ABSTRACT AND REFERENCES

APPLIED MECHANICS

RESEARCH AND ANALYSIS OF THE STRESSED-STRAINED STATE OF METAL CORRUGATED STRUCTURES OF RAILROAD TRACKS (p. 4-9)

Vitalii Kovalchuk, Joseph Luchko, Iryna Bondarenko, Ruslan Markul, Bohdan Parneta

We conducted research into, and analysis of, bearing capacity of metal corrugated structures (MCS), which are in service in the railroads of Ukraine. To assess the stressed-strained state of MCS, a calculation was carried out of equivalent forces that arise from the rolling stock when there is an irregularity in a railroad track, formed in the course of using a pipe. We ran analysis of the MCS bearing capacity at boundary load from the rolling stock of railroads by the indicator of influence of the type of corrugation (corrugattion dimensions) and characteristics of soils on their stressed-strained state. A calculation of equivalent forces was conducted by the method of calculation of a railroad track by strength and stability. A mathematical algorithm was programmed by the Peterson method to calculate the stressed-strained state of MCS. An analysis of multi-choice calculations of the MCS strength, which is made from the corrugated structure Multiplate MR150 with thickness of corrugated sheet 6 mm and dimensions of the corrugation waves 150×50 mm and 380×140 mm, demonstrated that its bearing capacity is provided. The degrees of compaction of the soil backfill are from 0.9 to 1.0. A metal corrugated structure that is made from corrugated sheets of size 200×55 mm, at the degree of compaction of the soil backfill 0.9, there occur stresses that exceed the permissible. Further accumulation of residual stresses from the action of dynamic wheel load, taking into account time parameter, may affect the occurrence of fluidity of material of a metal pipe. This may lead to the formation of its plastic irreversible deformations. Results of the MCS bearing capacity that we received are necessary for the optimal design of MCS, to establish the causes of occurrence of defects, to make timely relevant engineering decisions to increase bearing capacity of MCS and substantiate reasonable use of funds for the construction or renovation of existing transport facilities using metal corrugated pipes. These studies may be used by engineers at the bridge-testing stations of Ukrainian Railroads and Ukravtodor and by design organisations engaged in the design of metal corrugated structures of large diameters.

Keywords: metal corrugated structure, thickness of metal corrugated pipe, equivalent forces, dynamic load, stresses.

References

1. Kovalchuk, V. V. (2015). The effect of corrugated elements thickness on the deflected mode of corrugated metal structures. Bulletin of Dnipropetrovsk National University of Railway Transport, 3 (57), 199–207. doi: 10.15802/stp2015/46079
2. Luchko, Y. Y., Kovalchuk, V. V., Nabochenko, O. S. (2015). Study of carrying capacity of a corrugated metal construction by criterion of yield hinge development. Bulletin of Dnipropetrovsk National University of Railway Transport, 5 (59), 180–194. doi: 10.15802/stp2015/55340
3. Koval, P. M., Babiak, I. P., Sitdykova, T. M. (2010). Normuvannia pry proektuvanni i budivnytstvi sporud z metalevykh hofrovanykh konstruktsii. Visnyk Dnipropetr. nats. un-tu zal. transp. im. ak. V. Lazariana, 39, 114–117.
4. Novodzinskij, A. L., Kleveko, V. I. (2012). Uchet vlijanija tolshhiny gofrorovannogo jelementa na prochnost' i ustojchivost' metallicheskoj vodopropusknoj truby. Vestnik PNIPU. Stroitel'stvo i arhitektura, 1, 81–94.
5. Wysokowski, A., Janusz, L. (2007). Mostowe konstrukcje gruntowo – powlokowe. Laboratoryjne badania niszczace. Awarie w czasie budowy i eksploatacji. XXIII konferencja naukowo-techniczna. Szczecin, 541–550.
6. Esmaeili, M., Zakeri, J. A., Abdulrazagh, P. H. (2013). Minimum depth of soil cover above long-span soil-steel railway bridges. International Journal of Advanced Structural Engineering, 5 (1), 7. doi: 10.1186/2008-6695-5-7
7. Ahad, F. R., Enakoutsa, K., Solanki, K. N., Tjiptowidjojo, Y., Bammann, D. J. (2013). Modeling the Dynamic Failure of Railroad Tank Cars Using a Physically Motivated Internal State Variable Plasticity/Damage Nonlocal Model. Modelling and Simulation in Engineering, 2013, 1–11. doi: 10.1155/2013/815158
8. Saat, M. R., Barkan, C. P. L. (2011). Generalized railway tank car safety design optimization for hazardous materials transport: Addressing the trade-off between transportation efficiency and safety. Journal of Hazardous Materials, 189 (1-2), 62–68. doi: 10.1016/j.jhazmat.2011.01.136
9. DBN V.2.3-14: 2006. Sporudy transportu. Mosty ta truby. Pravyla proektuvannia (2006). Kyiv, 359.
10. VBN V.2.3-218-198:2007. Sporudy transportu. Proektuvannia ta budivnytstvo sporud iz metalevykh hofrovanykh konstruktsii na avtomobilnykh dorohakh zahalnoho korystuvannia (2007). Kyiv: 122.
11. Duncan, J. M., Drawsky, R. H. (1983). Design Procedures for Flexible Metal Culvert Structures. Reports No. UCB/GT/83-02. Berkeley.
12. Vaslestad, J. (1994). Long-term behaviour of flexible large-span culverts. Publication No. 74. Oslo, 38–56.
13. Handbook of steel drainage and highway construction products, American Iron and Steel Institute (2002). Canada, 482.
14. AASHTO: Standart Specifications for Highway Bridges. American Association of State Highway and Transportation Officials (2001). Washington, D. C.
15. Waster, M. (2008). Verifiering av nyutvecklat dimensioneringsprogram samt vidareutveckling for jernvagstrafik. Sweden, 143.
16. Pettersson, L., Sundquist, H. (2007). Design of soil steel composite bridges. Stockholm, 84.
17. Danilenko, E. I., Rybkin, V. V. (2006). Pravyla rozrakhunkiv zaliznychnoi kolii na mitsnist i stiikist. TsP-0117. Kyiv: Transport Ukrainy, 168.

OPTIMIZATION OF UNIFORMLY STRESSED STRUCTURES OF CYLINDRICAL TANKS IN CAD (p. 10-16)

Oksana Saveleva, Yurii Khomyak, Iraida Stanovska, Alla Toropenko, Evgeniya Naumenko

It was established that in the housings of apparatuses that work under pressure, a flat bottom is the weakest element, because of which it is necessary to increase its thickness by 3–5 times in comparison with the wall thickness. This is connected with the fact that under conditions of loading of the bottoms of vessels, mechanical stresses in

them are distributed extremely unevenly. Therefore, we set the purpose to decrease metal intensity of apparatuses at the stage of their automated designing by creating uniformly stressed structural elements with the retention of indices of their reliability through rational redistribution of the used materials inside the element, which ensures equal stress and minimally permissible mass of the finished product.

We attempted to solve this problem through varying one of the main design characteristics – thickness of the flat bottom of a tank, loaded with internal pressure.

To achieve this aim, a method for the optimization of shape of a round plate with variable thickness was developed. It implies transition from the fixed thickness of the plate in its center to its fixed volume. Within the method of optimization, we proposed a model of bend of a round plate with variable thickness in the form of exponential Gauss function, with regard to dependence of thickness in the center of a plate on its volume.

In the method for solving the equation of plate bending, degenerate hyper-geometric functions of Kummer and Whittaker are used. The method was tested in the process of real automated design of the tank for storing caustic liquids.

Keywords: uniformly stressed components, Kummer and Whittaker functions, plates of variable thickness, CAD.

References

1. Arnab, B., Islam, S. M. R., Khalak, A. A., Afsar, A. M. (2014). Finite Difference Solution to Thermoelastic Field in a Thin Circular FGM Disk with a Concentric Hole. Procedia Engineering, 90, 193–198. doi: 10.1016/j.proeng.2014.11.836
2. Cerulli, C., Meijer, P., van Tooren, M., Hofstee, J. (2004). Parametric Modeling of Aircraft Families for Load Calculation Support. 45th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics & Materials Conference. doi: 10.2514/6.2004-2019
3. Goncharova, O., Maksimov, V., Jankovich, D. (1997). Method of Durability Life Approval of Motor Vehicle Axle Beam for Design Optimization. XVI Conference "Science and Motor Vehicles-97". Belgrade, 175–178.
4. Vodopyanov, A. I., Pavlenko, P. V. (2007). Prichiny i mehanizmyi razrusheniy v ekspluatatsii lopatok turbinyi dvigatelya NK-8-2U. Nauchnyiy vestnik MGTU GA. Seriya Aeromehanika i prochnost, 119, 36–40.
5. Aryassov, G., Gornostajev, D. (2013). The calculation of round plates under the action of local loading by generalized functions. 13th International Symposium «Topical Problems in the Field of Electrical and Power Engineering». Parnu, 296–299.
6. Stanovskiy, A. L., Maksimov, V. G., Goncharova, O. E. (1998). Optimizatsiya profilya nesuschih elementov metallokonstruktsiy. Naukoviy visnik OGPU, 6, 139–144.
7. Daschenko, O., Stanovskyi, O., Khomiak, Yu., Naumenko, E. (2016). Mathematical model of connections cylindrical shell with the bottom variable thickness. «Information technology and automation – 2016»: Proceedings IX Annual scientific conference. Odessa, ONAFT, 29–30.
8. Mousavi, S. M., Reddy, J. N., Romanoff, J. (2016). Analysis of anisotropic gradient elastic shear deformable plates. Acta Mechanica, 227 (12), 3639–3656. doi: 10.1007/s00707-016-1689-z
9. Evseychik, Yu. B., Medvedev, K. V. (2008). Chuvstvitelnost gidroakusticheskogo datchika davleniya. Gidravlika i gidrotehnika, 62, 10–16.
10. Shlyahin, D. A. (2013). Vyinuzhdennyie osesimmetrichnyie kolebaniya tonkoy krugloy bimorfnoy plastinyi stupenchatoy tolschinyi i zhestkosti. Inzhener-nyiy vestnik Dona, 1 (24), 21–25.
11. Brar, G. S., Hari, Y., Williams, D. K. (2010). Calculation of Working Pressure for Cylindrical Vessel Under External Pressure. ASME 2010 Pressure Vessels and Piping Conference: Volume 3. doi: 10.1115/pvp2010-25173
12. Bovnegra, L. V., Bondarenko, V. V., Koshulyan, S. V. (2013). Obobschenie metoda virtualnogo obekta na raschetyi optimalnyih parametrov slozhnyih system. Materialy XXI seminara «Modelirovanie v prikladnyih nauchnyih issledovaniyah», 112–113.
13. Prihodko, N. B., Leyzerovich, G. S., Konova, G. V. (2014). O dvuh sposobah postroeniya teorii plastin peremennoy tolschinyi. Uchenyie zapiski KnAGTU, 4-1 (20), 46–54.
14. Rogalevich, V. V., Timashev, S. A. (2012). Novyiy priblizhennyiy metod rascheta gibkih plastin postoyannoy i peremennoy tolschinyi. Akademicheskiy vestnik UralNIIproekt, 1, 67–71.
15. Novikov, V. V., Maksimov, V. G., Balan, S. A., Goncharova, O. E. (1999). Matematicheskoe modelirovanie profilya ravnogo soprotivleniya. Optimizatsiya v materialovedenii. Odessa: AstroPrint, 151.
16. Gradshteyn, I. S., Zwillinger, D., Moll, V. (2015). Mathematical Physics and Mathematics. Amsterdam: Academic Press, 1133.
17. Homyak, Yu. M., Tshigam, G. Zh. (2015). Rozvyazok zadachi viginu krugloyi plastini zminnoyi tovschini z vikoristannyam funktsiy UIttekera. Pedagogicheskoe masterstvo prepodavatelja vysshej shkoly, 3, 94–95.
18. Aomoto, K., Kita, M. (2011). Theory of Hypergeometric Functions. Springer Monographs in Mathematics. doi: 10.1007/978-4-431-53938-4

RESEARCH BY A 3D MODELLING OF THE SCREEN BOX FLAT TRANSLATORY VIBRATIONS EXCITED BY A BALL AUTO-BALANCER (p. 16-22)

Gennadiy Filimonikhin, Volodymyr Yatsun, Mihail Lichuk, Irina Filimonikhina

The study investigates vibrations of a screen box with its flat translational motion being excited by a ball auto-balancer.

The CAD system Solidworks is used to develop a 3D model of a vibration machine and a dual-frequency vibroexciter in the form of a ball auto-balancer.

The 3D modeling has helped establish the law of motion of the center of mass of the box. The trajectory of its motion is studied, and the tests have shown that the motion is the sum of two circular motions:

– a slow circular motion at an angular velocity of the balls' rotation;

– a fast circular motion at an angular velocity of the rotor rotation.

The motion trajectory of the center of mass of the box is an epitrochoid. The projections of the center of mass of the box onto the coordinate axes in the motion plane allegedly change under the law of dual-frequency vibrations.

Under the assumption that the projections of the center of mass of the box produce dual-frequency vibrations, the software package Statistica for statistical analysis was used to choose the coefficients under a relevant law. Eventually, it has been established that:

– the process of determining the values of the coefficients is steady (robust), and the coefficients practically do not change with changes in the time interval;

– the amplitude of slow vibrations is directly proportional to the total mass of the balls;

– the amplitude of fast vibrations is directly proportional to the unbalance on the auto-balancer body.

For both short and long intervals of time (during several slow vibrations of the box), the discrepancy between the law of vibrations of the center of mass of the box that was found through the 3D modeling and the law of dual-frequency of vibrations found by the method of statistical analysis does not exceed 1 %.

The results of the study show that the auto-balancer works as two independent inertial vibroexciters. The first vibroexciter is formed by the balls that are closely pressed to each other. They rotate around the longitudinal axis of the shaft at the frequency of the box's own vibrations. It generates its slow resonant circular vibrations. The second vibroexciter is formed by the unbalanced mass on the auto-balancer body. It excites a fast circular motion of the box at the speed of the shaft rotation.

Keywords: vibroexciter, dual-frequency vibrations, 3D modeling, unbalance, resonant vibration machine, auto-balancer, screen.

References

1. Vlasova, V. V. (2007). Mineral processing. Irkutsk: IGTU, 159.
2. Lapshin, E. S., Shevchenko, A. I. (2012). Analysis of the condition of development vibrating screening at dehydration of mineral raw materials. Geotechnical Mechanics, 101, 84–104.
3. Hou, Y., Gao, J., Liang, J. (2012). Dynamics Simulation for Solid Conveyance of Dual-Frequency Vibrating Screen. Advanced Science Letters, 15 (1), 391–395. doi: 10.1166/asl.2012.4149
4. Bulat, A. F., Shevchenko, G. A. (2010). Influence polyfrequency oscillation sieving surfaces of vibrating screens on separation of bulk materials. Scientific Bulletin of National Mining University, 4, 137–143.
5. Filimonikhin, G. B., Yatsun, V. V. (2015). Method of excitation of dual frequency vibrations by passive autobalancers. Eastern-European Journal of Enterprise Technologies, 4 (7 (76)), 9–14. doi: 10.15587/1729-4061.2015.47116
6. Filimonikhin, G. B., Yatsun, V. V. (2016). Investigation of the process of excitation of dual-frequency vibrations by ball auto-balancer of GIL 42 screen. Eastern-European Journal of Enterprise Technologies, 1 (7 (79)), 17–23. doi: 10.15587/1729-4061.2016.59881
7. Filimonikhin, G., Yatsun, V., Dumenko, K. (2016). Research into excitation of dual frequency vibrational-rotational vibrations of screen duct by ball-type auto-balancer. Eastern-European Journal of Enterprise Technologies, 3 (7 (81)), 47–52. doi: 10.15587/1729-4061.2016.72052
8. Artyunin, A. I., Khomenko, A. P., Eliseev, S. V., Ermoshenko, Y. V. (2015). The generalized model of vibration mechanics and nonlinear effect of "jam" of the pendulum at the resonant frequencies of the mechanical system. Mechanical Industry and Engineering Education, 1 (42), 61–67.
9. Artyunin, A. I. (1993). Research of the movement of a rotor with the autobalancer. Mechanical engineering, 1, 15–19.
10. Artyunin, A. I., Alhunsaev, G. G. (2005). About special regime of movement rigid rotor with elastic supports and pendulum autobalancing. Proceedings of the higher educational institutions. Mechanical Engineering, 10, 8–14.
11. Artyunin, A. I., Ermoshenko, Y. V., Popov, S. I. (2015). Experimental study of the effect of "jam" of the pendulum at the resonant frequencies of the mechanical system. Modern technologies. System analysis. Modeling, 2 (46), 20–25.
12. Ryzhik, B., Sperlingm, L., Duckstein, H. (2002). Display of the Sommerfeld-Effect in a Rigid Rotor One-plain Autobalancing Device. Proc. Of XXX Summer School "Advanced Problems in Mechanics", 554–563.
13. Ryzhik, B., Sperling, L., Duckstein, H. (2004). Non-synchronous Motions Near Critical Speeds in a Single-plane Autobalancing Device. Technische Mechanik, 24, 25–36.
14. Lu, C.-J., Tien, M.-H. (2012). Pure-rotary periodic motions of a planar two-ball auto-balancer system. Mechanical Systems and Signal Processing, 32, 251–268. doi: 10.1016/j.ymssp.2012.06.001
15. Lavendel, E. E. (1981). Vibration technique: Enchiridion. In 6 Vol. Vol. 4. Vibrating processes and machines. Moscow, 509.
16. Savelov, A. A. (1960). Flat curves: Systematization, properties, applications (reference guide). Moscow: FIZMATLIT, 293.
17. Halafyan, A. A. (2007). STATISTICA 6. Statistical analysis of data. Moscow: LLC "Binom-Press", 512.

RESEARCH OF STABILITY AND TRANSITION PROCESSES OF THE FLEXIBLE DOUBLE-SUPPORT ROTOR WITH AUTO-BALANCERS NEAR SUPPORT (p. 22-27)

Valery Goncharov, Andrey Nevdakha, Yuriy Nevdakha, Vasiliy Gutsul

Within the discrete model the stability of main motions and transition processes of the flexible unbalanced two-support rotor at its balancing by two passive auto-balancers located in close proximity to supports is investigated.

The simplified system of differential equations describing the process of auto-balancing of the flexible rotor with respect to four Lagrange coordinates – displacements of the shaft in supports and the given total rotor unbalances is received.

It is shown that the received system of equations accurate within designations matches the equations describing the process of dynamic auto-balancing of the rigid rotor on pliable supports with two auto-balancers. Therefore, main motions of the flexible rotor on condition of their existence are always steady on above resonance velocities of rotation.

At velocities close to any critical velocity the conditions of existence of main motions can be violated. For expansion of the area of stability of main motions it is necessary to increase the balancing capacity of auto-balancers.

Analytically (using the roots of the characteristic equation) the assessment of duration of passing of transition processes when balancing the flexible rotor is carried out. At the same time, it is established that:

– transition processes are divided into: fast at which fast relative motions of corrective weights stop and the motion of rotor corresponding to the current given total rotor unbalances of the flexible rotor is established; slow at which corrective weights come to the auto-balancing positions;

– at the increase in forces of resistance to relative motion of corrective weights duration of exit of corrective weights to the cruiser velocity of rotor decreases and duration of arrival of corrective weights to the auto-balancing position increases;

– duration of passing of transition processes does not decrease at the reduction of the mass of corrective weights, rigidity of supports, remoteness of supports from the center of mass of the flexible rotor;

– duration of passing of transition processes does not increase at the increase in the cruiser velocity of the rotor

at velocities higher than the first critical (if at the same time the conditions of existence of main motions are not violated).

Keywords: flexible rotor, auto-balancer, auto-balancing, main motions, stability, transition processes.

References

1. Simonovsky, V. (2002). Dinamika rotorov tsentrobezhnykh mashin [The dynamics of the rotors of centrifugal machines]. Sumy: Izd-vo Sumy State University, 143.
2. Yamamoto, T., Ishida, Y. (2012). Linear and Nonlinear Rotordynamics: A Modern Treatment with Applications. 2nd edition. Wiley-VCH Verlag GmbH & Co. KGaA, 474. doi: 10.1002/9783527651894
3. Filimonikhin, G., Gadiaka, V., Panenko, V., Goncharov, V. (2015). Pat. 107719 Ukraine (of 20 years), IPC G01M 1/32. Sposib balansuvannya hnuchkoho dvoopornoho rotora pasyvnymy avtobalansyramy [Method for balancing flexible double-seat rotor with passive auto balancers]. The applicant and the patentee: Kirovograd National Technical University. № a201301213; declareted: 11.08.2014; published: 10.02.2015, Bul. 3, 8.
4. Detinko, F. (1956). Ob ustoychivosti raboty avtobalansira dlya dinamicheskoy balansirovki [On the stability of work auto-balancer for dynamic balancing]. Proceedings of the Academy of Sciences of the USSR. Meh. and machine building, 4, 38–45.
5. Majewski, T., Szwedowicz, D., Melo, M. A. M. (2015). Self-balancing system of the disk on an elastic shaft. Journal of Sound and Vibration, 359, 2–20. doi: 10.1016/j.jsv.2015.06.035
6. Goncharov, V., Filimonikhin, G., Dumenko, K., Lychuk, M. (2016). Studying the peculiarities of balancing of flexible double-support rotors by two passive automatic balancers placed near supports. Eastern-European Journal of Enterprise Technologies, 4 (7 (82)), 4–9. doi: 10.15587/1729-4061.2016.75115
7. Filimonikhina, I. I., Filimonikhin, G. B. (2007). Conditions for balancing a rotating body in an isolated system with automatic balancers. International Applied Mechanics, 43 (11), 1276–1282. doi: 10.1007/s10778-007-0132-5
8. Filimonikhin, G., Filimonikhina, I., Dumenko, K., Lychuk, M. (2016). Empirical criterion for the occurrence of auto-balancing and its application for axisymmetric rotor with a fixed point and isotropic elastic support. Eastern-European Journal of Enterprise Technologies, 5 (7 (83)), 11–18. doi: 10.15587/1729-4061.2016.79970
9. Blekhman, I. (1971). Sinkhronizatsiya dinamicheskikh sistem [Synchronization of dynamical systems]. Moscow: Nauka, 896.
10. Sperling, L., Ryzhik, B., Duckstein, H. (2004). Single-Plain Auto-Balancing of Rigid Rotors. Technische Mechanik., 24 (1), 1–24.
11. Sperling, L., Ryzhik, B., Duckstein, H. (2001). Two-plain automatic balancing. Machine Dynamics Problems, 25 (3/4), 139–152.
12. Rodrigues, D. J., Champneys, A. R., Friswell, M. I., Wilson, R. E. (2011). Two-plane automatic balancing: A symmetry breaking analysis. International Journal of Non-Linear Mechanics, 46 (9), 1139–1154. doi: 10.1016/j.ijnonlinmec.2011.04.033
13. Gorbenko, A. (2011). Obshchaya struktura uravneniy dvizheniya rotornykh mashin s avtobalansirom passivnovo tipa [The overall structure of the equations of motion of rotating machines with passive type auto-balancer]. Aviatsionno-kosmicheskaya tekhnika i tekhnologiya. Dvigateli i energoustanovki aerokosmicheskikh letatelnykh apparatov, 8 (85), 71–76.
14. Gorbenko, A. (2014). Mass-Inertial Characteristics and Dimensionless Equations of Two-bearing Rotor Motion with Auto-balancer in Terms of Compensating Body Mass. Science and Education of the Bauman MSTU, 15 (12), 266–294. doi: 10.7463/1215.0827773
15. Goncharov, V. (2015). Doslidzhennya stiykosti rotora v korpysi na podatlyvykh oporakh, yakyy dynamichno srivnovazhuyetssya dvoma avtobalansyramy [Research of stability of rotor that dynamically is counterbalanced by two auto-balancers, in corps on pliable supports]. Ukrainian National Scentific Journal, Vibratsiyi v tekhnitsi ta tekhnologiyakh, 4 (80), 10–18.

DEVELOPMENT OF ALGORITHM FOR CALCULATING DYNAMIC PROCESSES OF RAILROAD TRACK DEFORMABILITY WORK (p. 28-36)

Iryna Bondarenko

A creation of algorithm for the calculation of dynamic processes of the track deformability is highlighted. It is a method for the description of transfer of impact of the rolling stock on the track. It is proposed, as a dynamic influence of the rolling stock on the track, to consider a parametric impact of the pulses that act in the point of contact between rails and wheels and propagate maintaining the properties of elastic waves. Characteristic features of the algorithm are the application of principles of the theory of wave propagation in solid materials. Due to these peculiarities, the possibility is provided for the determination of a wave front at a non-stationary wave process that occurs when the source of oscillations moves in a motionless environment and possesses the Doppler Effect with its registration in the experiments. We took into account that the special features of the transfer of dynamic load are:

– the period of load action on the track that defines the frequency of pulse oscillation that is transferred to the track design;

– variable directivity of the oscillation pulse over time, which is predetermined by changes in mode, polarization and waves shape at propagation. This allows us: to obtain spatial parameters of propagation of the process of deformability in the track design; to predict the change in the stressed-strained state of the elements of design and the design itself depending on the characteristics of materials and structure elements of the track design; to solve problems about the interaction between the contacting surfaces at the propagation of loads with regard to relations between the amplitudes of oscillations in the transition of waves from one element to another one.

Thus, our research demonstrated the possibility of directed regulation of the process of deformability of a railroad track by changing the characteristics of materials and design of the elements of a railroad track.

The algorithm presented complements the research on modeling for the purpose of establishing assessment of conditions of functional safety of a railroad track. Based on the developed algorithm, further studies may be conducted for determining the mechanical performance of elements of the track and the track design itself from the influence of the rolling stock for the purpose of evaluating and predicting the terms of operation of the elements and design of the track.

Keywords: dynamic load, amplitude of oscillations, excitation frequency by force pulse, oscillations propagation.

References

1. Sokol, E. N., Perejmybida, A. A., Radkevich, D. A. (2006). «Klassicheskij» shod rel'sov podvizhnogo sostava. Kyiv: Feniks, 168.
2. Danilenko, E. I. (2010). Zaliznychna kolija. Ulashtuvannja, proektuvannja i rozrakhunky, vzajemodija z rukhomym skladom. In 2 volumes. Vol. 1. Kyiv: Inpres, 528.
3. Ushkalov, V. F., Podel'nikov, I. V. (2009). Tipovye formy iznoshennyh profilej koles. Tehnicheskaja mehanika, 1, 50–55.
4. Ushkalov, V. F., Bezrukavyj, N. V. (2015). Uvelichenie resursa kolesnyh par za schet ispol'zovanija iznosostojkih profilej koles. Tehnicheskaja mehanika, 1, 97–103.
5. Bondarenko, I. O. (2016). Analiz vplivu kolisnoi pari na proces deformativnoi roboti kolii Problemy mehaniki zheleznodorozhnogo transporta. XIV mezhdunarodnaja konferencija, 26–27.
6. Auersch, L. (2008). The Influence of the Soil on Track Dynamics and Ground-Borne Vibration. Noise and Vibration Mitigation for Rail Transportation Systems, 122–128. doi: 10.1007/978-3-540-74893-9_17
7. Hussein, M. F. M., Hunt, H. E. M., Rikse, L., Gupta, S., Degrande, G., Talbot, J. P. et. al. (2008). Using the PiP Model for Fast Calculation of Vibration from a Railway Tunnel in a Multi-layered Half-Space. Noise and Vibration Mitigation for Rail Transportation Systems, 136–142. doi: 10.1007/978-3-540-74893-9_19
8. Lombaert, G., Degrande, G., François, S., Thompson, D. J. (2015). Ground-Borne Vibration due to Railway Traffic: A Review of Excitation Mechanisms, Prediction Methods and Mitigation Measures. Noise and Vibration Mitigation for Rail Transportation Systems, 253–287. doi: 10.1007/978-3-662-44832-8_33
9. Thompson, D. (2014). Railway noise and vibration: the use of appropriate models to solve practical problems. 21st International Congress on Sound and Vibration, 1–16.
10. Feng, Z., De-Cheng, F., Xian-Zhang, L., Qiong-Lin, L. (2013). Numerical simulation of dynamic response of subgrade under moving heavy truck in cold regions. Sciences in Cold and Arid Regions, 5 (4), 468–477. doi: 10.3724/sp.j.1226.2013.00468
11. Avillez, J., Frost, M., Cawser, S., Skinner, C., El-Hamalawi, A., Shields, P. (2012). Procedures for Estimating Environmental Impact From Railway Induced Vibration: A Review. ASME 2012 Noise Control and Acoustics Division Conference, 381–392. doi: 10.1115/ncad2012-1083
12. Bondarenko, I. O. (2016). Modeling for establishment of evaluation conditions of functional safety of the railway track. Eastern-European Journal of Enterprise Technologies, 1 (7 (79)), 4–10. doi: 10.15587/1729-4061.2016.59874

RESEARCH OF INFLUENCE OF RANDOM CHANGE OF ANNULAR SEAL PARAMETERS ON EFFICIENCY OF CENTRIFUGAL PUMP (p. 37-42)

Yuliia Tarasewych, Ievgen Savchenko, Nataliia Sovenko, Anna Savchenko

Development of reliable methods of increasing of centrifugal pump efficiency is a very actual scientific and practical problem. One of ways to increase reliability and efficiency of centrifugal pump is an improvement of constructions of annular seals of running part and methods of their calculation. Now in engineering practice several approaches to research of complicated spiral flow of liquid in the small gaps of annular seals are used. Divergences in the conclusions of researchers are likely to be linked with assumptions that are accepted when solving nonlinear equations of non-stationary motion of liquid in the gap of annular seal. It is necessary to mark that divergences between the calculation values of hydrodynamic characteristics of annular seals and rotor-dynamic characteristics of pump that arise during exploitation are first of all possible to explain by the absence of account of possible change of geometrical parameters of the annular seals, caused by the accepted tolerances in the calculations. Using of probabilistic methods of calculation with existent statistical information got on the stages of design and operating of centrifugal pumps will allow to forecast reliability and efficiency of centrifugal pumps taking into account influence and changing of basic operating factors.

Determination of influence of random change of annular seal parameters on flow-rate characteristics and volume efficiency of centrifugal pump is the goal of this research. Dependences to determinate the flow-rate of liquid through the annular seal are got by solving the problem of liquid flow in a cylindrical channel with taking into account the influence of random factors. Influence of random variations of basic geometrical and regime parameters of annular seal on efficiency pump is considered. It is shown on the example of cantilever pump with one impeller, that its efficiency can substantially (up to 1 %) decrease under exploitation. This decrease can be higher in case when pump has more stages.

Keywords: centrifugal pump, annular seal, flow-rate, volume efficiency, random parameters.

References

1. Martsinkovskii, V. A. (1980). Beskontaktnyie uplotnienia rotornykh mashin. Moscow: Mashinistroienie, 200.
2. Martsinkovskii, V. A. (2005). Shchelewyie uplotnenia: teoria i praktika. Sumy: Izdatelstvo Sumskogo gosuniversiteta, 416.
3. Childs, D. W., Kim, C.-H. (1985). Analysis and Testing for Rotordynamic Coefficients of Turbulent Annular Seals With Different, Directionally-Homogeneous Surface-Roughness Treatment for Rotor and Stator Elements. Journal of Tribology, 107 (3), 296. doi: 10.1115/1.3261054
4. Childs, D., Garcia, F. (1987). Test Results for Sawtooth-Pattern Damper Seals: Leakage and Rotordynamic Coefficients. Journal of Tribology, 109 (1), 124. doi: 10.1115/1.3261303
5. Villasmil, L. A., Chen, H.-C., Childs, D. W. (2005). Evaluation of Near-Wall Turbulence Models for Deliberately Roughened Liquid Annular Seals. AIAA Journal, 43 (10), 2137–2146. doi: 10.2514/1.6931
6. Morrison, G. L., Johnson, M. C., Thames III, H. D. (2002). Comparison of the Flow Inside Whirling and Non-Whirling Smooth Annular Seals at 50 % Eccentricity. International Journal of Rotating Machinery, 8 (2), 141–152. doi: 10.1155/s1023621x02000131
7. Lee, Y. B., Shin, S. K., Ryu, K., Kim, C. H., Jang, G. (2005). Test Results for Leakage and Rotordynamic Coefficients of Floating Ring Seals in a High-Pressure, High-Speed Turbopump. Tribology Transactions, 48 (3), 273–282. doi: 10.1080/05698190590948250
8. Athavale, M. M., Hendricks, R. C., Steinetz, B. M. (1996). Numerical Simulation of Flow in a Whirling Annular Seal And Comparison With Experiments. Proc. of the 6th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, 1, 552–562.
9. Choe, B. S., Ha, T.-W. (2010). Prediction of leakage and rotordynamic coefficients for annular-type-plain-pump seal using CFD analysis. IFToMM-Conference on Rotor dynamics, 470–474.

10. Kundera, C. A., Korczak, A., Zahorulko, A., Gerasimiva, K., Plykin, M. (2008). CFD simulation of short and long annular seals. Zeszyty Naukowe Politechniki Swietokrzyskiej. Nauki Techniczne, 77–89.
11. Yang, R., Yang, J., Qi, M., Shi, L., Peng, Z. (2010). Numerical investigation of leakage and power loss for different seal types in turbine stage environment. ASME Proceedings. Heat Transfer, 1081–1090. doi: 10.1115/gt2010-22743
12. Pugachev, A. O. (2009). CFD Optimization of Liquid Annular Seals for Leakage and Rotordynamics Improvement. ASME Proceedings. Structures and Dynamics, 657–667. doi: 10.1115/gt2009-59173
13. Ratner, A. V., Zelenskii, V. G. (1966). Erosia materialov teploenergeticheskogo oborudovania. Moscow: Energia, 272.

ANALYTICAL DESCRIPTION OF THE FLOW OF THE NEWTONIAN LIQUID IN A ROUND TUBE AND ON A HORIZONTAL PLATE (p. 43-49)

Vitaliy Budarin

The object of research is obtaining general integrals and some particular solutions for two common flow conditions of incompressible liquid – laminar and averaged turbulent flow. Mathematical description is based on the system of equations of motion in stresses (Navier) and its special case for the Newtonian liquid. A condition of integrating the equations is the constancy of pressure drop and viscosity along the flow.

The block schemes of obtaining the general integrals for flow in a pipe and turbulent flow on a plate are represented.

Are as a result, three new general integrals and four particular solutions, which are compared with the known equations, were found. It was shown that the integrals of the Navier equation describe the distribution of tangential stress for turbulent flow. An analysis of solutions for the distribution of velocity showed that the Poiseuille equation for laminar flow in a pipe and the Blasius curve for laminar flow on a plate are particular solutions of one general integral. An analysis of the particular solutions made it possible to estimate the thickness of the laminar sublayer under turbulent flow condition. The results of the work create prerequisites for a more detailed further analysis of laminar and turbulent flows.

Keywords: laminar and turbulent flows, general integral, particular solutions, distribution of velocity, tangential stresses.

References

1. Loitsyansky, L. G. (1978). Mechanics of Liguid and Gas. Moscow: Nauka, 736.
2. Munson, B. R. (2009). Fundamentals of fluid mechanics. Wiley, 730.
3. Pijush, K. K., Cohen, I. M., David, R. D. (2012) Fluid mechanics. Elsevier, 891.
4. Shterenliht, D. V. (1991). Hydraulics: Training. Moscow: Energoatomizdat, 351.
5. Fabrekant, N. Y. (1964). Aerodynamics. Moscow: Nauka, 816.
6. Lipanov, A. M. (2011). Theoretical hydromechanics of Newtonian fluids. RAN. Inst. mechanics. Moscow: Nauka, 550.
7. Ferziger, J. H. (1998). Numerical methods for engineering application. New York: Wiley, 400.
8. Isachenko, V. P. (1981). Heat transfer. Moscow: Energy, 417.
9. Kumar, J., Umavathi, J., Prema, H. (2011). Free convection of Walter's fluid flow in a vertical double-passage wavy channel with heat source. International Journal of Engineering, Science and Technology, 3 (1). doi: 10.4314/ijest.v3i1.67643
10. Ingel, L. H. (2008). On the theory of rising convective jets. Russian Academy of Sciences. The physics of the atmosphere and ocean, 44 (2), 178–185.
11. Xia, K.-Q. (2011). How heat transfer efficiencies in turbulent thermal convection depend on internal flow modes. Journal of Fluid Mechanics, 676, 1–4. doi: 10.1017/jfm.2011.50
12. Lawson, J. M., Dawson, J. R. (2015). On velocity gradient dynamics and turbulent structure. Journal of Fluid Mechanics, 780, 60–98. doi: 10.1017/jfm.2015.452
13. Veltzke, T., Thöming, J. (2012). An analytically predictive model for moderately rarefied gas flow. Journal of Fluid Mechanics, 698, 406–422. doi: 10.1017/jfm.2012.98
14. Shiibara, N., Nakamura, H., Yamada, S. (2013). Visualization of turbulent heat transfer to a water flow in a circular pipe using high-speed infrared thermography. Journal of Flow Visualization and Image Processing, 20 (1-2), 65–81. doi: 10.1615/jflowvisimageproc.2014010365
15. Vyatkin, A. A., Ivanova, A. A., Kozlov, V. G. (2016). Convective heat transfer in a rotating horizontal cylindrical fluid layer. Journal of Applied Mechanics and Technical Physics, 57 (2), 344–351. doi: 10.1134/s0021894416020188
16. Budarin, V. (2016). The method of calculating the velocity field and shear stresses in incomressible fluid. Eastern-European Journal of Enterprise Technologies, 2 (7 (80)), 43–48. doi: 10.15587/1729-4061.2016.65900

SIMULATION OF INFLUENCE OF PERTURBATION PARAMETERS ON THE NEW DUAL-CHANNEL CAPACITIVE MEMS GRAVIMETER PERFORMANCE (p. 50-57)

Olena Bezvesilna, Tetiana Khylchenko, Andriy Tkachuk, Sergii Nechai

The paper considers a new dual-channel capacitive MEMS gravimeter of the automated aviation gravimetric system whose accuracy exceeds that of gravimeters that exist at present. It describes in detail its design, which consists of two identical channels. Each of them contains capacitive elements. The connection in series of the adder, amplifier, digital module and OC is performed by means of shielded coaxial cables. All this provides for an increased accuracy in measuring the anomalies of the acceleration of gravity and eliminates the impact of error from vertical acceleration. The simulation of the suspension with complex shape was carried out: the magnitude of impact amounted to 10 μN, displacement of the end of the elastic element equaled 0.5 μm. Based on this refinement, it is possible to accurately determine the value of coefficient of elasticity of the folded suspension. The system was tested on stability by the Nyquist and Hurwitz criteria. Using PC, a change in the initial signal was examined for different values of perturbation amplitudes and frequency for the most unfavorable resonance cases of a dual-channel capacitive gravimeter. An analysis of data revealed that an increase in amplitudes of horizontal acceleration does not affect the amplitude of the forced DCG oscillations.

Thus, the aviation gravimetric system proposed provides for a significant increase in accuracy of measuring the anomalies in the acceleration of gravity, and is appropriate for implementation.

Keywords: dual-channel capacitive gravimeter, MEMS gravimeter, aviation gravimetric system, acceleration of gravity, sensing element.

References

1. Bezvesil'na, O. M. (2007). Aviacijni gravimetrychni systemy ta gravimetry. Zhytomyr: ZhDTU, 604.
2. Bykovskij, A. V., Polynkov, A. V. (2013). K voprosu o razrabotke malogabaritnogo ajerogravimetra. Vestnik MGTU im. N. Je. Baumana, 2 (14), 32–41.
3. Girnjak, Ju. V. (2008). Mikroelektromehanichni systemy u suchasnomu pryladobuduvanni. Vymirjuval'na tehnika ta metrologija, 69, 97–102.
4. Korobijchuk, I. V. (2015). Tehnichni zasoby avtomatyzacii'. Zhytomyr: ZhDTU, 904.
5. Bezvesil'na, O. M., Tkachuk, A. G., Hyl'chenko, T. V. (2016). Pat. № 113038. Aviacijna gravimetrychna systema dlja vymirjuvan' anomalij pryskorennja syly tjazhinnja. MPK: G01V 7/02, G01V 7/16, G01P 15/09. No. a201512205; declareted: 09.12.2015; published: 25.11.2016, Bul. 22.
6. Huang, Y., Olesen, A. V., Wu, M., Zhang, K. (2012). SGA-WZ: A New Strapdown Airborne Gravimeter. Sensors, 12 (12), 9336–9348. doi: 10.3390/s120709336
7. Calvo, M., Hinderer, J., Rosat, S., Legros, H., Boy, J.-P., Ducarme, B., Zurn, W. (2014). Time stability of spring and superconducting gravimeters through the analysis of very long gravity records. Journal of Geodynamics, 80, 20–33. doi: 10.1016/j.jog.2014.04.009
8. Agostino, G. D., Desogus, S., Germak, A., Origlia, C., Quagliotti, D., Berrino, G. et. al. (2008) The new IMGC-02 transportable absolute gravimeter: measurement apparatus and applications in geophysics and volcanology. Annals of geophysics, 51 (1), 39–49.
9. Roussel, C., Verdun, J., Cali, J., Maia, M., d' EU, J. F. (2015). Integration of a strapdown gravimeter system in an autonomous underwater vehicle. ISPRS – International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL-5/W5, 199–206. doi: 10.5194/isprsarchives-xl-5-w5-199-2015
10. Bykovskij, A. V., Polynkov, A. V., Arsen'ev, V. D. (2013). Ajerogravimetricheskij metod izmerenija gravitacionnyh anomalij. Aviakosmicheskoe priborostroenie, 12, 11–19.
11. Bezvesil'na, O. M., Tkachuk, A. G., Koz'ko, K. S. (2014). Pat. № 105122. Aviacijna gravimetrychna systema dlja vymirjuvannja anomalij pryskorennja syly tjazhinnja. MPK G01V 7/00. No. a201304061; declareted: 01.04.2013; published: 10.04.2014, Bul. 7.
12. Godovicyn, I. V., Sajkin, D. A., Fedorov, R. A., Amelichev, V. V.; Stempkovskiy, A. L. (Ed.) (2010). Raschet i modelirovanie osnovnyh parametrov differencial'nogo emkostnogo MJeMS-akselerometra. Moscow: IPPM RAN, 642–647.
13. Shurygina, V. V. (2002). Dolgozhdannye MJeMS. Tehnologija malyh form. Jelektronika: Nauka, Tehnologija, Biznes, 4, 8–13.
14. Sovremennye MJeMS-giroskopy i akselerometry. Available at: http://www.sovtest.ru/news/publications/sovremennye-mems_giroskopy-i-akselerometry/
15. Implications of Emerging Micro and Nanotechnology (2002). Washington, D.C., 266. doi: 10.17226/10582
16. Afonin, A. A., Sulakov, A. S., Jamashev, G. G., Mihajlin, D. A., Mirzojan, L. A., Kurmakov, D. V. (2013). O vozmozhnosti postroenija besplatformennogo upravljajushhego navigacionno-gravimetricheskogo kompleksa bespilotnogo letatel'nogo apparata. Trudy MAI, 66, 47–53.
17. Bezvesil'naja, E. N., Hil'chenko, T. V. (2016). Analiz metodicheskih pogreshnostej dvuhkanal'nogo emkostnogo gravimetra. Sodruzhestvo, 3 (3), 51–54.
18. Dekker, K., Verver, Ja. (1988). Ustojchivost' metodov Runge-Kutty dlja zhestkih nelinejnyh differencial'nyh uravnenij. Moscow: Mir, 334.
19. Rukovodstvo po programmirovaniju na C#. Microsoft. Available at: https://msdn.microsoft.com/en–us/library/67ef8sbd.aspx