Технічні науки

UDC 675.026

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MIXING OF PAINT COMPONENTS IN LEATHER PRODUCTION

Summary. *Dynamic, vortex mixing of oil paint components in a sealed, classical vortex tube formed by pigment powder and spiral tangential flows of oil solvent*

Key words: *Mixing of paint components, Tannery, Dynamic vortex mixing, Sealed dynamic vortex tube, Classic vortex tube, Pigment powder, Spiral flows, Tangential flows, Oil solvent flows, Innovative intervention, Implementation of new mixing methods, Egg oil, Albumin, Examination of the paint layer under a microscope, Homogeneity of paint, Homogeneity of paint.*

Annotation. In the production of high-quality leather goods, the key indicators of the durability of the finishing coating remain the homogeneity of the pigment-oil mixture, the elasticity of the film and the chemical purity of the binder. Traditional mechanical mixing methods (rollers, ball mills, turbine dispersers) often leave pigment microagglomerates and introduce metallic impurities, which manifests itself in uneven color saturation, the risk of cracking when bending and accelerated aging of the surface. In this paper, we propose to introduce vortex (quasi-turbulent) mixing, which ensures complete dispersion of the pigment with minimal heating and no contact with metal elements. The method allows preserving natural egg oil, a binder historically used in artistic painting, and at the same time achieving a super-homogeneous paint structure, which is critically important for the premium

leather segment. Experimental tests on chrome- and vegetable-tanned hides showed a 28% increase in bending resistance, color uniformity by $\Delta E < 0.8$, and a 15% reduction in pigment consumption compared to classic rollers. Thus, vortex mixing forms the technological basis for the production of environmentally friendly, durable, and visually impeccable leather goods, increasing the competitiveness of tanneries.

Introduction

The purpose and objectives of the study:

The aim of this work is to develop and optimize innovative methods of vortex mixing of oil paint components for leather production and restoration of works of art. The main objectives of the study include:

- Development of methods for obtaining ultra-pure starting components, such as egg oil and natural preservatives;
- Determination of optimal vortex mixing parameters for obtaining homogeneous paint;
- Analysis of the possibilities of encapsulation of pigment microparticles to increase the durability of paint;
- Evaluation of the effect of new mixing methods on the quality and durability of paint.

Relevance of the study:

The issues of durability and stability of paints remain extremely relevant both in the leather industry and in the restoration of works of art. Modern methods of paint production often do not provide sufficient purity and homogeneity, which can lead to deformation of the paint layer, shrinkage and cracks. Therefore, the development of new technologies, such as vortex mixing, is of great practical importance.

Review of existing paint mixing methods:

There are currently several approaches to mixing oil paint components, including mechanical, ultrasonic and electromagnetic mixing.

Mechanical methods. Classic two- and three-roller rollers and ball mills are the basis of industrial paint production today. The resulting shear between the rollers crushes large pigment particles, but contact mechanics always produces metallic contamination, and the temperature rise during friction accelerates the oxidation of the oil. In addition, even with repeated runs through the rollers, long-tail fractions remain, which appear as "grain" and uneven gloss when using paints obtained by this production method.

Ultrasonic (cavitation) mixing. Sound frequency of 20-40 kHz creates cavitation bubbles; collapsing, they crush pigment particles to submicron size in a matter of minutes. The method hardly wears out the equipment and provides minimal heating, but the homogeneity of cavitation drops sharply at volumes > 1 l, which does not allow use on an industrial scale. Another disadvantage of this method is microjets that can damage the crystalline structure of sensitive mineral pigments and introduce excess air into the paint, which worsens the mechanical properties of the film.

Electromagnetic and magnetohydrodynamic mixing. The induction field swirls the conductive suspension flows, providing contactless energy transfer and operation in a sealed reactor. The technology is promising for clean conditions, but requires additives that increase electrical conductivity, and when scaling up, uneven heating occurs: local overheating of the oil leads to darkening and a decrease in the lightfastness of some pigments.

Comparative limitations. All three approaches share common problems: unavoidable large particles, risk of thermal-oxidative degradation of the binder, and residual impurities. These factors are critical for premium and exclusive leather products, where the acceptable range of defects is extremely small and the leather requires an impeccably smooth, stable, durable, and elastic paint layer.

Stages of formation of oil paints.

This paper proposes to consider the feasibility of an innovative transformation of the process of manufacturing highly homogeneous paints, from restoration work to leather production, in which the issues of quality and durability, especially for premium and exclusive leather products, are key and decisive.

As is known from the history of the development of technology, previously all oil paints that were used by artists were made from completely natural components, in which the yolk of chicken eggs was used as oil.

Even today, separating the yolk (egg oil) from the white (albumin) is difficult.

Thus, in almost all cases in these two separated materials, egg oil contains albumin, and albumin contains egg oil.

This state of the paint solvent leads to the fact that such paint quite quickly loses its uniformity and homogeneity.

When examining the paint layer under a microscope, destructive phenomena are clearly visible in the paintings - shrinkage of the paint, deformation and cracks in the outer surface of the paint layer.

All this leads over time to the gradual destruction of paint and to the loss of the appearance of works of art.

A similar loss of homogeneity is seen in leather products, since the leather base remains flexible and constantly works on repeated bending. Incomplete wetting of the pigment and the residual protein-fat "cross" in the oil lead to localized drying zones: the film contracts unevenly, forming microvacuoles. At the very first load cycle, a network of cracks (craquelure) appears, and delamination occurs along the edges.

As a result, the visual continuity of color is lost, abrasion increases and, most importantly, the elasticity of the finish drops sharply - a parameter critical for premium straps, shoes and small haberdashery. An additional danger is "crocking": poorly fixed pigment is transferred to clothing after just a few weeks of wear. Restoration of such a defect is labor-intensive and rarely returns the product to its original class.

It is these risks that dictate the need for ultra-homogeneous dispersion and chemically pure binder. Vortex mixing, proposed in this work, eliminates the described problems: a uniform shear field completely wets the pigment, eliminates metal contamination and forms a film that can work together with leather fiber without cracking. Thus, the technology translates the requirements of museum restoration to an industrial level of quality, increasing the durability and consumer value of leather products.

As before, so now the key problem is the most complete separation of the yolk (egg oil) and protein (albumin).

The issue of homogeneous mixing also remains, but this is a secondary issue, since obtaining pure initial paint components determines the final quality, in almost all parameters.

Thus, in order to solve the issue of forming all stages of creating a new type of oil paints for use in leather production and in the restoration process in an innovative direction, an integrated complex solution of the same level is required for each of the materials and technological operations included in the complex process.

1. obtaining pure or even ultra-pure egg oil; This issue is resolved using on-line control in real time using sensors built on the basis of electromagnetic resonance spectroscopy elements;
2. obtaining a natural preservative for paint to ensure its stability and durability;

3. reliable and fast mixing of pigment powder with ultra-pure egg white;
4. encapsulation of pigment microparticles in a shell of ultra-pure egg oil;
5. enveloping the resulting capsules by mixing, with a core of pigment particles and a shell of ultra-pure egg oil with a liquid natural preservative

Let's assume that the issues of obtaining ultra-pure egg oil and a natural preservative of the same purity have been resolved (since this is not the topic of this article).

Mixing and encapsulation, which are much more complex technologically, require a detailed explanation.

There are technologies of so-called vortex mixing.

To implement such technologies, special vortex generators are required, which are joined along the axis in the process, in such quantity that ensures the specified productivity.

In this generator, the pigment in the form of micropowder is placed in the central axial hole, and egg oil or its equivalent is fed under pressure into an annular trapezoidal channel from where it is fed through peripheral axial channels into tangential channels, from where it is injected into the pigment.

The tangential channels are designed such that the oil outlet opening has dimensions ranging from 5 to 10 microns.

The dispersion of oil spray drops is from 5 to 10 microns.

The topology of the tangential channels is designed and executed in such a way that the injection from each of the channels has a spiral trajectory.

Since the number of such channels in one generator can reach 15, such a generator provides 15 spirals at the entrance to the pigment, the injection of which transforms the pigment and spiral flows of oil into a vortex tube in the axial opening of the generator, in which micro-encapsulation occurs.

Vortex generator model;

There is another important factor that follows from the properties of the vortex tube - the contact time between the oil and the pigment in such a tube increases by at least 3.5 times compared to conventional mechanical mixing, but the linear speed of the mixture does not decrease.

Vortex generators are quite technologically advanced in manufacturing and operation and can work with any pumps, which is very important when used in the restoration or painting process of leather production.

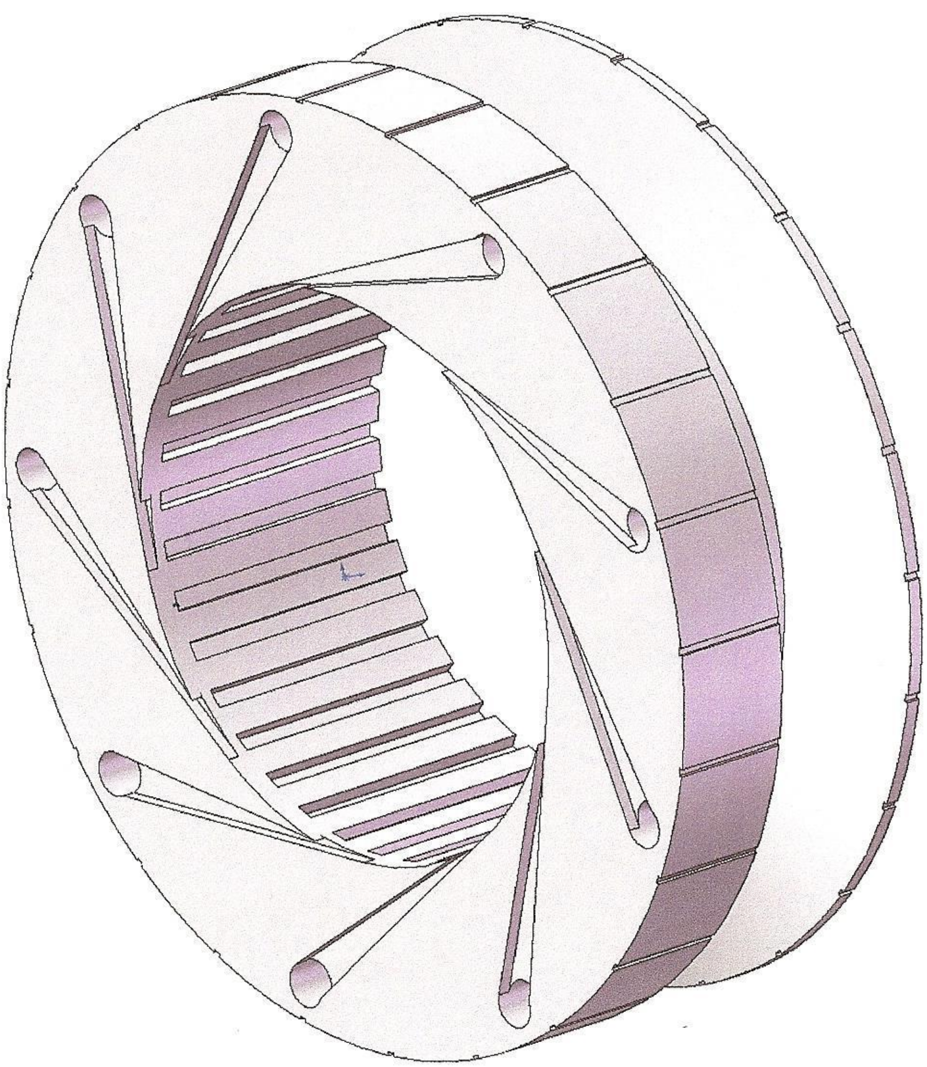

Fig. 1. Vortex cartridge module

Generators of this kind can be manufactured in any scale factor, which is also important for both restoration and production where the amount of paint required is either negligible (for restoration), with the most stringent requirements for its quality, as well as on a production scale (premium leather production) where large volumes are needed with high quality.

This unit can be connected to any oil supply pump, making it easy to use in any restoration or manufacturing environment.

The diameter of such a vortex generator determines its productivity, which allows us to assume that in reality for local mixing of paint components for restoration a diameter of no more than 35 mm will be needed, and for production, depending on the paint consumption requirements, this size can be 10 times greater.

The general concept of such an installation is very simple and allows the use of the simplest geometry for all parts, which in turn makes it possible for such a device to be operated by people without special production skills.

This mechanism also determines the low cost of manufacturing such a device, which is an important factor when organizing a restoration site or cost-effective production;

Internal structure of a system of coaxial vortex generators;

I propose to consider models of the device that demonstrate the simplicity and technological advancement of all components, ease of assembly, scalability and operation in leather production conditions.

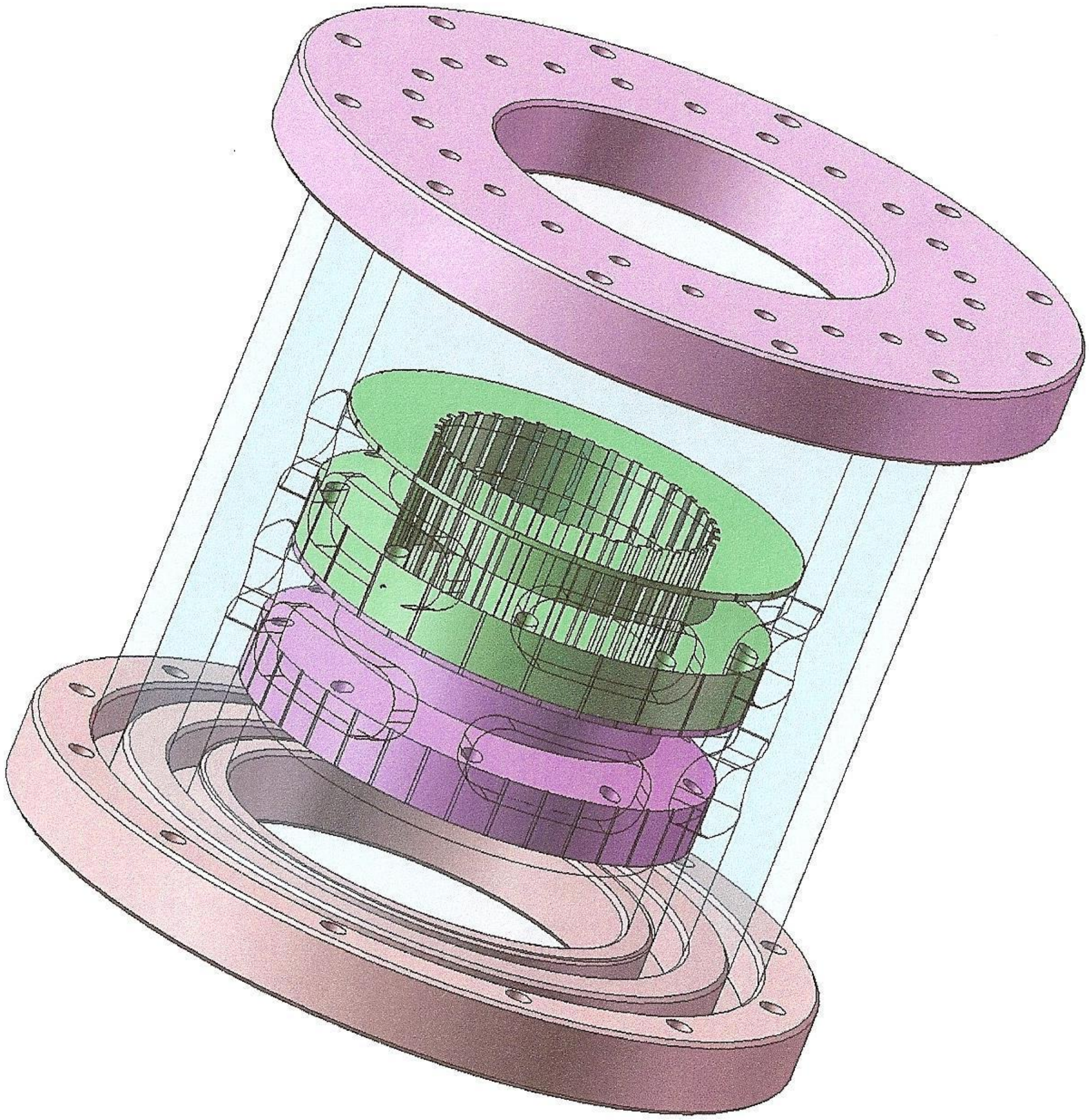

Fig. 2. Assembly of a flow-through vortex generator in isometric view (the casing is made conditionally transparent to show the internal components)

As can be seen from the model, all body parts center the vortex generators in contact with them, which eliminates many special parts and significantly reduces the cost of installation, while ensuring the proper level of paint preparation quality.

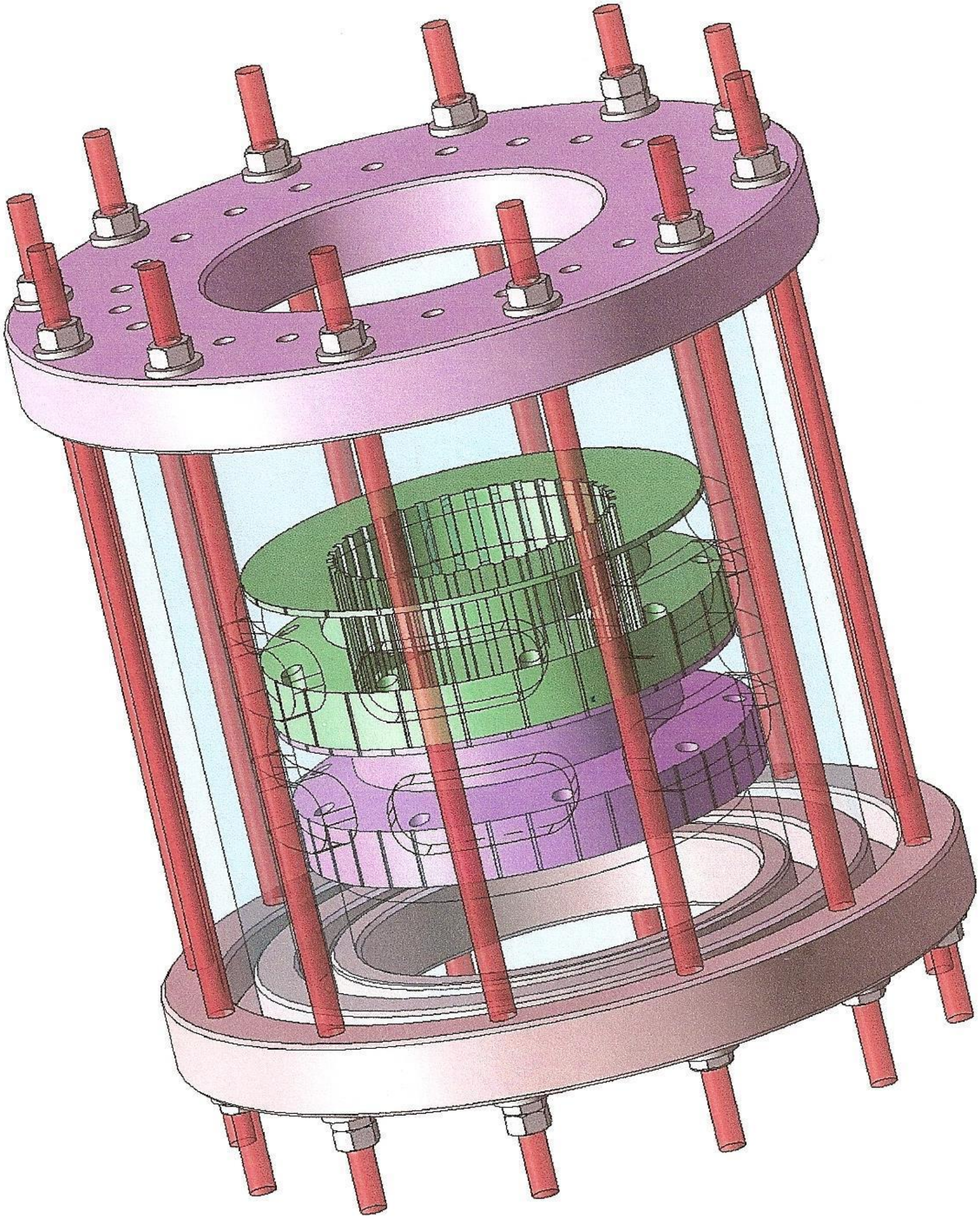

Fig. 3. The unit is assembled using standard studs, which simplifies the design and operation

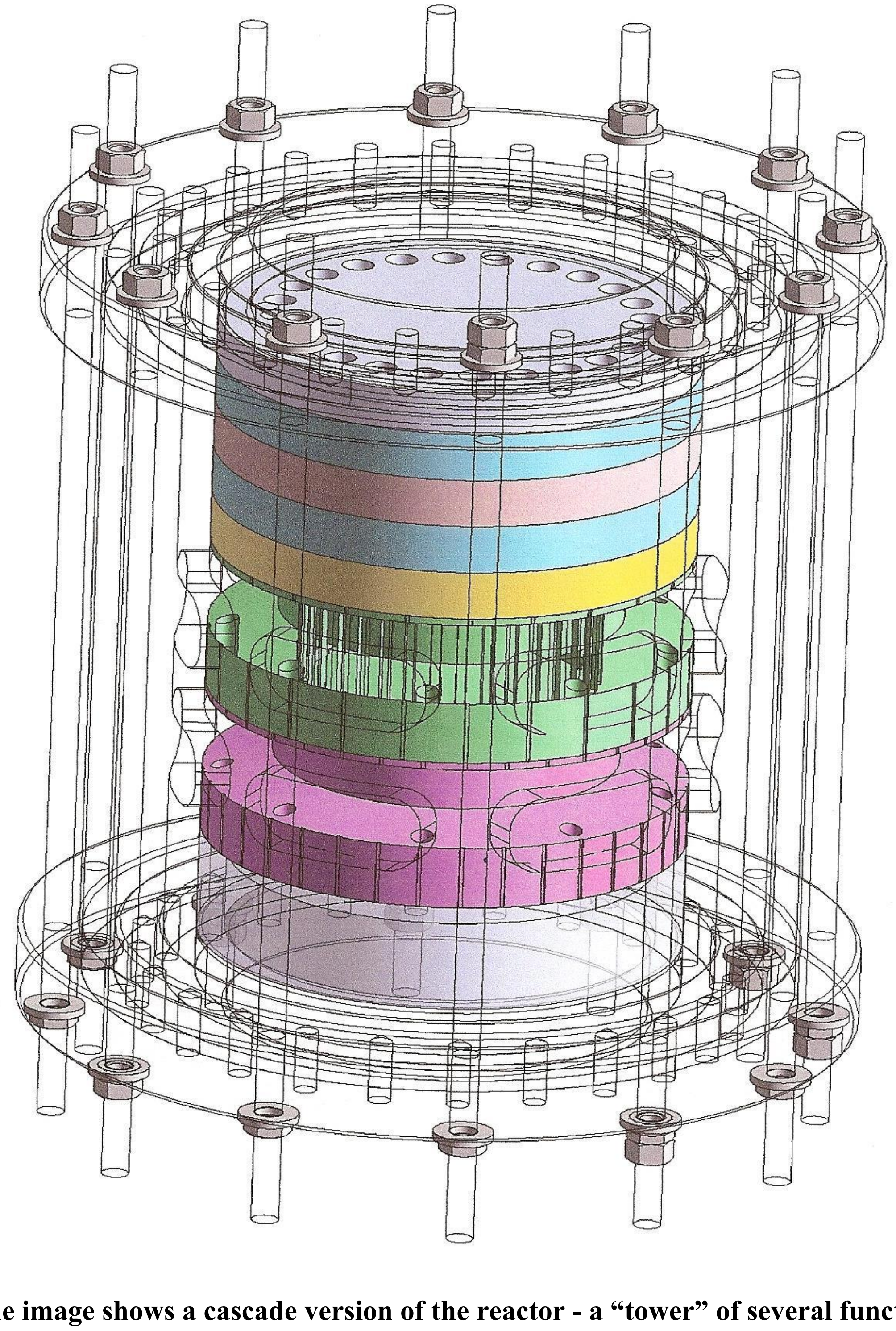

Fig. 4. The image shows a cascade version of the reactor - a “tower” of several functional cartridges with coaxial vortex generators, assembled in a single power frame

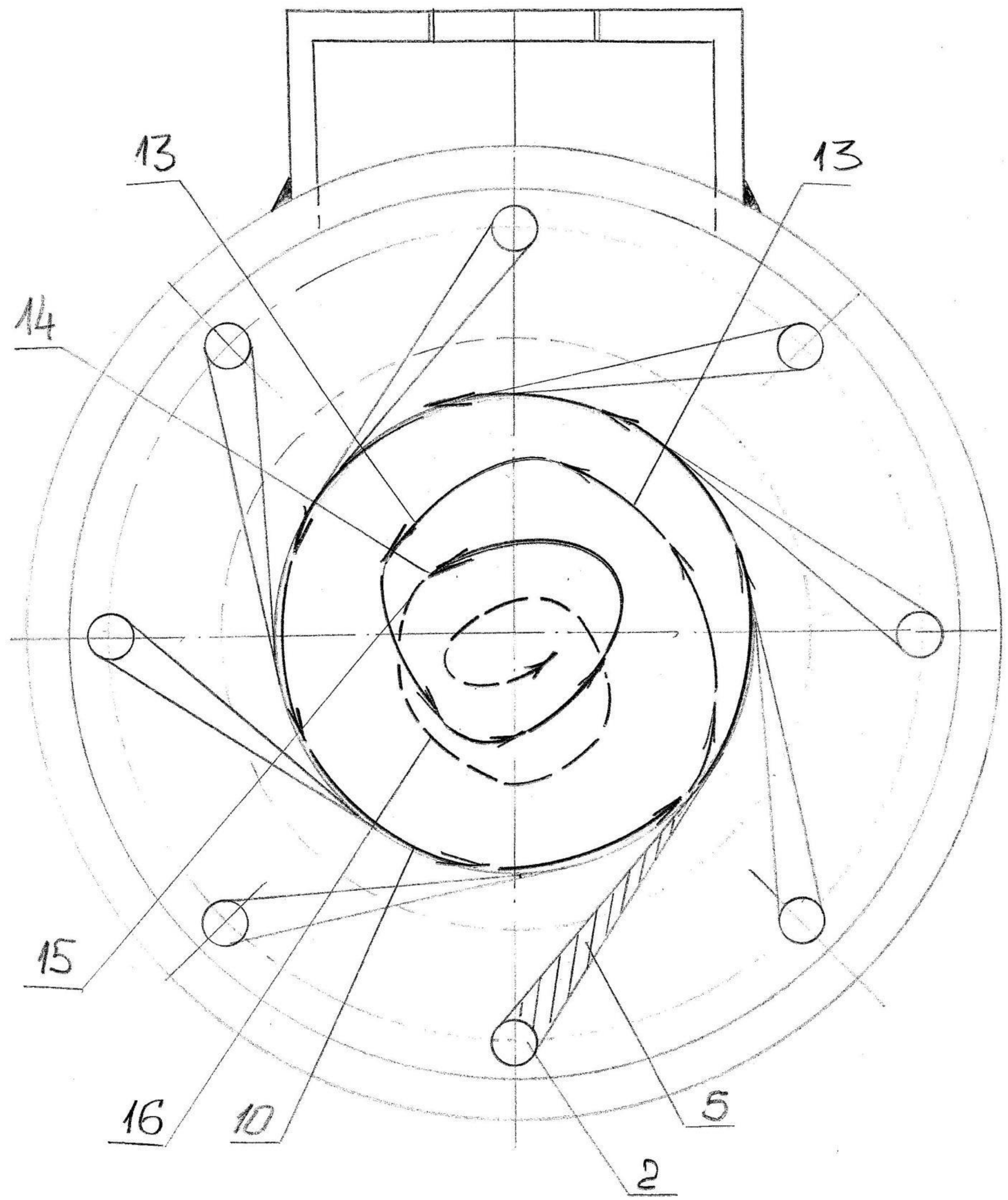

Fig. 5.

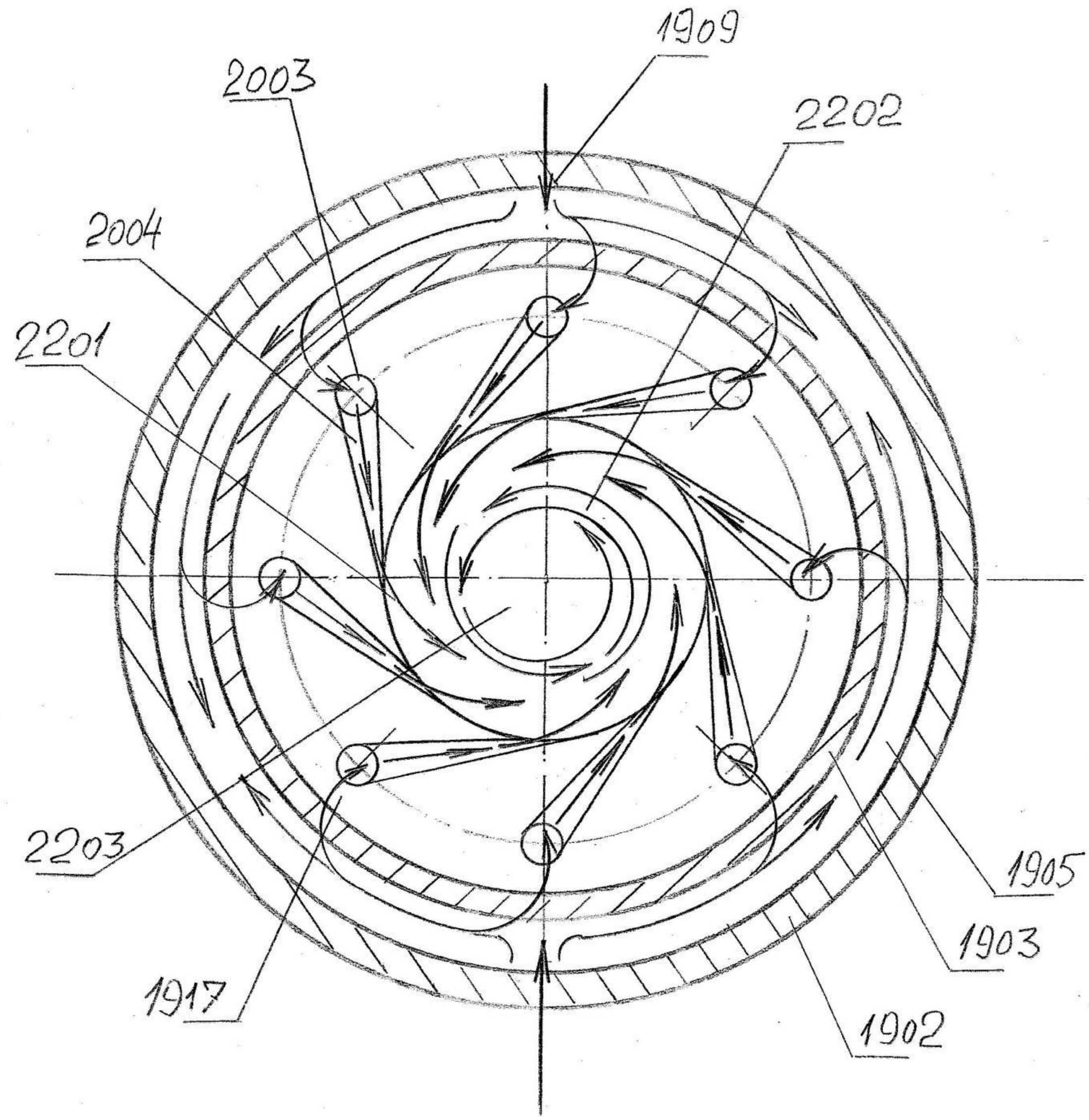

Fig. 6.

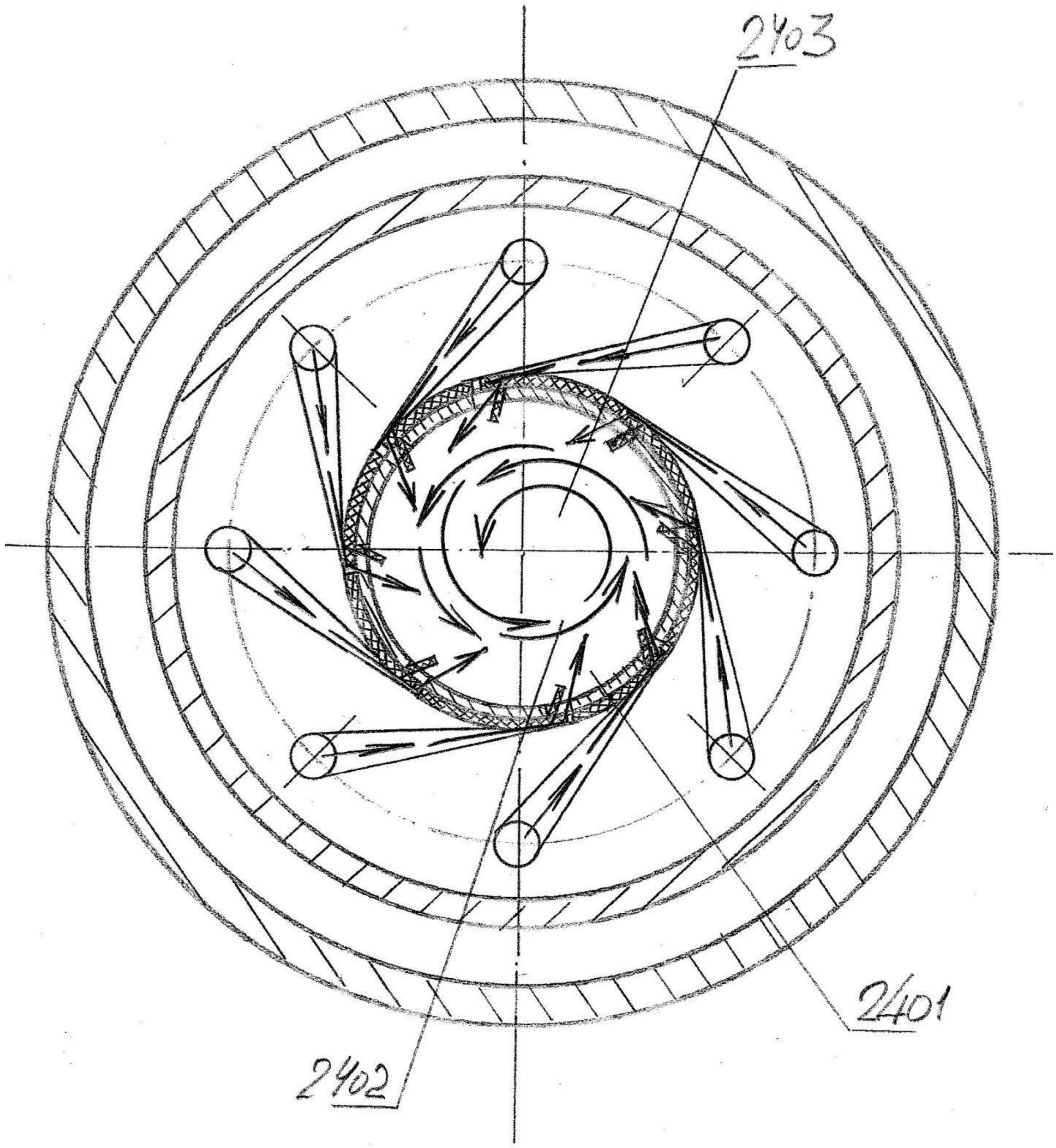

Fig. 7. The presented diagrams Fig. 5 and Fig. 6. Fig. 7. show in detail the dynamic mechanisms of the formation of a vortex tube in an installation for the preparation of encapsulated paint

As can be seen from the diagrams, the mechanisms for forming a vortex tube are simple and reliable enough to allow the use of such a setup in real conditions of a restoration or production site.

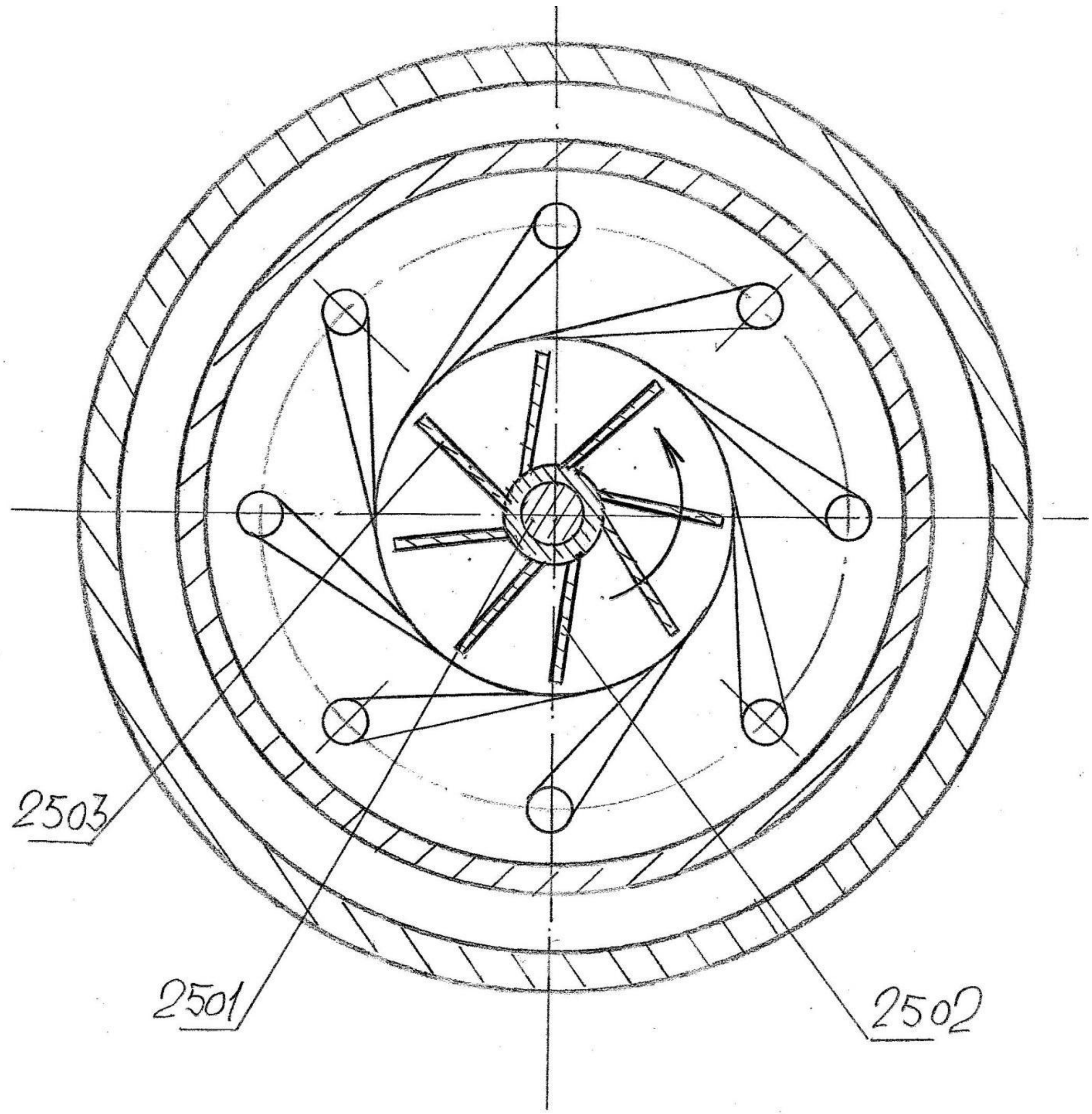

Fig. 8.

Fig. 8 shows a version of such an installation with modifications, in particular with filter elements made of carbon-carbon composite materials.

Fig. 9.

View of finished parts in a vortex generator in one of the projects.

Choosing Oil as a Paint Solvent

After describing the installation itself for vortex mixing of paint components, I propose to return to the question of choosing oil as a paint solvent.

At the same time, the latest innovative technology for processing chicken eggs is proposed, which is not the subject of this article.

According to this technology, eggs (including substandard ones) are processed using a special technology into ultra-pure egg powder.

Next, using special solvents, alpha-lecithin is obtained from the powder, which is the equivalent of paint oil, but significantly superior to oil in purity.

After this, during the egg processing process, ultra-pure lysozyme, a natural preservative, is also obtained.

Thus, when producing leather paint or restoration, we are offered an absolutely pure set of materials, ultimately obtained from the same chicken eggs, but significantly cleaner.

This paint significantly increases the purity and environmental friendliness for premium and exclusive leather products, painting restoration and any other natural fiber painting where premium quality, environmental friendliness and durability are required.

Prospects for further development:

Further development of vortex mixing technology may include automation of processes, implementation of sensor systems for quality control and artificial intelligence in real time for modeling complex multi-component mixtures. In addition, a promising direction is the development of environmentally friendly solvents and pigments, which will minimize the impact on the environment.

Prospects for application in leather production

The vortex mixing technology described in this paper has high application prospects in leather production. The high degree of homogeneity of the paint composition, achieved through the use of innovative vortex generators, allows to significantly improve the quality of leather goods dyeing. This is especially important for premium and exclusive leather products, where the requirements for homogeneity and durability of the paint layer are key. In addition, the technology allows to optimize the consumption of pigments and reduce production costs, which makes it attractive for premium leathers. Thus, the introduction of this technology can significantly increase the competitiveness of leather production, improve the quality of finished products and reduce the costs of their production.

List of references, patent and license information:

Appendix 1

Dynamic Mixing of Fluids

Abstract

Methods, systems, and devices for preparation and activation of liquids and gaseous fuels are disclosed. Method of vortex cooling of compressed gas stream and water removing from air are disclosed.

Appendix 2

Method of Dynamic Mixing of Fluids

Abstract

Methods are provided for achieving dynamic mixing of two or more fluid streams using a mixing device. The methods include providing at least two integrated concentric contours that are configured to simultaneously direct fluid flow and transform the kinetic energy level of the first and second fluid streams, and directing fluid flow through the at least two integrated concentric contours such that, in two adjacent contours, the first and second fluid streams are input in opposite directions. As a result, the physical effects acting on each stream of each contour are combined, increasing the kinetic energy of the mix and transforming the mix from a first kinetic energy level to a second kinetic energy level, where the second kinetic energy level is greater than the first kinetic energy level.

Appendix 3

SYSTEM AND APPARATUS FOR CONDENSATION OF LIQUID FROM GAS AND METHOD OF COLLECTION OF LIQUID

Abstract

The present disclosure generally relates to an apparatus for the condensation of a liquid suspended in a gas, and more specifically, to an apparatus for the condensation of water from air with a geometry designed to emphasize adiabatic condensation of water using either the Joule-Thompson effect or the Ranque-Hilsch vortex tube effect or a combination of the two. Several embodiments are disclosed and include the use of a Livshits-Teichner generator to extract water and unburned hydrocarbons from exhaust of combustion engines, to collect potable water from exhaust of combustion engines, to use the vortex generation as an improved heat process mechanism, to mix gases and liquid fuel efficiently, and an improved Livshits-Teichner generator with baffles and external condensation.

Appendix 4

PROCESS AND APPARATUS FOR COMPLEX TREATMENT OF LIQUIDS

Abstract

Methods and apparatus for complex treatment of contaminated liquids are provided, by which contaminants are extracted from the liquid. The substances to be extracted may be metallic, non-metallic, organic, inorganic, dissolved, or in suspension. The treatment apparatus includes at least one mechanical filter used to filter the liquid solution, a separator device used to remove organic impurities and oils from the mechanically filtered liquid, and an electroextraction device that removes heavy metals from the separated liquid. After treatment within the treatment apparatus, metal ion concentrations within the liquid may be reduced to their residual values of less than 0.1 milligrams per liter. A Method of complex treatment of a contaminated liquid includes using the separator device to remove inorganic and non-conductive substances prior to electroextraction of metals to maximize the effectiveness of the treatment and provide a reusable liquid.

Appendix 5

FOAMING OF LIQUIDS

Abstract

Methods and systems for processing of liquids using compressed gases or compressed air are disclosed. In addition, methods and systems for mixing of liquids are disclosed.