

Energy and Resource Saving in Mobile Pneumatic Transporters

Victor Gennadievich Chertov,
Evgeny Ivanovich Evtushenko and Artem Alexandrovich Mochalin
Belgorod State Technological University Named after V.G. Shukhov,
Kostyukova Street 46, 08012 Belgorod, Russia

Abstract: Researchers propose fundamentally new design of some Mobile Pneumatic Transporters (MPT) which are widely used now and allow to perform dust handling not only dust handling of flat surfaces (two dimensional) but also three dimensional (volumetric) dust handling in a manual and automatic mode; they have maximum unit capacity per nozzle which is up to hundred times higher than in conventional industrial vacuum cleaners. Implementation of the design will allow to obtain triple ecological effect: to improve essentially economic and technical parameters of cleaning equipment to increase productivity in some times to mechanize and to automate vacuum cleaning process in perspective. The pneumatic transport differs by its high efficiency, ease maintenance and control, an opportunity of transportation processes automation and use of remote control that is especially actual in transportation of explosives. Dosed filling of explosive machines directly on a site of their application increases a level of safety of blasting operations technique.

Key words: Energy and resource saving, mobile pneumatic transporters, mechanized dust handling, nozzle, blasting operations

INTRODUCTION

During processing of various loose materials significant amounts of a spillage are generated but a plenty of dust is deposited on building structures, crane and other equipment. The dust formed during production operations pollutes air environment of premises, surfaces of building structures and the equipment. The spillage and the settled dust are the main sources of a secondary dust formation originating in the course of manual cleaning. Manual dust handling causes moving significant amounts of a dust, it is rather labor-consuming but it is carried out in ecologically harmful conditions. When cleaning building structures and the equipment but upon downfall of significant amounts of a dust, working conditions in working zones worsen in dozens times but equipment wearing process is sped up. In the case of its significant amounts, the dust may slump, agglomerate, set, stick together, adhere and be collected on building structures and the equipment. Besides, a newly settled dust is easily removed in the case of regular cleaning but for example, slumped and set cement dust is hardly removed even by means of a rock-drill. Such, dust may lead to failure

of structures that repeatedly proved to be true in practice. The similar problem is represented with cleaning from roads of a fresh snow and a snow ice. Clearing internal surfaces of the equipment of various purpose, mills, loading pockets, dust collectors and also rectification of the consequences of accidents and catastrophes of technogenic character are of greater labor content at essential economic losses. Flammable and explosive dusts of a cellulose or a flour type, a wood and coal dust, production wastes of fabricated rubber products but wastes of the textile industry and chemical production but so forth, increase fire both explosive risks. Traditionally, manual and mechanized dust handling is carried out in 3 stages: in the beginning the dust is moved from place to place but then it is directly cleaned and processed or salvaged. Vacuum cleaning allows to combine those 3 stages in one and is actual practically for all industries where cleaning is usually carried out manually, especially for effective preventive maintenance and rectification of aftereffects of various harmful, flammable and explosive emissions. This problem has become strained recently in connection with essential curtailment of production and the personnel, absence or cutout of funds on

transition to safe technologies but to technical upgrading. In the conditions of an economic crisis, many factories do not hold activities on the safety precautions and even do not have corresponding services. Industrial dust handling provides compliance with sanitary-and-hygienic demands to premises and increases workplace safety level. Not only dust handling of flat surfaces but also mechanization of cleaning of remote places in the entire volume of a premise which it is offered to name volumetric (three dimensional) is important for the factories. Decrease of a dust amount in premises in many respects depends on duly repair of the equipment, the rational organization of a production process, application of effective ventilation devices, regular vacuum cleaning but other preventive measures (Chertov, 2009a-c, 2006a, b).

MAIN PART

A water wash devices, Transportable Pneumatic Transporters (TPT), Mobile Pneumatic Transporters (MPT) and Centralized Vacuum Cleaning Systems (CVCS) are applied in order to increase an over-all performance of dust handling and removal of a secondary dustiness. The water wash demands a significant amount of the water, special modification of the process equipment, sludge removal system an additional waterproofing of the equipment and building structures but can be applied only in heated premises and could not be applied to adjoining territories (Chertov, 2006b, 2009d, e).

TPTs are intended mainly for cleaning greater even areas with a low dustiness and are inapplicable in conditions of high dustiness and clutter of the factory site with the equipment and service platforms at various levels. TPT deficiencies are also an atmospheric pollution of a premise by the most harmful fine dust after the filter, necessity to transport the trapped dust, low productivity and capacity of a dust pocket but so on.

Effective means of a spillage and dust removal in conditions of dry production of building and others dust-forming materials is vacuum cleaning by Centralized Vacuum Cleaning Systems (CVCS). Advantage of CVCS is its high efficiency an opportunity to integrate with any configuration of the equipment, automatic dust recycling to a production line. A large-scale implementation of CVCS in the industry is hindered by lack of manufacture of the equipment necessary for these systems.

Researchers propose basically new design of some Mobile Pneumatic Transporters (MPT) which are widely used recently and allow to carry out cleaning not only flat surfaces but also volumetric vacuum cleaning in an automatic mode have the maximum unit capacity per nozzle up to hundred times higher than conventional industrial vacuum cleaners. Classification of vacuum cleaning devices is presented in Table 1.

Implementation of the design will allow to obtain triple ecological effect: to improve essentially economic and technical parameters of installations to increase productivity in some times, to mechanize and to automate vacuum cleaning process in the future.

A modification of MPT is also the new type of Stationary Vacuum Cleaning Devices (SVCD) which have both the most simple design and minimum cost price. They are executed in the form of the container installed permanently in places with the greatest dust emission and have a possibility to move using special devices or to be installed on a mobile platform if necessary in the case of changing the configuration of the equipment or dust circumstances. Application of SVCD simplifies repair, maintenance and modernization of installations by arrangement of an exchange fleet that increases their reliability. General view of an SVCD is presented in Table 1.

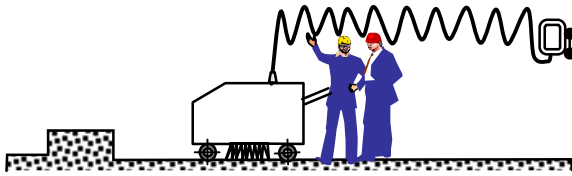
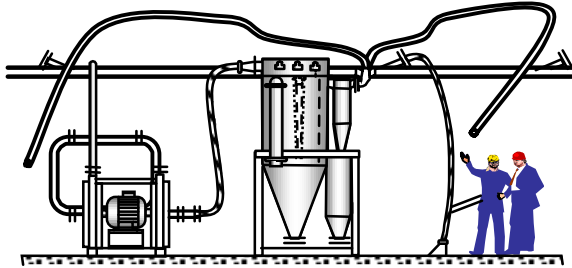
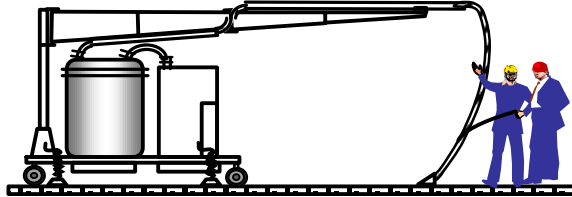

MPTs are a part of a widely used pipeline transport. Now the mobile pipeline installations having the spatial pipelines are presented only by concrete pumps.

It is proposed to add this range by a series of mobile pneumatic transporters but the new name for the entire class of these machines is represented: Mobile Pipeline Installations (MPI). General views of mobile pipeline installations are shown in Fig. 1 and 2. The general view of the recommended waste processing plant is shown in Fig. 3a. Dry plant debris collected in time from adjoining territories are valuable raw material for manufacturing of ecologically friendly new building materials of wood chipboard, wood fiber board or cement wood type, Fig. 3b.

Figure 4 shows general views and technical data of MPT with various productivity under various conditions of users.

In the conditions of many-fold increased loading on roads their maintenance and keeping in good order become the important factor. Cracks forming on roads upon their intensive usage became rapidly broken and a road-bed rapidly becomes out of service without its operative repair.

Table: Classification of dust handling installations

Productivity per V nozzle (t/h)	General view of the installation	Types of dust collecting installations	A cleaning kind
1		Active (AIC)	Manual flat without adjoining territories
1		Centralised (CIC)	
10*		Stationary (SIC)	
100*		Mobile (MIC)	Automatic volume with adjoining territories

*Designed by researchers

In the city of Belgorod, the planned overloaded place is Shchorsa street, a single route for passenger conveyances between significant by their population the central and southern parts of the city. A machine for opening cracks and their simultaneous filling by the collected and modified composition made from the road bed material can be executed on the basis of the installation presented in Fig. 5. Opening and filling of cracks can be carried out in a semi-automatic or automatic mode in a night time at decreasing of traffic volume and a minimum quantity of the operating personnel and without damage to traffic.

The transport problem is essentially escalated with increase in a fleet of motor vehicles and the system approach is necessary for its solving in view of all factors. So, it is necessary to consider errors in

designing and organization of traffic in a large megacity of Moscow when upon the invested significant means, the expensive highway network and huge quantity of valuable cars are idle because of traffic jams not carrying out their function.

Under conventional mechanical cleaning of territories, a dust removal from place to place is carried out and amount of a dust in the territory and in an atmosphere does not decrease but increases. So, in the course of snow removal from roads, some machines moving in parallel and not cleaning but pushing a snow bulge in front of them are necessary. The installation presented in Fig. 5 and executed with turbine drive allows waste-heat energy to use for melting the collected ice layer from roads with decrease of its volume in dozens times and its further salvaging

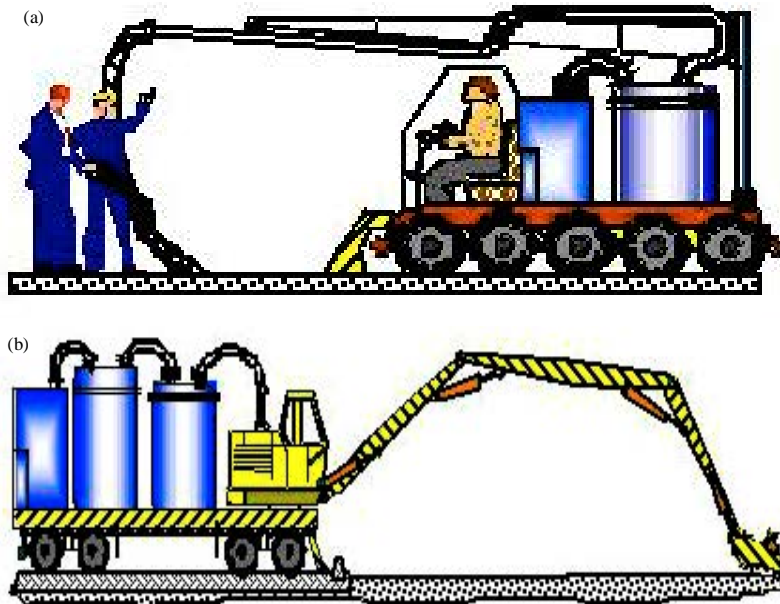


Fig. 1: Mobile Pneumotransport Installations (MPI); a) road and territories productivity 40 time (h) and b) premises productivity 10 time (h)

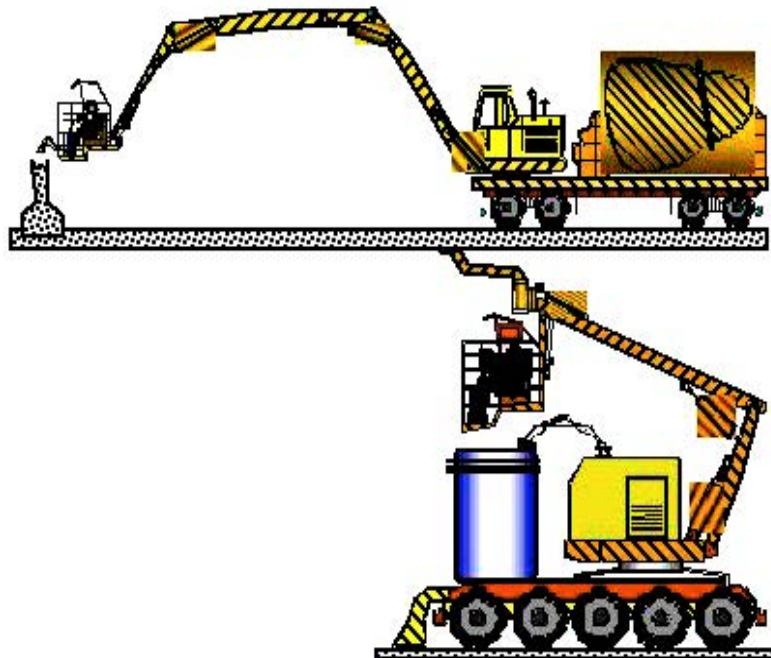


Fig. 2: Cars for repair of roads and constructions, roads and territories productivity till 50 time (h)

into the sewerage. Application of MPT for cleaning roads allows clearing of a road bed from ice build-up to carry out and to refuse application of artificial pollution of roads by salt and other components which are inefficient and are the

ecologically dangerous pollutant for land and subsoil water which are sources of a human food chain.

General view of high capacity MPT and the inventions obtained upon participation of researchers in the given direction are presented in Fig. 5. Machine

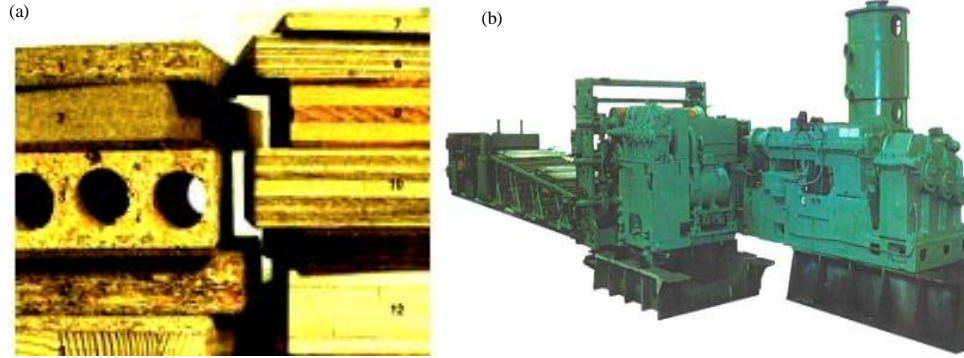


Fig. 3: Amalotonnazhnaja line of manufacture of sheet materials from a waste productivity to 1 time (h); a) samples of building materials from a waste and b) for premises productivity till 10 time (h)

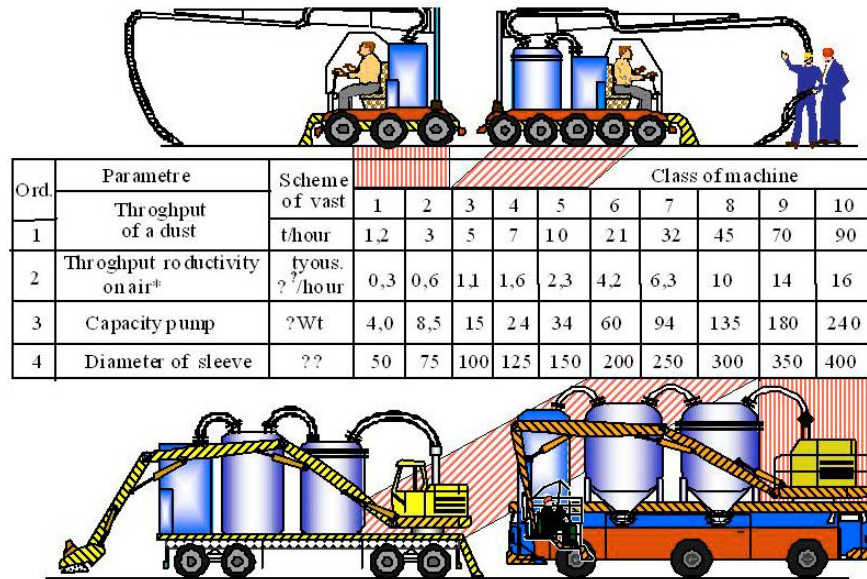


Fig. 4: Cars of cleaning of the enterprises and territories (MIC-*)

compartment of high capacity MPT is shown in Fig. 6. New economic and constructive prospects open in the case of application in the high capacity MPT of a gas-turbine plant complete with a pneumatic drive in the capacity of the blowing machine. Application of air makes the drive safer, in some times re-duces its specific consumption of materials and the cost price, essentially simplifies its design. Thus necessity for the repeated transformation of energy causing superfluous losses disappears as it is not required to turn energy of gas in electric power and then in mechanical energy. Thus necessity in expensive generator, frequency con-verter and the high-speed reduction gearbox disappears, expenses on which can make in total >60% of GTU cost. General view of GTU for the high capacity MPT is presented in Fig. 7.

Active magnetic bearings are applied in modern designs of domestic and foreign gas turbines of low and medium power (Chertov, 2009e; Komarov, 1994; Schweitzer *et al.*, 1994; Carrere *et al.*, 1994; Zhuravlyov, 2000; Lin, 1993).

Application of magnetic bearings allows automatic balancing of a rotor when running to perform, optimally to set practically any rpm value which upper limit is restricted to mechanical strength of materials of a rotor that is characteristic for low power turbines. The basic advantages of magnetic bearings (Nonami and Ito, 1994; Schob and Bichsel, 1994; Shpak, 1995; Truston, 1991; Voronkov and Denisov, 1994; Williams *et al.*, 1994) are: high rotational speed of a rotor, high bearing ability, rigidity; accuracy of rotor axis positioning, operational reliability; large running

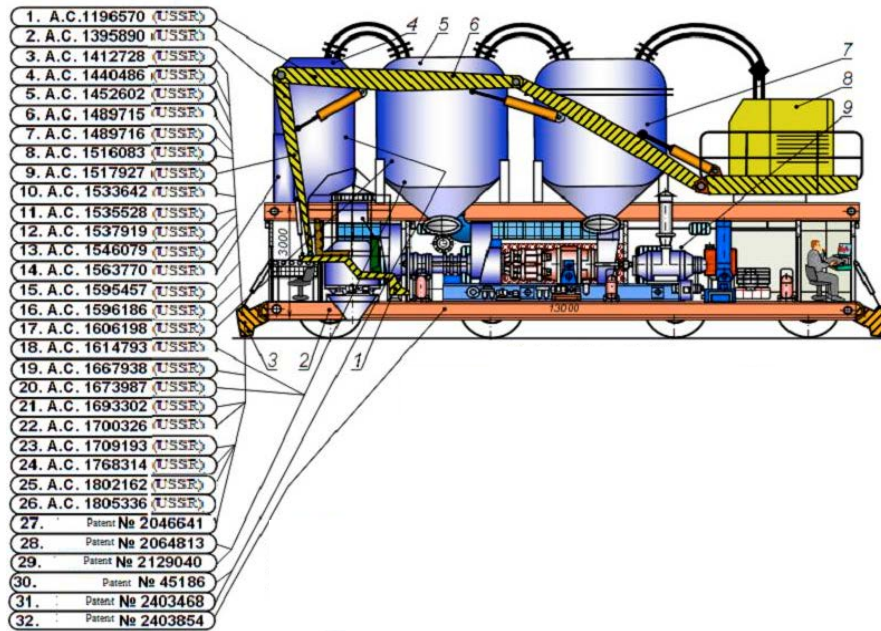


Fig. 5: General view MIC of the big productivity; 1: nozzles of the manipulator; 2: platform the mobile; 3: basic of nozzles of the big productivity; 4: block of the vacuum pump; 5: block of thin clearing of air; 6: manipulator; 7: block of rough clearing of air; 8: engine room of the manipulator; 9: engine room installation. Technical characteristics; (productivity time (h) = 120); nominal load-carrying capacity (kg) = 70000; weight of the equipped platform (kg) = 50000; the maximum speed (km/h) = 80; base (mm) = 6000; capacity of the engine (kWt) = 680; overall dimensions (mm) = 13000×4000×5495

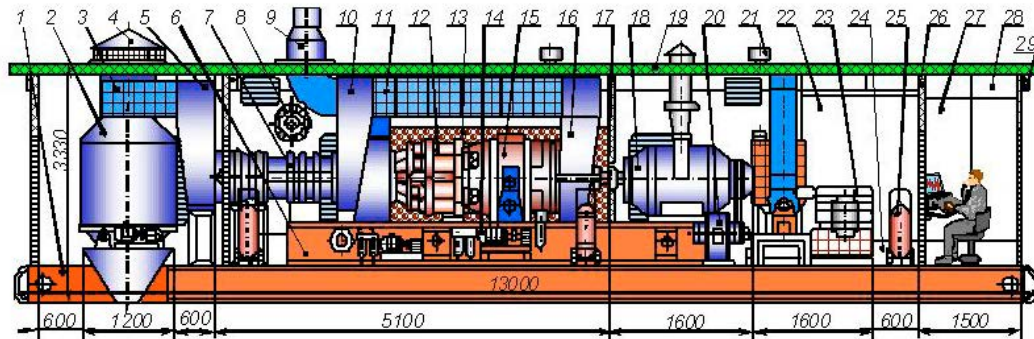


Fig. 6: Engine room MPI of the big productivity; 1: frame the general; 2: filter the entrance; 3: heat exchanger of transmission; 4: air inlet; 5: snail entrance; 6: fram CTY with built in by greasing and fuel tanks; 7: compressor; 8: fan; 9: pipe an exhaust; 10: snail of a heater of air; 11: regenator; 12: cahmber of combustion; 13: thermal protection; 14: lubricant station; 15: turbine; 16: snail exhaust; 17: Myφpa; 18: generator; 19: roof a demountable; 20: starting drive; 21: пeфлeктop; 22: tiristors the converter; 23: auxiliary diesel engine; 24: emergency accumulator; 25: fire extinguisher; 26: fireproof partition; 27: case of management; 28: conditioner; 29: chamber of visual supervision. Technical characteristics; capacity of the power turbine on a shaft MBT = 1.0; effective efficiency = 0.218; gas temperature in front of turbine (°C) = 921; gas temperature on an exhaust (°C) = 349; degree of increase of pressure = 6.0; air expense through the compressor (kg with) = 12.5; the specific expense of fuel gas; in thermal units of (VT/KWh) = 15653; frequency of rotation of the turbine (rpm) = 12000; weight of installation (T) = 15.0; technical resource газогенератора (h) = 40000; dimension transport (mm) = 13000×3300×3300

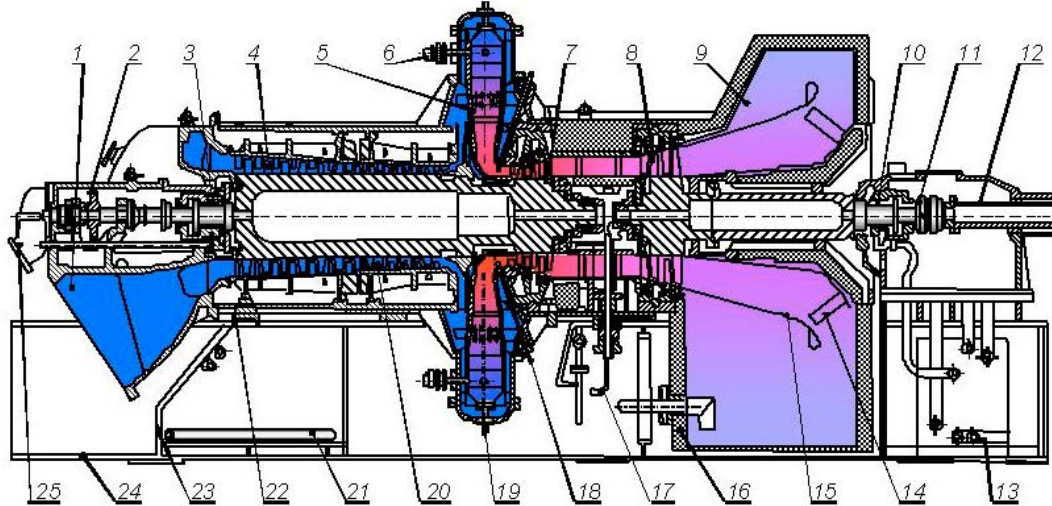


Fig. 7: The general view of GTI MCI of the big productivity; 1: entrance branch pipes; 2: drive of the pump of graesing of the compressor; 3: bearing of the compressor; 4: working shovel of the compressor; 5: chamber of combustion; 6: fuse; 7: turbine of a high pressure; 8: Turbine of Low Pressure (TLP); 9: snail exhaust; 10: bearing TLP; 11: drive of greasing of the pump of the turbine; 12: target shaft; 13: system of cooling of greasing of hte turbine; 14: directing shovel of a snail; 15: partiton of a snail; 16: thermal protection; 17: converter of temperature of the bearing of the turbine; 18: converter of temperature of the chamber of combustion; 19: atomizer; 20: directing shovel of the compressor; 21: system of cooling greasing of the compressor; 22: support of the compressor; 23: tank of graesing of the compressor; 24: frame; 25: branch pipe of greasing

clearance; low friction losses and power consumption, small overall dimensions and weight (Williams *et al.*, 1994; Zhuravlyov, 1998, 2000; Andrejev, 1994; Biswas and Ishizuka, 1995; Childs and Noronha, 1997).

In order to decrease in power inputs, increase safety in operation and convenience of industrial vacuum cleaners maintenance application of effective automation is necessary. As distribution of a dust on the cleaned square is random in character, therefore in the case of dust absence the rpm and power inputs of the blowing machine should be minimal and upon increase in a dust amount rpm of the blowing machine also should increase. The power of the blowing machine defining main power inputs of MPT has cubic dependence on a rpm value.

Automation will allow regulating of the blowing machine drive to provide depending on dust loading that will allow to reduce power inputs up to 2 times. The maximum effect is provided by the integrated automation allowing regulating, diagnostic of units and systems as a whole to perform, to predict failures to carry out continuous multilevel training of operators with simulation of failures in a training mode and in real conditions. Qualification of the personnel has crucial importance for reliable and safe maintenance of sophisticated engineering.

RESULTS

Now there is no serial production of MPT in Russia. Implementation of proposals on serial manufacturing of mobile pneumatic transporters is actual for the entire industry, it allows to obtain multiple social, ecological and economic benefit: to obtain effective mechanized and ecologically friendly new type of the volumetric cleaning providing utilizing of a dust and accident prevention to remove dangerous land and ground water contaminant, salt from the road cleaning process to reduce amount of waste by their useful secondary use and accordingly amounts of a commercial timber harvested (for urban territories) to solve a vacuum cleaning problem in the intellectual way provides busyness for science and manufacture to improve essentially industrial standards, the inhabitancy condition and job conditions of inhabitants of a region is improved to mechanize and to automate in the future vacuum cleaning and road repair process, the profit to the region from sale of new machinery to the third parties increases even in conditions of an economic slack.

CONCLUSION

The proposed devices for cleaning premises and adjoining territories allow not only to mechanize manual cleaning but also to apply technology of recycling of secondary waste that will allow additional profit to obtain on their use. When cleaning adjoining territories and the streets, the dry plant debris collected in time are valuable raw material for manufacturing ecologically friendly materials of wood chipboards or fiber boards, or cement wood type.

Effective energy and resource saving in the developed mobile pneumatic transporters is carried out due to increase in productivity, high-grade salvaging of a cleaned material which prevent a dust to set, slump, stick together, lose its properties and due to economy of labor and material resources on cleaning process. The proposed technology and the equipment of waste processing for adjoining territories reduces amount of waste by their useful secondary use. Reduction of material transportation distance provides the minimal air resistance and power inputs of installations. Duly effective dust handling of the volatile dust also provides multi-fold decrease of power inputs in comparison with cleaning of set and packed dust.

ACKNOWLEDGEMENTS

Researchers expresses deep and sincere acknowledgement to the member of BSTU named after V.G. Shukhov professor V.A. Minko who has defined a direction of researches and also to members of the department "Heat and gas supply and ventilation" and "Applied-research laboratory of ventilation and air purification" for the help and valuable advices in manufacturing and installation of the bench and conducting of experimental researches.

REFERENCES

- Carrere, F., S. Font and G. Due, 1994. H-control design of flexible rotor magnetic bearing system. Proceedings of the 4th International Symposium on Magnetic Bearings, August 24-26, 1994, Zurich, pp: 65-70.
- Andrejev, V.A., 1994. Interaction of permanent cylindrical magnets with axial magnetization. Proceedings of the 4th International Symposium on Magnetic Bearings, August 1994, Zurich, Switzerland, pp: 165-170.
- Biswas, D. and M. Ishizuka, 1995. An improved low re number k-e model to predict laminar-turbulent transition (IGTC-111). Proceedings of the Yokohama International Gas Turbine Congress and Exhibition, October 22-27, 1995, Yokohama, Japan, pp: 57-64.
- Chertov, V.G., 2006a. Great opportunities of small-scale power generation. Bulletin of BSTU No. 13, pp: 231-238.
- Chertov, V.G., 2006b. Technological breakthrough of small-scale power generation. Bulletin of BSTU No. 13, pp: 239-249.
- Chertov, V.G., 2009a. Energy and resource saving in mobile pneumatic transporters in construction, manufacture, repair, maintenance. Bulletin of BSTU No. 1, pp: 82-86.
- Chertov, V.G., 2009b. New technology, engineering, ecology of cleaning, maintenance and repair of roads, territories, factories. Bulletin of BSTU No. 2, pp: 72-77.
- Chertov, V.G., 2009c. Improvement of productivity of mobile pneumatic transporters in construction, manufacture, repair, maintenance. Bulletin of BSTU No. 2, pp: 107-112.
- Chertov, V.G., 2009d. [The automatic belt tensioning device]. Patent No. 20403468 of the Russian Federation.
- Chertov, V.G., 2009e. [Combine vacuum cleaner for repair and construction purposes]. Patent No. 2064813 of the Russian Federation.
- Childs, P.R.N. and M.B. Noronha, 1997. The impact of machining techniques on centrifugal compressor impeller performance. The American Society of Mechanical Engineers Paper 97-GT-456.
- Komarov, V.N., 1994. Regulating the magnetic gyroscope's motion. Proceedings of the 4th International Symposium on Magnetic Bearings, August 1994, Zurich, Switzerland, pp: 19-22.
- Lin, C.F., 1993. Advanced Control Systems Design. Prentice Hall, USA., ISBN-13: 978-0130063052, Pages: 640.
- Nonami, K. and T.U. Ito, 1994. Synthesis of flexible rotor magnetic bearing systems. Proceedings of the 4th International Symposium on Magnetic Bearings, August 24-26, 1994, Zurich, Switzerland, pp: 73-78.
- Schob, R. and J. Bichsel, 1994. Vector control of the bearingless motor. Proceedings of the 4th International Symposium on Magnetic Bearings, August 24-26, 1994, Zurich, Switzerland, pp: 327-332.
- Schweitzer, G., H. Bleuler and A. Traxler, 1994. Active Magnetic Bearings. VDF Hochschulverlag AG, Zurich, Switzerland, Pages: 244.

- Shpak, V.N., 1995. Gas distribution station with power plant. Patent No. 5425230 A, IPC., USA. <http://www.google.com/patents/US5425230>.
- Truston, A., 1991. Recovering energy in gas pressure reduction. *Control and Instrument*, Volume 23, No. 5.
- Voronkov, V.S. and G.G. Denisov, 1994. The effect of body's autorotation in activemagnetic bearings. *Proceedings of the 4th International Symposium on Magnetic Bearings*, August 24-26, 1994, Zurich, pp: 339-342.
- Williams, R.D., P.M. Wayner and J.A. Ebert, 1994. Reliable, high-speed digital control for magnetic bearings. *Proceedings of the 4th International Symposium on Magnetic Bearings*, August 1994, Zurich, Switzerland, pp: 1-6.
- Zhuravlyov, Y.N., 1998. Linear-quadratic optimal control of active magnetic bearings for high speed rotor. *Proceedings of the 6th International Symposium on Magnetic Bearings*, August 5-7, 1998, Cambridge, MA., USA., pp: 587-596.
- Zhuravlyov, Y.N., 2000. On LQ-control of magnetic bearing. *IEEE Trans. Control Syst. Technol.*, 8: 344-350.