use of him as the local sucking: on the desktops of solders in execution Dc80, Dc100 and on the workplaces of welders in execution Dc200, Dc250.

Device of «Tornado» has high efficiency and unique action suction stream, excelling single world analogues.

For example, the device of «Tornado» in execution Dc80 mm provides the speed rationed for the workplaces of shareholders 0,6 m/s in the distance 3,25 diameters of suction pipe, i.e. 260mm, and for welders – at Dc250 mm speed 0,3 m/s – in the distance 0,9 m.

Device of «Tornado» has the KMS influx and drawing union coupling, accordingly, equal 8 and 1.

In addition, speed of the sucked air in a working area at the use of device of «Tornado» changes substantially more smooth, than at the use of the ordinary local sucking. This property allows more high-quality to produce soldering, because high speed of air results in the substantial cooling of soldering iron, and low – to the decline of efficiency of the local sucking.

For work of device of «Tornado» it is required to provide an influx and extraction of air in the amount indicated in the following table 1.

<table>
<thead>
<tr>
<th>Dc</th>
<th>Expense mm/m³/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>110</td>
</tr>
<tr>
<td>100</td>
<td>175</td>
</tr>
<tr>
<td>200</td>
<td>700</td>
</tr>
<tr>
<td>250</td>
<td>1000</td>
</tr>
</tbody>
</table>

Functioning of device of «Tornado» on the chart of « circulation» allows using his maximal possibilities.

For implementation of other tasks, the device of «Tornado» can be modified taking into account the concrete features of application.

One of modifications of device of «Tornado» will allow producing collection of the unfixed radio-active dust at radio-active incidents and failures for utilization and burial place without direct participation of man.
Device of «Tornado» is in positions for modifications with the purpose of receipt of necessary form and sizes of suction stream. Dependence is following thus: at greater action is less corner of cone of suction stream and vice versa.

Technology of «Tornado» allows to realize principle – «where excretions (harmful matters, warm) are – there localization, capture, delete and, at possibility, utilization».

**PRE-CONDITIONS OF CREATION OF MATHEMATICAL MODEL OF TECHNOLOGY OF «TORNADO»**

By basic equalization characterizing functioning of the supply-drawing device «Tornado», is

\[ \text{Min} = \text{Mout} \]  

where Min, Mout is mass expense, accordingly, supply and drawing air, kg/s.

A mass expense is determined by a next formula

\[ \text{Mi} = \text{Li} \times \rho_i \]  

where Li is by volume expense, conformable, supply and drawing air, m³/s;

\[ \rho_i \]  is air density, kg/ m³.

Equalization (3) is expression of balance of supply and drawing air, but insignificant superiority of amount of the deleted air above the supply air for the greater guarantee of non-proliferation of air of containing the harmful matters is assumed in practice. As a rule, such misbalance makes 10 – 15 %.

Researches of supply-drawing device of «Tornado» allowed to set character of basic dependences between geometry of device and whirlwind created to them, charges of supply and deleted air. Estimation of these dependences carries high-quality character, and exact equalizations allowing to give quantitative estimation are subject to determination as a result of researches.

Below resulted high-quality to interdependence between the basic parameters of device of «Tornado».

A form and sizes of area of suction depend on correlation of geometrical sizes of supply-drawing device of «Tornado».

Bring the increase over of amount of supply and drawing air to intensification of ventilation «influx is extraction» at saving of sizes of area of suction, practically.

Character of distributing of the fields of speeds and pressure of air in the device and his supply and drawing streams is difficult enough and must be certain as a result of researches.
Whirlwind technologies allow on principle other gates to decide the questions of ventilation on industrial and civil objects with the powerful sources of coming of heat.

On the example of the circulation system of cooling of air of apartment, the powerful source of coming of heat is located in which, we will consider advantages of whirlwind technology of «Tornado».

In general case the taken thermal power $Q$ is some function with variables in a kind

$$ Q = T_0 F \theta $$

(5)

where $T_0$ is coefficient of diversion of heat, W/(m$^2$×°C);

$F$ is surface of heat exchange, m$^2$;

$\theta$ it is a temperature pressure, °C.

We will consider the process of taking of heat from the equipment by means of the circulation venting system.

At the ordinary chart of ventilation equipment is source warm – gives him in all volume of apartment, which he is set in. The circulation venting system, pumping the heated air of apartment through air cooler, returns him in the apartment. Thus in ventilation all volume of apartment and temperature pressure participates has the small value.

At the use of whirlwind technology of «Tornado» the equipment gives a heat in the local volume of apartment, directly joining in the outward surface of equipment. Thus in ventilation the local volume of apartment and temperature pressure participates has the greater value. A heat exchange on the surface of equipment goes more intensive due to the organized blast, which results in the increase of diversion of heat. Consequently, for taking of equal amount warm due to the increase of diversion of heat and temperature pressure the less surface of heat exchange will be required, that diminishes material production inputs change of heat, improves his mass indexes. Diminishment of pumped volume from the value of volume of all apartment to the value of local volume results in the use of less powerful ventilators, that carries the direct economy of electric power, material resources and, as a result, financial means.

Application of whirlwind technology of «Tornado» on the base of air cooler in the venting systems without channels of connected to two- or to the three-contour technical water systems allows to reduce expenses on cooling of equipment multiple. For major industrial concerns, such as Zaporozhian NPP, the indicated expenses have permanent character and large absolute value, and can be diminished in 3 – 5 times.

CONCLUSIONS

The increase of reliability, power and ecological efficiency of the systems of ventilation is the purpose of the advanced study, based on energy saving whirlwind technologies.
For this purpose it is necessary to decide the following tasks:

- to execute the analysis of the existent systems and compare their application to the offered technology;
- to execute the mathematical design of processes (aerodynamic, thermal) in the device of whirlwind maker;
- to conduct experimental researches of device of «Tornado»;
- to develop recommendations on application of whirlwind technologies and supply-drawing device of «Tornado»;
- to execute technical, economic and power comparison of whirlwind technologies and used presently.

REFERENCES

6. SN 952-72. «Sanitary rules of organization of processes of soldering of shallow wares by alloys containing a lead».
8. The RO 45-007-96. SWEAT «Governed on a labour protection at works on telephone exchanges and telecolumns». Russia.
9. DNAOP 5.2.30-1.08-96 (NPAOP 64.2-1.08-96). «Rules of safety at works on telephone and telegraph exchanges».
10. «Instruction on a labour protection for working, related to soldering by table of contents of lead alloys». Byelorussia.