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A System of Gas-Dynamic Equations with the Processes of Vibrator-Air Interaction Solution

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Abstract:

The system of gas-dynamic equations as it relates to the complex operations of vibrator-air interaction is thoroughly examined in this work. Aerospace, fluid dynamics and acoustic engineering are just a few of the many technical applications that include vibrator-air interactions. Optimizing design and performance requires a thorough understanding of and accurate modeling of these relationships. In this study, we provide a theoretical framework that unifies the mechanics of vibrating structures with the gas-dynamic equations. By taking into account variables like frequency, amplitude, and the shape of the vibrating structure, we examine the dynamic coupling between vibrating bodies and the surrounding air. The vibration response and air pressure distributions are characterized in detail after the governing equations are solved using sophisticated computational techniques

***Keywords* —** Vibration dynamics, Air-vibrator interaction, Numerical simulations, Engineering applications.

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Introduction

It is common practice to clean seeds using their aerodynamic qualities, particularly to get rid of contaminants like straw and spike particles. Such impurities have a critical velocity that is distinct from seeds', have a dramatically different specific weight, and are simple to separate from the airflow. Simple (winnows) and sophisticated seed-cleaning equipment alike exploit this cleaning principle to the fullest extent and with great effectiveness. Critical seed velocity varies greatly depending on the form of the seed; it is rather consistent in spherical seeds and can be used for cleaning. A certain class of weed seeds has a range in their sailing ratio; by taking use of this characteristic, they can be entirely eliminated. Devices that separate seed mixtures based on form, roughness, and elasticity rather than a single attribute—instead, based on a collection of physical-mechanical qualities—are used to effectively separate seed mixtures with noticeable aerodynamic features [1, 2]. These tools include vibratory machines, which for many small-seeded crops have demonstrated good separation efficiency [3-5].

Investigating the way that air interacts with the machine's working surfaces is interesting for such devices. The fact that there is air movement in the region between the oscillating work surfaces necessitates the employment of gas-dynamic models. The pattern of vibration movement of seeds with obvious aerodynamic features is significantly impacted by these phenomena. It is vital to develop suitable mathematical models for estimating the airflow characteristics across vibrating work surfaces, based on the parameters of the operating mode and design features of vibratory machines, in order to examine this interaction process.

The aerodynamic element is not fully taken into account by the existing theory of the vibration movement of microscopic seeds (particles). This is mostly caused by the absence of three-dimensional air movement patterns caused by a vibratory machine's active components. This prevents further development of vibration cleaning techniques and tools, which are now the best approach to separate small-seeded crops. For instance, despite offering a major performance boost, a new mechatronic vibratory cleaning machine [6-8] has to be improved to account for the aerodynamic component. Only on the basis of multivariate studies on workflow modeling that take into account the dynamics of air mass movement is it feasible to choose the reasonable structural parameters for the enhanced machine. In order to compute the kinematic characteristics of air medium movement that interacts with the processed seed crop, gas-dynamic equations must be solved using current numerical techniques. The approach should not necessitate an exorbitant increase in computer resources, as is the case, for example, in the gas-dynamic calculations of thermal machines, while simultaneously establishing a three-dimensional pattern of air flow.

Literature review and problem statement:-

Numerous practical fields of Endeavour use numerical approaches that are continually developing to solve the challenges of hydro-gas dynamics. These fields deal with the design of numerous assemblies and equipment, including air, water, and ground-based vehicles, whose functioning necessitates taking into account the effects of the surrounding air (gas) or water environment. In order to calculate the characteristics of the gas-air (water) environment while interacting with the structural components of planned vehicles (assemblies), several estimating approaches and models have so far been developed [9]. The grid technique, the generators method, or the Mascot method is the three primary foundations for the used estimate methodologies [10, 11]. These techniques enable the resolution of the non-linearity of differential equation systems, which commonly characterize the investigated gas dynamic (hydrodynamic) processes, while exhibiting evident advantages in terms of simplicity and adaptability. The cost is the unstable convergence and poor convergence of the solutions obtained, which rely on the method and grid settings for dividing the research regions.

The study of estimate strategies employed in the field of thermo-gas-dynamic processes is centered on the issue of convergence of the numerical solution to gas-dynamic equations.

The solution of the finite difference equations of Euler was proposed in [12]. Due to the method's simplicity, the solution procedure has a sluggish convergence rate, which is unsatisfactory for computations involving variables.

A matrix time step and a method of directed grid coarsening were suggested in [13] to enhance convergence. This allowed for a huge boost in computation speed convergence, but it also made the method much more complex.

The techniques of multi-level multiple grids are examined in papers [14, 15], in which the error of the solution found on a small grid is transferred to a big grid, and the smoothed solution found on a large grid is then transmitted back to a small grid. The approaches suggested are more complex and expensive in terms of the use of computer resources, even if they perform better than the prior way in terms of convergence rate and the attained accuracy of calculations.

It was mentioned in [11] that a sweep approach may be added to the toolkit of applied computational methods for the situation of a perfect gas when differential equations are converted to a quasi-linear form, reducing the estimate model to a boundary value issue. It is asserted that a particular approach is indifferent to the manner in which an area splitting grid is produced in accordance with the findings mentioned in [16]. The precision of the solution always increases when a breakdown step is reduced, and converges to a certain value. No extra steps, such as the adoption of data formats with more bits, are necessary to assure the stability of the solution.

In [9], it was suggested that while handling a problem involving heat exchange on a plane, a calculation technique for solving the boundary value issue using a sweep approach for a two-dimensional example should be used. The authors are not aware of any outcomes in obtaining the estimate strategies to solve a three-dimensional system of gas dynamics equations using a sweep approach.

It is desirable to priorities the sweep approach for researching relatively straightforward gas-dynamic processes, such as the usage of the ideal gas model within an acoustic range of velocities and pressures. This is because the computational pace increased significantly at a very straightforward analytical stage of the computational process.

Therefore, it appears appropriate to undertake study on the analytical development of estimating schemes utilizing a sweep technique when taking into account the processes of interaction between the working surfaces of vibratory machines and an air environment when there are weak (acoustic) disturbances.

The aim and objectives of the study:-

The goal of this research is to develop a sweep-based approach for solving a boundary value problem for a three-dimensional system of differential equations describing air dynamics under the impact of a vibratory machine. It is feasible to guarantee the convergence and stability of computation methods, independent of the step and other grid characteristics, by using the sweep approach to tackle problems of this nature.

The following tasks have been established to achieve the goal: - to build a numerical sweep algorithm for three orthogonal axes; - to implement the computer algorithm on a PC using the MATLAB programming environment, in order to show its viability by computing the field of velocities and pressures of air medium for the typical positions of the working bodies of a vibratory machine.

Building a numerical sweep technique on three orthogonal axes:-

The description of a boundary value problem to determine the field of velocities and air pressures situated between two parallel synchronously oscillating working surfaces of a vibratory machine is provided in general form in [19]. Analytical and finite difference presentation formats are used for the results.

As a mathematical representation of the process under investigation, the Euler equation was combined with a continuity equation.

$$\rho \mathbf{a} = \rho \mathbf{F} - \text{grad } p,$$

$$\dot{p}\frac{1}{\rho c^2} + \text{div } \mathbf{V} = 0$$

where an is the air medium's acceleration vector, F is the vector of acceleration brought on by the action of mass forces (gravity), ρ is the air pressure at the location in question, is the air density, V, p is the motion vector, and c is the speed of sound, respectively.

The equation system being solved has the following form in the coordinate form:

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = g_x - \frac{1}{\rho}\frac{\partial p}{\partial x}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = g_y - \frac{1}{\rho}\frac{\partial p}{\partial y}$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} = g_z - \frac{1}{\rho}\frac{\partial p}{\partial z}$$

$$\left[\frac{\partial p}{\partial t} + u\frac{\partial p}{\partial x} + v\frac{\partial p}{\partial y} + w\frac{\partial p}{\partial z}\right]\frac{1}{\rho c^2} + + \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

Where g_x, g_y, and g_z are projections of the acceleration of free fall onto the axes of the chosen coordinate system and u, v, and w are the projections of the air medium velocity vector, V, onto the X, Y, and Z axes of the chosen coordinate system.

The following are the boundary conditions for the boundaries of the area contained between two synchronously oscillating work surfaces:

- Along the contour of the computed region, edges C, D, E, and G have an unhindered relative air movement and a pressure that is equivalent to atmospheric pressure.

$$\frac{\mathbf{V}(t)}{C}, D, E, G = -\mathbf{V}^{\kappa}(t),$$

$$p/C, D, E, G = p_0,$$

where p/C, D, E, G is the air pressure along the C, D, E, and G border; p_0 is the atmospheric pressure; V(t)/C, D, E, G is the velocity vector of air particle motion, which belong to the C, D, E, and G edges of region, relative to the system of coordinates of the working surface; and $\mathbf{V}^{\kappa}(t)$ is the velocity vector of the oscillations of points at the working surface relative to the inertial.

The air completely stops when it contacts the surface for the A and B edges, which come into touch with the surfaces of the lower and higher working planes of a vibratory machine (the air at rest is moved by the oscillating working surfaces). A pressure differential of positive or negative sign, p, forms. Depending on which way the work surface is moving, the sign of this difference is decided. In other words, the following describes the boundary requirements for edges A and B:

$$u(t)/A,B = {}^{v(t)}/A,B = {}^{w}(t)/A,B = 0,$$

$$p(t)/A = p_0 + +\rho\frac{V_x^K(t)^2+V_y^K(t)^2+V_z^K(t)^2}{2}\left(-\text{sign}\,\{V_z^K(t)\}\right)$$

$$p(t)/B = p_0 + +\rho\frac{V_x^K(t)^2+V_y^K(t)^2+V_z^K(t)^2}{2}\text{sign}\,\{V_z^K(t)\}$$

$$\text{sign}\,\{\mathbf{V}_z^k(t)\} = \begin{cases} 1, & \text{if } V_z^k(t) \geq 0, \\ -1, & \text{if } V_z^k(t) < 0, \end{cases}$$

Where ρ $V_x^K(t)$, $V_y^K(t)$, $V_z^K(t)$ are projections of the oscillation velocity and is the air density.

In [20], an estimating technique that executes the sweep for three orthogonal axes of the coordinate system connected to the working planes of a vibratory machine was developed.

The set of equations (3) through (6) is expressed in matrix form to develop an estimating scheme:

$$\mathbf{I}\frac{\partial\mathbf{Q}}{\partial t} + \mathbf{B}\frac{\partial\mathbf{Q}}{\partial x} + \mathbf{C}\frac{\partial\mathbf{Q}}{\partial y} + \mathbf{D}\frac{\partial\mathbf{Q}}{\partial z} = \mathbf{F},$$

Where

$$\mathbf{I} = \begin{Vmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{Vmatrix}, \mathbf{B} = \begin{Vmatrix} u & 0 & 0 & c^2 \\ 0 & u & 0 & 0 \\ 0 & 0 & u & 0 \\ 0 & 0 & 0 & u \end{Vmatrix},$$

$$\mathbf{C} = \begin{Vmatrix} v & 0 & 0 & 0 \\ 0 & v & 0 & c^2 \\ 0 & 0 & v & 0 \\ 0 & 0 & 0 & v \end{Vmatrix}, \mathbf{D} = \begin{Vmatrix} w & 0 & 0 & 0 \\ 0 & w & 0 & 0 \\ 0 & 0 & w & c^2 \\ 0 & 0 & 0 & w \end{Vmatrix},$$

$$\mathbf{Q} = \begin{vmatrix} u \\ v \\ w \\ p/\rho c^2 \end{vmatrix}, \mathbf{F} = \begin{vmatrix} g_x \\ g_y \\ g_x \\ 0 \end{vmatrix}.$$

The X axis and the Y axis will be used for the sweep. As a result, each j-th node belonging to the Y axis is given a collection of nodes sitting on the vertical axis that passes through the j-th node for a direct sweep along the X axis. By shifting it from the ZOY plane along the OX axis, the created left boundary of the examined region along the j-th segment is swept to the right boundary. As a result, nodes (i, j, and k),

The j-th node of the Y axis is also assigned the values i=0,..., b/h, k=0,..., H/s. The constructed portion is then moved to the side end of the region being investigated, or node j=a/l. In Figure 1, arrows indicate the directions of direct sweep along the X and Y axes. Reverse sweep is done in the opposite direction.

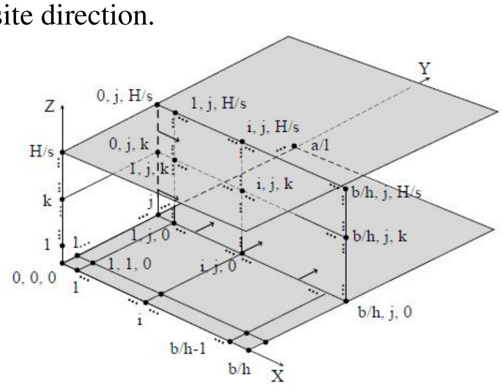

Fig. 1. Sweep scheme

The set of equations its translation to get the recurring direct-to-reverse sweep ratios are given in papers [19, 20] in finite difference notation.

Using the following recurrent ratios, one computes the elements of the Xj and Yj tensors during a direct sweep for j=0,..., a/l, =1,..., T.

All of the steps j=0,..., a/l store the calculated elements.

$$\mathbf{X}_{(j+1),\tau} = \left\{ \begin{matrix} -\mathbf{AA}^0_{j(\tau-1)}\left(\mathbf{AAA}^+_{(j+1)(\tau-1)}\right)^{-1} + \\ +\mathbf{AAA}^-_{(j-1)(\tau-1)}\left(\mathbf{AAA}^+_{(j+1)(\tau-1)}\right)^{-1}\mathbf{X}_{j,\tau} \end{matrix} \right]^{-1},$$

$$\mathbf{y}_{(j+1),\tau} = -\mathbf{AAA}^-_{(j-1)(\tau-1)}\left(\mathbf{AAA}^+_{(j+1)(\tau-1)}\right)^{-1} \times$$

$$\times \mathbf{X}_{(j+1),\tau}\mathbf{y}_{j,\tau} - j(\tau \overset{\mathbf{F}}{-} 1)_{(\mathbf{z}}\left(\mathbf{AA}^+_{(j+1)(\tau-1)}\right)^{-1}\mathbf{X}_{(j+1),\tau}$$

Where

$$\mathbf{AA}^0_{j,\tau} = \begin{Vmatrix} -\mathbf{A}^-_{0,j,\tau} & \mathbf{A}^0_{1,j,\tau} & \mathbf{A}^+_{2,j,\tau} & 0 & 0 & \dots & 0 \\ 0 & -\mathbf{A}^-_{1,j,\tau} & \mathbf{A}^0_{2,j,\tau} & \mathbf{A}^+_{3,j,\tau} & 0 & \dots & 0 \\ & & \dots\dots. & & & \dots & \\ 0 & 0 & 0 & 0 & 0 & \dots & \mathbf{A}^+_{\frac{b}{h},\tau} \end{Vmatrix},$$

$$\mathbf{A}^+_{i,j,\tau} = \begin{Vmatrix} 0 \\ 1/2h \cdot \mathbf{B}_{i,j,1,\tau} \\ \dots \\ 1/2h \cdot \mathbf{B}_{i,j,H/s,\tau} \end{Vmatrix}, \mathbf{A}^-_{i,j,\tau} = \begin{Vmatrix} 1/2h \cdot \mathbf{B}_{i,j,9,\tau} \\ 1/2h \cdot \mathbf{B}_{i,j,1,\tau} \\ \dots \\ 0 \end{Vmatrix},$$

$$\mathbf{B}_{i,j,k,\tau} = \begin{Vmatrix} u_{i,j,k,\tau} & 0 & 0 & c^2 \\ 0 & u_{i,j,k,\tau} & 0 & 0 \\ 0 & 0 & u_{i,j,k,\tau} & 0 \\ 0 & 0 & 0 & u_{i,j,k,\tau} \end{Vmatrix}$$

$$\mathbf{D}_{i,j,k,\tau} = \begin{Vmatrix} w_{i,j,k,\tau} & 0 & 0 & 0 \\ 0 & w_{i,j,k,\tau} & 0 & 0 \\ 0 & 0 & w_{i,j,k,\tau} & c^2 \\ 0 & 0 & 0 & w_{i,j,k,\tau} \end{Vmatrix}$$

$$\mathrm{AAA}^+_{j,\tau} = \begin{Vmatrix} 0 \\ \mathrm{AA}^+_{1,j,\tau} \\ \dots \\ \mathrm{AA}^+_{b/h,\tau,\tau} \end{Vmatrix}, \mathrm{AAA}^-_{j,\tau} = \begin{Vmatrix} \mathrm{AA}^+_{0,j,\tau} \\ \mathrm{AA}^+_{1,j,\tau} \\ \dots \\ 0 \end{Vmatrix}$$

$$\mathrm{AA}^+_{i,j,\tau} = \begin{Vmatrix} 0 \\ 1/2l \cdot \mathbf{C}_{i,j,1,\tau} \\ \dots \\ 1/2l \cdot \mathbf{C}_{i,j,H/s,\tau} \end{Vmatrix}$$

$$\mathbf{C}_{i,j,k,\tau} = \begin{Vmatrix} v_{i,j,k,\tau} & 0 & 0 & 0 \\ 0 & v_{i,j,k,\tau} & 0 & c^2 \\ 0 & 0 & v_{i,j,k,\tau} & 0 \\ 0 & 0 & 0 & v_{i,j,k,\tau} \end{Vmatrix}$$

$$\breve{\mathbf{F}}_{j,\tau} = \begin{Vmatrix} \breve{\mathbf{F}}_{0,j,\tau} \\ \breve{\mathbf{F}}_{1,j,\tau} \\ \dots \\ \breve{\mathbf{F}}_{b/h,j,\tau} \end{Vmatrix},$$

$$\breve{\mathbf{F}}_{i,j,\tau} = \begin{Vmatrix} \mathbf{F}_\tau + \frac{1}{\Delta t}\mathbf{I}_{i,j,0,\tau} \\ \mathbf{F}_\tau + \frac{1}{\Delta t}\mathbf{I}_{i,j,1,\tau} \\ \dots \\ \mathbf{F}_\tau + \frac{1}{\Delta t}\mathbf{IQ}_{i,j,H/s,\tau} \end{Vmatrix},$$

$$\mathbf{F}_z = \begin{vmatrix} g_s(\tau\Delta t \\ g_y(\tau\Delta t) \\ g_s(\tau\Delta t) \\ 0 \end{vmatrix}.$$

The following are the components of the tensor-section for the far-right location (at the conclusion of the direct sweep), "a/l":

$$\Xi_{a/l,\tau} = \begin{Vmatrix} \Psi_{0,a/l,\tau} \\ \Psi_{1,a/l,\tau} \\ \dots \\ \Psi_{b/h,a/l,\tau} \end{Vmatrix}$$

Where

$$\Psi_{i,a/l,\tau} = \begin{Vmatrix} \mathbf{Q}_{i,a/l,0,\tau} \\ \mathbf{Q}_{i,a/l,1,\tau} \\ \dots \\ \mathbf{Q}_{i,a/l,H/s,\tau} \end{Vmatrix},$$

$$\mathbf{Q}_{i,a/l,k,\tau} = \begin{Vmatrix} u_{i,a/l,k,\tau} \\ v_{i,a/l,l,\tau} \\ w_{i,a/l,k,\tau} \\ p_{i,a/l,k,\tau}/\rho c^2 \end{Vmatrix}.$$

Based on the boundary conditions for edge D, values are derived for $u_{i,a/l,k,\tau}$, $v_{i,a/l,l,\tau}$, $w_{i,a/l,k,\tau}$ and $p_{i,a/l,k,\tau}/\rho c^2$

The reverse sweep is performed next. For all intermediate places to the left of the sweep interval's right end, we compute the tensor-section elements:

$$\Xi_{j-ft} = X_{jz}\Xi_{f:z} + y_{fz}$$
$$j = a/l, (a/l-1), (a/l-2), \dots, 1.$$

The results obtained and their analysis

We have developed an estimating method based on the suggested analytical expressions (14) to (25), which is implemented in the used software programmed MATLAB created to address the issues of technical calculations. For time moments t=0 (Fig. 2), t=1/4 (Fig. 3), and t=1/2 (Fig. 4), the findings that were achieved utilizing it are shown. The planes of a vibratory machine are at their neutral position at time t=0. The magnitude of the velocity has a maximum (by module) value, while the acceleration of the movement of oscillating planes has a zero value. The planes' location where their departure from the zero position is greatest corresponds to the time point t=1/4. A plane can travel at a maximum acceleration or at zero velocity. The working planes of a vibratory machine are moving at a speed that is oriented in the opposite direction, yet the motion parameters and location of the planes at time point t=1/2 are identical to those at time point t=0.

The examples above (Fig. 2-4) demonstrate how the vertical (transverse) and horizontal (longitudinal) components of air velocity change over time in the working space restricted between two oscillating planes. With a change in movement direction, the law of change in the longitudinal and transverse components of velocity is periodic. With unequal velocities both vertically and horizontally in the estimate region, the superposition of these two movements results in a complicated distribution pattern of the movement speed of the components inside the examined air continuum.

For the region's height, the resulting pressure distribution exhibits unevenness. At time t=0 (Fig. 2), there is a maximum pressure differential at the inner surface of the upper plane while travelling from top to bottom. When the planes' velocity is zero and the working bodies are at their most extreme position, there is no dynamic pressure differential (Fig. 3). Backward motion causes an increase in pressure at the inner surface of the lower plane (time point t=1/2; Fig. 4).

The ratio of relative air velocity to the surplus pressure is proportional. The boundary condition (9), which inhibits the layer of air immediately near to the inner surface of the plane, applies. Its relative speed drops to zero. The boundary conditions (10) to (12) are created when the kinetic energy of air movement transforms into the energy of excess pressure.

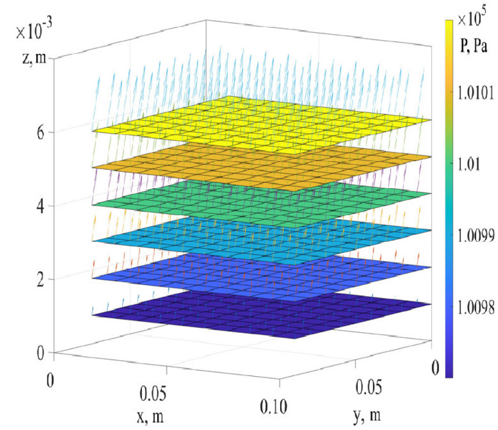

Fig. 2

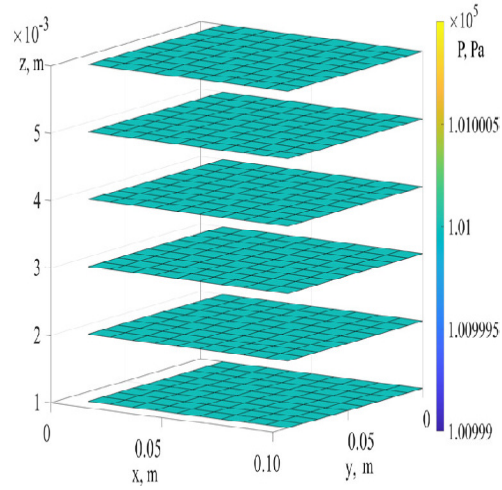

Fig. 3

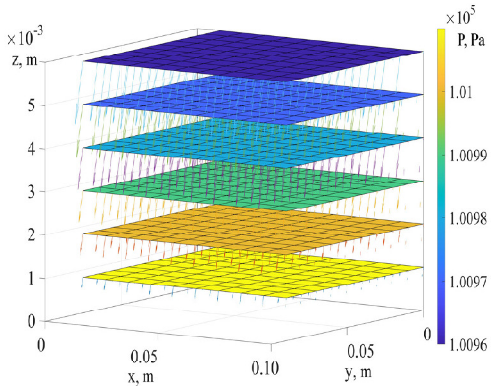

Fig. 4

As a result, the working bodies of a vibratory machine pass the neutral position when the maximum air velocity relative to working surfaces is reached. The highest relative air velocity, while travelling from top to bottom, is found close to the lower plane. Near the top plane when climbing from the bottom to the top.

Results of a research on the use of a sweep approach are discussed.

The aforementioned calculation results (Fig. 2-4) show that the field of velocities and pressures varies in accordance with the harmonic law during an interval that is equivalent to the period of oscillations of a vibratory machine's operating surfaces. The direction of air motion turns to the opposite for t =[0; 1/2], which is equivalent to the half-period of oscillations of the working planes, and the pattern of the distribution of velocities and pressures for t=1/2 (Fig. 4) mimics the pattern for t=0 (Fig. 2). It is evident that the pattern of the distribution of velocities and pressures would assume the shape depicted in Fig. 2 for the initial time point t=0 during the whole period of oscillations, for t=1/. The dynamic pressure, which is applied to the air by the arriving plane on the one hand and by sucking near the exiting plane on the other, causes a pressure decrease that influences the flow of the air.

The vortex phenomena that are most likely to really happen are not included in the pattern of air movement dynamics that results. However, a calculated derivation of swirls is not feasible due to the utilized model, which ignores the viscosity of the air. Such vortex effects would be attained by employing the Navier- Stokes equation as a kinematic model rather than the Euler equation.

The methodological issue is highlighted, although it has little bearing on the issue's practical implications. The accounting of the tangential components of air velocity is crucial for understanding how the aerodynamic factor affects the nature of the vibration movement of seeds. They can also be effectively calculated at low time and computer memory costs thanks to the suggested calculation approach. However, at the same time, the estimating methodology would be significantly more complex and might not allow for the implementation of the sweep approach.

The formalized description of the boundary conditions must be improved in order to take into account the numerous structural components employed to mitigate the negative impacts of the aerodynamic factor. This will boost future chances for the advancement of the findings provided here. Additionally, we think the suggested approach has a standalone benefit for use in gas dynamic computations across the entire spectrum of gas currents. Without taking into account viscosity, the automated convergence of the sweep method's solution might greatly reduce the many computing challenges involved in figuring out the properties of a gas (air) in subsonic flows.

Conclusions

1. A system of gas-dynamic equations recorded for the situation of ideal gas across the acoustic range has been solved using an algorithm for sweeping along three orthogonal axes.
2. 2. The method determines the field of pressures and velocities in the air mass, which is situated between two parallel oscillation planes of a vibratory machine. It is advisable to use the resulting three-dimensional air dynamics pattern to create complex models to investigate the interactions between the air environment and the oscillating components of vibratory machines when tackling the tasks of their design (improvement). This is because the

pattern doesn't require a lot of computational resources.

References

1. Adamchuk, V. V., Prilutsky, A. N. (2017). Theoretical studies of non-grid pneumovibrating centrifugal separation of seed mixtures. Mekhanizatsiya ta elektryfikatsiya silskoho hospodarstva, 5 (104), 17–27.
2. Antoshchenkov, R. V. (2017). Dynamika ta enerhetyka rukhu bahatoelementnykh mashynno-traktornykh ahrehativ. Kharkiv: KhNTUSH, 244.
3. Chadwick, P. (1999). Continuum Mechanics: Concise Theory and Problems. Dover Books on Physics, 192.
4. Chattot, J. J., Hafez, M. M. (2015). Theoretical and Applied Aerodynamics. Springer. doi: https://doi.org/10.1007/978-94-017- 9825-9
5. Dimov, I., Fidanova, S., Lirkov, I. (2015). Numerical Methods and Applications. Springer, 313. doi: https://doi.org/10.1007/978- 3-319-15585-2
6. Durst, F. (2008). Fluid Mechanics. Springer, 723. doi: https://doi.org/10.1007/978-3-540-71343-2
7. Dzyuba, O., Dzyuba, A., Polyakov, A., Volokh, V., Antoshchenkov, R., Mykhailov, A. (2019). Studying the influence of structural-mode parameters on energy efficiency of the plough PLN-3-35. Eastern-European Journal of Enterprise Technologies, 3 (1 (99)), 55–65. doi: https://doi.org/10.15587/1729-4061.2019.169903
8. Khodabakhshian, R., Emadi, B., Khojastehpour, M., Golzarian, M. R. (2018). Aerodynamic separation and cleaning of pomegranate arils from rind and white segments (locular septa). Journal of the Saudi Society of Agricultural Sciences, 17 (1), 61–68. doi: https://doi.org/10.1016/j.jssas.2016.01.003
9. Lei, L., Chaolu, T. (2011). A new method for solving boundary value problems for partial differential equations. Computers & Mathematics with Applications, 61 (8), 2164–2167. doi: https://doi.org/10.1016/j.camwa.2010.09.002
10. Luk'yanenko, V. M., Galich, I. V., Nikiforov, A. A. (2015). Mehatronnaya vibratsionnaya semyaochistitel'naya mashina. Mehanizatsiya sel'skohozyaystvennogo proizvodstva, 156, 413–419.
11. Luk'yanenko, V. M., Nikiforov, A. A. (2017). Postanovka zadachi rascheta polya skorostey vozdushnogo sredy mezhdu dvumya ekvidistantnyh ploskostyami pri osushchestvlenii imi sinhronnyh garmonicheskih kolebaniy. Inzheneriya pryrodokorystuvannia, 2, 33–37.
12. Lukianenko, V., Nikiforov, A., Petrik, A. (2017). The method of calculating the velocity field of the air environment between two equidistant ploskostyami when they commit synchronous harmonic. Vestnik HNTUSG im. P. Vasilenko, 180, 100–105.
13. Mastorakis, N., Sakellaris, J. (Eds.) (2009). Advances in Numerical Methods. Lecture Notes in Electrical Engineering. Springer. doi: https://doi.org/10.1007/978-0-387-76483-2
14. Nazir, A., Khan, K., Maan, A., Zia, R., Giorno, L., Schroën, K. (2019). Membrane separation technology for the recovery of nutraceuticals from food industrial streams. Trends in Food Science & Technology, 86, 426–438. doi: https://doi.org/10.1016/ j.tifs.2019.02.049
15. Okunola, A. A., Igbeka, J. C. (2009). Development of a reciprocating sieve and air blast cereal cleaner. African Crop Science Conference Procedding, 9, 3–8.
16. Posner, E. S. (2009). CHAPTER 5: Wheat Flour Milling. WHEAT: Chemistry and Technology, 119–152. doi: https:// doi.org/10.1094/9781891127557.005
17. R.Antoshchenkov et. All. (2020) Applied Mechanics. DOI: 10.15587/1729-4061.2020.198501
18. Širca, S., Horvat, M. (2018). Computational Methods in Physics. Graduate Texts in Physics. Springer. doi: https://doi.org/ 10.1007/978-3-319-78619-3

19. Strauch, D. (2009). Classical Mechanics. Springer, 405. doi: https://doi.org/10.1007/978-3-540-73616-5
20. Volkov, K. N. (2009). Preconditioning of the Euler and Navier-Stokes equations in low-velocity flow simulation on unstructured grids. Computational Mathematics and Mathematical Physics, 49 (10), 1789–1804. doi: https://doi.org/10.1134/ s0965542509100133
21. Zavgorodniy, A. I., Sinyaeva, O. V. (2012). Dvizheniya shara vozdushnom potoke mezhdu vibriruyushchimi ploskostyami. Vibratsiyi v tekhnytsi ta tekhnolohiyakh, 3, 20–27.