MONITORING AND PREDICTIVE ANALYTICS OF TECHNOLOGICAL EQUIPMENT ON THE BASED OF INDUSTRIAL INTERNET OF THINGS

S.L. Dobrynin, V.L. Burkovskiy

Abstract: we carried out a review of technologies within the framework of the concept of the fourth industrial revolution; we considered examples of the implementation of new models of process control based on the industrial Internet of things. We described the technical structure of the main subsystems of the monitoring and control system to increase awareness of the actual state of production resources in particular machine tools and additive equipment in real time. The architecture of the proposed system consists of a data acquisition device (DAD) that implements fast and efficient data collection from machines and a gateway that transfers the liquid part of information to the cloud storage for further processing and analysis. We carried out the data transmission at two levels, locally in the workshop, using a wireless sensor network (WSN) based on ZigBee protocol stack from the data acquisition device to the gateways and from the gateways to the cloud using Internet protocols. An algorithm was developed for initializing communication protocols between a data acquisition device and a gateway, as well as an algorithm for detecting network malfunctions. Calculating the actual machining time of machine subsystems allows us to more efficiently scheduling preventive maintenance rather than performing maintenance tasks at fixed intervals without considering equipment usage

Key words: distributed control systems, industrial Internet of things, monitoring, predictive analytics, wireless networks, microcontroller

SEARCH FOR KINETIC CONSTANTS IN MODELING THE PROCESSES OF POLYCENTERS NON-BREAK POLYMERIZATION OF DIENES

E.R. Gizzatova, S.L. Podvalny, S.I. Spivak

Abstract: we present a technique for solving the inverse kinetic problem of finding the rate constants of the polymerization process for kinetically inhomogeneous catalytic systems of the Ziegler-Natta. We consider inhomogeneity of catalysts as the existence of several types of active centers, parallel to each other leading processes of growth and termination of polymer chains. The kinetic scheme of the process excludes material breaking of the chain, which entails the transfer of activity from one center to another. The observed condition for the constancy of the concentration of active centers is the material balance equation for the polymerization system. It is observed in a mathematical model that describes the process in the form of an autonomous system containing an infinite number of ordinary differential equations of the first order in monomer, transformed by the method of moments to a finite form. We note that the statistical moments present in the system of differential equations are the initial moments of the molecular weight distribution. On their basis, we give analytical dependences for the desired average molecular weights of the resulting polymers on each type of active centers and the entire polymer sample. We carried out a computational experiment for the process of isoprene polymerization on a 4-center vanadium-containing catalytic system in order to obtain a solution to the inverse kinetic problem. We found a cumulative set of rate constants for elementary stages of the process. We show graphical illustrations of comparisons of calculations and experiments on the values of the average molecular weights for each type of active site and the entire polymer as a whole

Key words: polymerization, mathematical model, kinetical inhomogeneity, method of moments, Ziegler-Natta catalysts

TEMPERATURE CONTROL FOR 3D ADDITIVE PROCESSES BASED ON THE VARIABLE ELECTRICAL PARAMETERS OF THE HEATED NOZZLE

A.A. Oskolkov, I.I. Bezukladnikov, D.N. Trushnikov

Abstract: the article is devoted to FDM 3D manufacturing. Most of the FDM 3D printers on the market use an indirect resistive nozzle heating method and standard thermoelectric temperature control methods, which leads to a high thermal inertia of the heating system and the inability to provide sufficient speed and accuracy of temperature control. The inability to control the temperature of the nozzle during the printing process leads to inconsistent of layer-to-layer adhesion quality, and on the larger scale – to heterogeneity of material inside the whole printed object. To mitigate and/or resolve these problems, we proposed an induction heating system of the nozzle with a minimum thermal mass. At the same time, we proposed a resonant (eddy current) method to control the temperature of the nozzle. To implement this method of temperature control, we required to determine the dependence of the electrical parameters of the nozzle material on temperature. To determine this dependence, we created a testbed system, consisting of the ultra-low weight induction heated nozzle, a power source, a high-frequency oscillator, an inductor coil, a measuring coil, a unit for recording and processing a measuring signal. We present the means for detection and amplification of the measuring signal. We show the steps for processing of the acquired signal to obtain final temperature values. We propose approaches for controlling the nozzle temperature based on the obtained dependences. We provide the experimental data for all the stages of conducted research

Key words: FFF, FDM, 3D-printing, induction heating, eddy-current testing, phase shift, resonance, measuring coil

NEURAL NETWORK METHOD OF ADAPTING THE PARAMETERS OF THE INFORMATION SYSTEMS INTERFACE

A.D. Obukhov, M.N. Krasnyanskiy, M.S. Nikolyukin

Abstract: here we consider the problem of choosing the optimal parameters of the interface in information systems with the aim of personalizing it for the preferences of the user and the capabilities of his equipment. Currently, algorithmic support and statistical processing of user preferences are used to solve it, which does not provide sufficient flexibility and accuracy. Therefore, in this work, we propose the application of the developed method for adapting interface parameters based on the analysis and processing of user information using neural networks. The scientific novelty of the method is to automate the collection, analysis of data and interface settings through the use and integration of neural networks in the information system. We consider the practical implementation of the proposed method in Python. An expert assessment of the adaptability of the interface of the test information system after the implementation of the developed method showed its availability and efficiency. The developed method shows the best accuracy and low complexity of software implementation relative to the classical algorithmic approach. The results obtained can be used to automate the selection of interface components for various information systems. Further research consists in the development and integration of the developed method within the framework of the information systems adaptation framework

Key words: interface adaptation, personalization, machine learning, artificial neural networks, electronic document management

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OBTAINING AND AUTOMATIC DATA PROCESSING FROM ELECTROMAGNETIC SCANNING OF ROAD PAVEMENTS WITH SUBSEQUENT VISUALIZATION

V.F. Barabanov, A.O. Kalashnikov, A.M. Nuzhnyy

Abstract: the article discusses the issues of obtaining and automatic data processing from electromagnetic scanning of road pavements with subsequent visualization. Georadar "OKO" was used as engineering equipment for georadar survey. As a result of collecting and analyzing the electromagnetic scanning data, destructive sections of the road surface were identified. Based on the study of processing methods, interpretation and visualization of GPR scanning data, we decided that it is necessary to develop specialized tools for automating the analysis of such data when scanning road structures. The analysis of the methods and means used for processing the radarogram data was carried out, the structure of the file for storing the data of electromagnetic scanning and the means of processing and converting data available in the GeoScan32 program were considered. A sequence of actions was proposed to implement the procedure for searching for traces characterized by an unacceptable level of deviation of signal characteristics from the average values

Key words: electromagnetic scanning, road pavements, automated data processing, visualization, diagnosis

METHODOLOGY TO DETERMINE GUARANTEED TRAFFIC DELIVERY RATE IN CORPORATE WLAN

L.I. Abrosimov, M.A. Rudenkova, H. Khayou

Abstract: the aim of the work is to improve the quality of service for multimedia traffic in corporate wireless local area networks at the expense of means that ensure the coordination of the intensity of multimedia traffic and the performance of the wireless local area network. To achieve this goal, the dependencies of the mathematical expectation of the packet service time are established using discrete-event modeling for the given structures of the wireless local area network. An analytical model of a wireless local area network was developed; and mathematical relationships were obtained for calculating the guaranteed intensity of multimedia traffic. Using discrete-event modeling and the obtained mathematical relationships, the dependences of the guaranteed intensity of multimedia traffic for the given parameters of the structure of the wireless local area network, the parameters of the wireless communication channel and channel access control protocols were established

Key words: WLAN, media access control protocols, performance evaluation, QoS

APPLICATION OF THE EXPERIMENTAL FACTOR PLANNING METHOD FOR REALIZING REACTIVE POWER COMPENSATION SETTING SYSTEM SETTINGS

V.V. Babenko, I.A. Khaychenko, Yu.V. Nefedov

Abstract: this article discusses how to coordinate the settings of local automatic control systems of reactive power compensation plants of a city power supply system in order to achieve the optimal mode of operation of the entire system according to the criterion of minimum loss of electric energy. Based on the analysis of the database of the automated system of commercial accounting of electricity of Municipal Unitary Enterprise "Voronezh City Electric Network" for five years, it was determined that the value of tg φ (reactive power factor) does not correspond to the values normalized by GOST and requires significant adjustment to reduce electrical energy losses. The optimal control mode of the considered power supply system at the point of connection and the value of reactive power of the required compensation plants is possible with the correct ratio of the selected criteria of local and system optimization of the hydroelectric power station operation modes. It was determined that in order to obtain an economically justified effect from optimizing the mode of operation of the hydroelectric power station according to the criterion of tg φ reaching a maximum of 0.35, it is necessary to install RM compensation devices at least 50% -70% of all RP energy-intensive consumers. In addition, the utility of using the regression principle of automatic control c based on the factor planning method of the experiment in this reactive power compensation method is shown. At sufficiently low costs for collection, processing of statistical material and optimization calculations, it is possible to obtain a series of regression equations, on which the calculated part of the settings of the control system of reactive power compensation plants, which should be installed in the main nodes of the Voronezh City Electric Network, is based. It was found that the parameters generated on the basis of regression equations for the control system can be successfully integrated into modern digital microprocessor regulators of reactive power compensation plants of complex power supply systems

Key words: reduction of electricity losses, method of factor planning of the experiment, control system, regulation of reactive power

SYNTHESIS OF HIGH-PRECISION MODAL CONTROL SYSTEMS

E.M. Vasil'ev, E.A. Serdechnaya, A.V. Tavolzhanskiy

Abstract: the article solves problem of synthesis of modal control systems with high astatism order. It shows that the traditional approach to solving this problem, which consists in consistent and independent provision of requirements for the nature of the transient process and for the indicators of its accuracy, faces the need to carry out synthesis under incomplete conditions. Ignoring this circumstance leads to the search for compromise solutions and unwanted deviations from technical requirements. When designing high-precision systems, such deviations become unacceptable. To overcome this difficulty, a transition to interval methods for formulating and solving modal synthesis problems is proposed. The theoretical possibility of such a transition is based on the excessive variety of possible placement of the eigenvalues of the characteristic matrix of the system in its spectrum. An example of the implementation of this possibility is considered for a system with a modal controller, in the structure of which additional output feedback is introduced. For this structure, a system of restrictions imposed on the spectrum of the specified matrix is formed, which determine the simultaneous fulfillment of the requirements for the monotonicity of the transient process, the regulation time and the accuracy of working out harmonic influences. It is noted that the non-uniqueness of the obtained solution creates the preconditions for a multi-alternative approach to system design. The possibilities of interval analysis are also demonstrated by the example of the synthesis of a system, into the structure of which a differentiating observer of the setting action is introduced. It is shown that as a result of such an analysis, the boundary conditions of the synthesis problem can be obtained, which guarantee the obtaining of the required quality indicators of the system. For all the examples considered in the work, the results of simulation are presented, which confirm the efficiency of the proposed synthesis method

Key words: modal control, servo systems, system oscillativity, control accuracy

DIAGONAL COMMUTATION MODEL FOR PARALLEL SORTING OF DATA ARRAYS

E.A. Titenko, E.V. Taldykin, V.L. Burkovskiy

Abstract: the object of the research is parallel sorting algorithms using the basic operation "compare-swap". The aim of the research is to reduce the steps of the algorithm for sorting the data array by reducing the number of intermediate permutations of the array elements. The goal is achieved by developing an original switching circuit of the array elements. This circuit forms the basis of the model for diagonal commutation of pairs of array elements. The array is 2D, which allows one to pair elements from its different halves. Due to the 2D representation of the array, the formed pairs of elements allow reducing the number of permutations. The novelty of the diagonal commutation model is that the “compare-exchange” operations are performed in parallel on non-conflicting pairs of elements taken from different halves of the array. This property of the model allows one to "jump" the element to the desired position in the array. The diagonal commutation model is combined with the well-known odd-even sorting model. The combination resulted in a parallel sorting algorithm with a hybrid switching scheme. This scheme implements the proposed model at even steps, and the even-odd sorting model at odd steps. Modeling algorithms for odd-even sorting and hybrid sorting showed the advantage of the developed model. Extension of even-odd sorting by the diagonal commutation model allows to reduce the average number of sorting steps by 6-10%. In addition to odd-even sorting, the diagonal commutation model is applicable for parallel sorting algorithms using the basic comparison-exchange operation - Butcher, Shell, merge sorting

Key words: a pare of elements, exchange, 2d array, inversion, hybrid scheme

RESEARCH OF THE IMPACT DEVICE MODEL OF THE ROD TYPE BY DIFFERENCE METHOD

A.M. Slidenko, V.M. Slidenko

Abstract: the article gives the analysis of mechanical vibrations of the impact device elements using the model of the rod type. The hammer and the tool are connected by elastic and dissipative elements that simulate their interaction. The interaction of the tool with the processing medium is simulated in a similar way. An initial boundary-value problem is formulated for a system of two wave equations taking into account the variable cross sections of the rods. Cross-sectional areas are determined by parametric formulas maintaining the volume of the rods. Parametric formulas allow one to obtain various dependence types of the cross-sectional area of the rod on its length. The initial and boundary conditions reflect the physical phenomenon of the tool interaction with the processing medium, and also describe the contact interactions of the hammer with the tool. The impacting of the hammer and the tool through an element of high rigidity is considered as a model problem. To control the limiting values, the solution of the model problem by the Fourier method is used. The initial-boundary-value problem is investigated by the difference method. A comparison of solutions obtained for the two-layer and three-layer difference schemes is given. Such schemes are realized in a common computer program in the Mathcad. It is shown that the two-layer scheme has the best properties in relation to stability while calculating the distribution of normal voltage along the length of the rod

Key words: impact device, pulsed loads, difference methods, the Fourier method, oscillations, boundary conditions, variable section

STUDY OF THE RADAR CROSS SECTION OF SIMPLE BODIES

S.A. Antipov, A.V. Volod'ko, E.A. Ishchenko, V.N. Kostrova, K.A. Razinkin, S.M. Fyedorov

Abstract: the article considers the figures of the monostatic effective scattering area for simple geometric bodies. For a simple metal plate, a theoretical calculation of the RCS value was carried out, as well as modeling using the Vayland method, the results of which proved the accuracy and efficiency of modeling in specialized software. To determine the effective area of dispersion of the ball, three cases were considered when the dimensions of the ball exceed the wavelength; the dimensions are small, and a conductor is selected as the material of manufacture; while maintaining the dimensions, the material of manufacture is replaced by glass. Based on the results obtained, conclusions are drawn about the importance of comparing the wavelength with the geometric dimensions of the body, as well as the positive effect of dielectric materials on the value of the RCS. In the study of the cylinder, two cases were considered that can arise when studying the RCS of a cylindrical object, namely, when the wave falls on the side surface of the body and on the upper face. It was shown that the worst values of the effective scattering area are observed when a plane wave is incident on the upper, ideally flat, faces of the cylinder. The results are presented in the form of monostatic RCS patterns, maximum values of the effective scattering area

Key words: radar cross section, monostatic RCS

APPROACH TO DETERMINING THE VALUE OF THE DYNAMIC RANGE OF AN OPTICAL RECEIVER THAT IMPLEMENTS DIRECT AND HETERODYNE DETECTION METHODS

A.Yu. Koziratskiy, A.I. Grevtsev, R.I. Burov

Abstract: here we consider issues related to determining the possibilities of using photodetectors in various detection schemes when receiving signals with varying amplitudes. We determined the features of the influence of practical detection schemes on the value of the dynamic range of the photodetector and the potentially achievable sensitivity. We developed an approach that allows for a comparative assessment of changes in the dynamic range depending on the implemented optical receiver scheme. We show that in contrast to the direct detection scheme, where the value of the dynamic range is directly determined by the properties of the photodetector itself, in the case of heterodyne detection, the level of the reference oscillation plays a decisive role in determining this value. Analysis of the obtained results shows that adaptive control of the reference oscillation value when switching to the heterodyne detection scheme with the preservation of the photodetector type allows us not only to significantly expand the range of changes in the amplitude of the received signals and maximize the dynamic range but also to realize a potentially achievable sensitivity, the value of which is determined by the noise properties of the photodetector itself

Key words: photodetector, the dynamic range, methods of reception of optical signals, sensitivity

METHOD FOR ESTIMATING DATA TRANSMISSION CHANNEL PARAMETERS, IMPLEMENTED BY OFDM-MIMO TECHNOLOGY

A.V. Bashkirov, O.Yu. Makarov, A.S. Demikhova, M.V. Dolzhenko, O.V. Il'ina

Abstract: in this paper, a method for combining OFDM with STBC is proposed. Codes with reduced decoding complexity and high bandwidth efficiency are proposed. Most of the works on this topic suggest a combination of STBC-OFDM codes for situations where the channel parameters are known in advance and are embedded in the receiver. With the introduction of new channel estimation methods, real-world conditions are modeled and analyzed to propose methods suitable for efficient operation of future wireless technologies such as 5G. The article explores a channel estimation technique for STBC-OFDM systems using different numbers of transmit and receive antennas, different modulation orders for pilot and data subcarriers, different numbers of pilot subcarriers, and different channel conditions. Simulation results for 2 and 4 transmitting antennas and 1 and 2 receiving antennas are presented, as well as a comparison of the channel estimation algorithm with the ideal case, when it is assumed that the channel parameters are known in the receiver. In addition, the effect of group decoding was investigated by analyzing the decoding time of one STBC-OFDM block and the time saved on decoding the entire group of data blocks. It can be seen from the simulation results that the proposed method has the advantages of increasing the computational efficiency of the system by reducing the computation time while increasing the number of pilot subcarriers. As part of the research carried out in the article, a new joint channel assessment and recovery of damaged data were proposed. The method is distinguished by its energy efficiency and simplicity of calculations due to the fact that the method does not require inversion of the matrix at the receiver, unlike other methods proposed in the literature

Key words: codes with reduced decoding complexity, channel estimation technique for STBC-OFDM systems using different numbers of transmitting and receiving antennas, channel estimation technique using a group decoding technique for STBC-OFDM, method for increasing the computational efficiency of a data transmission system by reducing computation time while increasing the number of pilot subcarriers

STUDY OF THE INFLUENCE OF DIELECTRIC PERMEABILITY OF THE MATERIAL ON THE RADAR COSS SECTION

S.A. Antipov, A.V. Volod'ko, E. A. Ishchenko, V.N. Kostrova, K.A. Razinkin, M.A. Sivash

Abstract: in the article, a sphere of dielectric material is considered as an object of study of the effective scattering surface, in which the dielectric constant of the medium can be changed during the simulation. A wide range of frequencies was chosen for modeling so that the influence of the ratio of the wavelength to the radius of the sphere, as well as the shift of the maximum RCS value of the object after changing the dielectric constant of the medium, could be tracked. According to the results, it was proved that it is impossible to provide a low RCS level in a very wide frequency band, since if the wavelength becomes close to the body size, a sharp surge in the RCS level occurs. It was also proved during the modeling process that an increase in the dielectric constant of the medium leads to an increase in the maximum RCS of the object, as well as a shift of this peak down in frequency. According to the obtained graphs of a monostatic RCS, it can be concluded that the use of complex frequency-dependent materials allows one to achieve a significant decrease in the effective scattering area even in a situation when the object becomes geometrically large, that is, comparable to the wavelength. These complex materials are used as a stealth coating

Key words: radar cross section, monostatic RCS

EQUIVALENT DIPOLE MODEL FOR ESTIMATING THE NEAR FIELD OF RES STRUCTURES

T.S. Glotova, A.S. Ivanitsky, V.V. Glotov

Abstract: electromagnetic compatibility of integrated circuits is becoming an increasingly important aspect in the design of high-speed printed circuit boards. International standards have been established to quantitatively and qualitatively assess the performance of integrated circuits as well as noise immunity using a variety of measurement methods. To solve problems associated with predicting electromagnetic interference between integrated microcircuits and printed circuit boards, models of integrated microcircuits are needed both at the in-hardware and in-system levels. Such models can be obtained from simulations if there is sufficient information about the integrated circuit. However, in most practical cases, detailed information on integrated circuits may not be available to avionics designers. An improved model of the dipole moment is proposed for analyzing the characteristics of the coupling of the near and far electromagnetic fields from an integrated circuit, obtained on the basis of scanning the near field. An array of electric and magnetic dipole moments is presented, used to reproduce the field distributions in the scanning plane above an integrated microcircuit. The obtained dipole moments can be used as sources of radiation for an integrated circuit. The advanced dipole moment model is especially useful for solving RFI problems when it is necessary to accurately analyze noise communications in the near field

Key words: electromagnetic compatibility, near field, dipole moment

INVESTIGATION OF THE INFLUENCE OF THE METAMATERIAL PYRAMIDAL HORN INTEGRATED INTO THE CONSTRUCTION ON THE DIRECTIONAL DIAGRAM

E.A. Ishchenko, Yu.G. Pasternak, M.A. Sivash, S.M. Fedorov

Abstract: the article discusses a metamaterial that is integrated into the structure of a pyramidal horn. Switching the nodes of the metamaterial allows you to control the radiation pattern of the antenna in question. To close the nodes in the lattice of the metamaterial, pin diodes are used, which in the open state have an equivalent circuit, which is a series connection of a resistance of 2.1 Ohm and an inductance of 0.6 nH. The proposed design makes it possible to achieve control over the characteristics of the radiation pattern of the antenna in question over a wide range. Antenna control by the use of metamaterials of various designs is an advanced method of a beam control. To obtain the results, electrodynamic modeling was used in specialized software, on the basis of the results obtained, directional patterns were constructed in the operating range of the horn antenna. The article presents the results of modeling in the form of three-dimensional models of the investigated metamaterial structures, switched nodes; directional diagrams of the received antennas, on which the changes introduced by the switched lines of the metamaterial were determined. The greatest change in the patterns of radiation patterns was observed at frequencies of 13 and 14 GHz, included in the target range of the horn antenna, the main studies were carried out in the H-plane of the horn, since the vertical lines of the metamaterial were subjected to commutation

Key words: pyramidal horn antenna, steerable metamaterial, radiation pattern

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CONTROLLED GENERATORS ON SAW FILTERS AND OF SYNTHESIZED NONLINEAR INDUCTANCE

M.I. Bocharov, A.V. Volod'ko

Abstract: we investigated qualitative characteristics of the single-stage FM generators made on a single-stage amplifier according to the scheme with a common collector and a narrow-band filter on surface acoustic waves (SAW) using synthesized nonlinear inductance (SNI) as a frequency controller. We obtained the calculated ratios for base frequency deviation, level of nonlinear distortions for third and fifth harmonics and slope of modulation characteristic, which is practically constant both during generator tuning by frequency and change of level of modulating signal. As a result, during modulation, the level of parasitic amplitude modulation does not increase, which provides a high purity of the spectrum of the generated FM radio signal. We carried out an analysis of the obtained technical characteristics, which showed that the FM signal generator under the control of the SNI voltage practically does not create a central frequency shift, which leads to a decrease in frequency stability during modulation. We found that when the main frequency deviates about 90 kHz, the non-linear distortion coefficient for the third and fifth harmonics is less than 1% and 0.1%, respectively. This is comparable to the level of non-linear distortion of the FM generator, in which varactors with a sharp law of changing the voltfarade characteristic are used as a frequency controller, which provides the minimum possible non-linear distortion when modulating generators using varactors and the almost complete absence of these distortions on even harmonics

Key words: SAW filter, synthesized nonlinear inductance, frequency deviation, odd harmonics, nonlinear distortions, slope of modulation characteristic

IMPROVING THE QUALITY OF THE PAINT COATING PROCESS ON CARS

V.Yu. Antsev, N.A. Vitchuk, P.V. Vitchuk, E.A. Petrenko

Abstract: one of the most important controlled parameters in assessing the quality of the paint coating of a car is the number of grains on the body coating. To reduce the amount of grains, it is necessary to analyze their type and origin. This analysis is carried out in three layers: in the cataphoretic layer, soil and in the finished paint coating. The article presents the results of the analysis of the number and type of grains in all three layers of paint coating of cars at one of the enterprises of the Kaluga automobile cluster. Based on the results of the analysis, it was concluded that it was advisable to reduce dirt in the cataforesis layer. This will affect the quality of the other two paint layers. Reduction of strength in cataforesis layer is possible on the basis of modernization of line for preparation of a car surface for painting. To upgrade the line for preparing the surface of a car for painting, it is proposed to change the existing system for filtering the working solution, replacing the existing tape filter with a system with bag filters. It is also proposed to equip the line with an intermediate tank with a filtration system to restore the working solution. The implementation of the proposed measures will reduce the cost of grinding materials; increase the performance at the inspection areas of the paint coating of a car, lower operating solution recovery costs

Key words: paint coating, dirt, cataforesis layer, surface preparation line for painting, filtration system