LIST OF ABSTRACTS
in Bulgarian
of the publications submitted for the competition for appointment to the academic position of "Professor"

I. PUBLICATIONS (25 items)

1. ***Kirilova, E.***, Vaklieva-Bancheva, N., (2018). ANN modeling of a two-stage industrial ATAD system for the needs of energy integration, Bulgarian Chemical Communications, Volume 50, Special Issue K, Pages 90-99.
https://bcc.bas.bg/BCC_Volumes/Volume_50_Special_K_2018/BCC-50-K-2018-90-99-%20Kirilova.pdf
SJR(Scopus):0.137 (Q4)

This study proposes an approach for Artificial Neural Network (ANN) modeling of a two-stage industrial Autothermal Thermophilic Aerobic Digestion (ATAD) system for wastewater treatment which can be incorporated in an energy-saving framework operating under uncertainties. For this purpose, ANN models with different architectures are developed for bioreactors from the first and second stages of the ATAD system. Then, they are connected in a common model of the two-stage ATAD system. Models are trained and validated using one-year records of data for a real ATAD system. Three different measures are used to assess their efficiency. The best models are used to create the model of the two-stage ATAD system which is validated with selected weekly data. The designed ATAD system model is able to capture the fluctuations in the parameters of the fresh sludge incoming into the system and to predict the expected target temperatures of the treated sludge at the end of each batch. The latter makes it suitable for use in energy-saving framework under uncertainties.

2. Vladova, R., ***Kirilova, E.***, Vaklieva-Bancheva, N., (2018). An approach for reduction of computational complexity of a two-stage stochastic optimization problem for capturing parameters uncertainty in an ATAD system, Bulgarian Chemical Communications, Volume 50, Special Issue K, Pages 100-105.
https://www.bcc.bas.bg/BCC_Volumes/Volume_50_Special_K_2018/BCC-50-K-2018-100-105-Vladova.pdf
SJR(Scopus):0.137 (Q4)

An approach for reduction of the computational complexity of a two-stage stochastic optimization problem for capturing parameters uncertainty in a conventional ATAD system is proposed in this study. The main aim is to find the boundary values of the variables of the first stage of the approach which will result in solutions into the boundaries of the stochastic space. The boundaries of variation of the first stage variables determine the variation of the parameters of the main equipment (heat exchangers surfaces and operating volumes of heat storage tank) which are affected by the change in stochastic parameters. The computational complexity is reduced as in any scenario vertex in the stochastic space a deterministic optimization problem is formulated and solved. As an optimization criterion, the minimum capital costs for purchase of heat exchangers

and heat storage tank are used. For the purpose of the study, data from measurements in a real ATAD system were used. As a result of the deterministic optimization problems solution, the values of the parameters of main equipment corresponding to the minimum capital costs are determined. Based on these values the lower and the upper boundaries of the variables of the first stage of the approach are determined.

3. Vaklieva-Bancheva, N., Vladova, R., ***Kirilova, E.***, (2019). Simulation of heat-integrated Autothermal Thermophilic Aerobic Digestion system operating under uncertainties through Artificial Neural Networks, Chemical Engineering Transactions, Volume 76, Pages 325-330.
   https://www.cetjournal.it/index.php/cet/article/view/CET1976055
   https://doi.org/10.3303/CET1976055
   SJR(Scopus):0.316 (Q3)

The aim of the study is verification of a stochastic optimization approach for redesign of heat-integrated two-stage Autothermal Thermophilic Aerobic Digestion (ATAD) bioreactors system for municipal wastewater treatment operating under uncertainties. It was implemented through simulation of the ATAD system operation using feed-forward Artificial Neural Networks (ANN) for bioreactors modelling of the both stages and heat integration model of ATAD system with one heat storage tank. For the simulation purpose the design parameters values of the heat integration equipment associated with the obtained optimal solution of the stochastic approach were used. The ANN models were applied for prediction of the thermal shock occurred in the first bioreactor stage at incoming of each new portion of raw sludge, the expected temperature of the sludge at the end of the process and the volatile solids reduction at constant parameters of the inlet flows. They were included in two sequentially linked modules for simulation of the bioreactors operation. An appropriate data transfer between the modules, simulating the bioreactors and the Heat Integration module was provided. The simulation was carried out for two 15 d winter and summer periods. The simulation results have shown that applying the heat-integration of the process can lead to an increase in the temperatures of the inlet raw sludge about 6-8 °C and a decrease in the depth of thermal shock in both bioreactors about 5-7 °C. It also can provide higher and sustainable temperatures of the hot treated sludge at the end of the process which get much closer to the optimal of 55 °C for the first bioreactor and 65 °C for the second bioreactor and higher volatile solids reduction in both bioreactors about 1.5 wt.%.

4. Vladova, R., Vaklieva-Bancheva, N., ***Kirilova, E.***, (2019). Application of flexibility index approach for sustainable operation of heat- integrated Autothermal Thermophilic Aerobic Digestion system, Chemical Engineering Transactions, Volume 76, Pages 331-336.
   https://www.cetjournal.it/index.php/cet/article/view/CET1976056
   https://doi.org/10.3303/CET1976056
   SJR(Scopus):0.316 (Q3)

The present study proposes a decision-making approach based on flexibility index calculation of already obtained solutions of a stochastic multi-scenario optimization model for redesign of heat-integrated two-stage Autothermal Thermophilic Aerobic Digestion (ATAD) bioreactors system for municipal wastewater treatment operating under uncertainties. Obtained solutions with minimal costs for redesign were presented in Vladova et al. (2018). Aiming to find the solution which provides sustainable operation of the heat-integrated ATAD system within the widest range

of variation of its uncertain parameters, the Flexibility Index (FI) approach should be applied. A fast approach for evaluation of the flexibility index by presenting it as an inscribed a hyper-rectangle in the scaled hyper-space of variation of the uncertain parameters so as to ensure no violation of the process feasibility constraints is proposed. An optimization problem for determining the maximal flexibility index is formulated and solved for each solution obtained in Vladova et al. (2018). Decision making is carried out to choose most sustainable solutions for redesigned ATAD system. Analyzing the results obtained, it can be concluded that not always the solutions with the minimal annual costs for redesigning provide the sustainable operation of the ATAD system.

5. Vaklieva-Bancheva, N., Vladova, R., ***Kirilova, E.***, (2019). Methodology for energy efficiency and sustainability improvement of batch production systems on the example of Autothermal Thermophilic Aerobic Digestion systems, Journal of Ecological Engineering, Volume 20, Issue 9, Pages 103-115.
   https://www.jeeng.net/Methodology-for-Energy-Efficiency-and-Sustainability-Improvement-of-Batch-Production,112501,0,2.html
   https://doi.org/10.12911/22998993/112501
   SJR(Scopus):0.312 (Q2)

Present study proposes a methodology for energy efficiency and sustainability improvement of the operating conditions of batch production systems. The methodology is applied a conventional system for municipal wastewater treatment using the process of Autothermal Thermophilic Aerobic Digestion (ATAD) of sludge. Its sustainable operation is essential for the quality of the treated sludge and the reduction of environmental impact. An analysis of the possibilities for energy integration of processes in ATAD systems has been made. Structures for indirect energy integration of processes using storage tanks and mathematical models for describing energy integration for the studied object have been proposed. The models are included within a two-stage stochastic optimization problem together with constraints on the physical, technical and technological feasibility of the integration frameworks and temperature constraints with an optimization criterion minimum redesign cost. The obtained results show significant energy savings as a result of energy integration and sustainability to temperature conditions in bioreactors.

6. ***Kirilova, E.***, Vladova, R., Vaklieva-Bancheva, N., (2020). Heat integration of two-stage autothermal thermophilic aerobic digestion system for reducing the impact of uncertainty, Energy, Volume 208, 118329.
   https://www.sciencedirect.com/science/article/pii/S0360544220314365
   https://doi.org/10.1016/j.energy.2020.118329
   JCR-IF (Web of Science):7.147 (Q1)

The operation of Autothermal Thermophilic Aerobic Digestion (ATAD) wastewater treatment systems is subjected to daily uncertainties regarding the parameters of the inlet streams, which lead to prolongation of the process and increase the energy consumption. This, together with the heat loss in the environment from the product tank, makes the ATAD system energy inefficient. Heat integration plays an important role in improving the sustainability of ATAD systems. In this study an approach for optimal redesign of heat integrated two-stage ATAD system operating under

uncertainties is presented. It includes a two-stage stochastic optimization model for heat integration with an optimization criterion - the annual capital cost for redesign of the heat integrated system and its operating costs. Artificial Neural Network (ANN) models of the bioreactors are used for simulation of the system operation. They are combined with the heat integration model for the obtained with the stochastic approach values of design parameters of the heat integration equipment. The simulation results show a thermal shock reduction of 5–6 °C, an increase of the inlet sludge temperature of 8–10 °C, achievement of close to normal operating temperatures in the ATAD system and reduction of solids in both bioreactors by about 2 wt%.

7. ***Kirilova, E.***, Vaklieva-Bancheva, N., Vladova, R., Petrova T., (2020). Optimal products portfolio design of a sustainable supply chain using different recipes for dairy products production, Chemical Engineering Transactions, Volume 81, Pages 61-66.
   https://www.cetjournal.it/index.php/cet/article/view/CET2081011
   https://doi.org/10.3303/CET2081011
   SJR(Scopus): 0.274 (Q3)

This study proposes a deterministic optimization approach for products portfolio design of a Sustainable Supply Chain (SSC) comprising suppliers, plants and markets for production of dairy products using different recipes. It includes three interconnected models of the recipes used for the production of the dairy products, the SC design and the SC environmental impact. The latter is assessed in terms of wastewater and CO_2 emissions associated with the dairy production and the transportation. The models are included in an optimization working frame along environmental and economic criteria. The proposed approach has been implemented on a case study from Bulgaria – for production of two types of curd at two recipes using two types of milk. Optimization problems have been formulated in terms of MINLP. They are solved at different imposed environmental pollution taxes on the dairies regarding both wastewater and CO_2 emissions. The optimal SC products portfolio for the production of the planned products is obtained satisfying the best trade-off between environmental and economic criteria.

8. Ganev, E., Dzhelil, Y., Ivanov, B., Vaklieva-Bancheva, N., ***Kirilova, E.***, (2020). Optimal design of a sustainable integrated biodiesel/diesel supply chain using first and second generations bioresources, Chemical Engineering Transactions, Volume 81, Pages 67-72.
   https://www.cetjournal.it/index.php/cet/article/view/CET2081012
   https://doi.org/10.3303/CET2081012
   SJR(Scopus):0.274 (Q3)

This study proposes an optimization model for strategic design of a sustainable Integrated Biodiesel/diesel Supply Chain (IBSC) using 1st & 2nd generations (1G & 2G) bioresources for biodiesel production such as sunflower and rapeseed; and waste cooking oil (WCO) and animal fats. The optimization model is formulated in terms of MILP providing all aspects of the sustainability – economic, environmental and social. The model takes into account key supply chain activities such as infrastructure compatibility, the demand distribution, the size and location of biorefineries for biodiesel production and the available biomass and carbon taxes. The economic and environmental performance of IBSC is assessed by the costs for IBSC design and Green House Gas (GHG) emissions of pollutants associated with its operation. As a social criterion, the number of expected new jobs associated with IBSC design and operation has been used. The approach is

implemented on a Bulgarian scale with corresponding districts. The results obtained give the optimal biodiesel facilities locations, logistics design, inventory management, and information exchange. It is shown that for the case of the environmental criterion used, the average biodiesel price for the considered period (2016-2020) is 14 % higher and the total GHG emissions are 6.6 % lower than ones obtained when an economic criterion is used.

9. Ganev, E., Ivanov, B., Vaklieva-Bancheva, N., Kirilova, E., Dzhelil, Y., (2021). A multi-objective approach toward optimal design of sustainable integrated biodiesel/diesel supply chain based on first- and second-generation feedstock with solid waste use, Energies, Volume 14, Issue 8, 2261.
   https://www.mdpi.com/1996-1073/14/8/2261
   https://doi.org/10.3390/en14082261
   JCR-IF (Web of Science):3.085
   SJR(Scopus):0.653 (Q1)

This study proposes a multi-objective approach for the optimal design of a sustainable Integrated Biodiesel/Diesel Supply Chain (IBDSC) based on first- (sunflower and rapeseed) and second-generation (waste cooking oil and animal fat) feedstocks with solid waste use. It includes mixed-integer linear programming (MILP) models of the economic, environmental and social impact of IBDSC, and respective criteria defined in terms of costs. The purpose is to obtain the optimal number, sizes and locations of bio-refineries and solid waste plants; the areas and amounts of feedstocks needed for biodiesel production; and the transportation mode. The approach is applied on a real case study in which the territory of Bulgaria with its 27 districts is considered. Optimization problems are formulated for a 5-year period using either environmental or economic criteria and the remainder are defined as constraints. The obtained results show that in the case of the economic criterion, 14% of the agricultural land should be used for sunflower and 2% for rapeseed cultivation, while for the environmental case, 12% should be used for rapeseed and 3% for sunflower. In this case, the price of biodiesel is 14% higher, and the generated pollutants are 6.6% lower. The optimal transport for both cases is rail.

10. Ivanov, B., Nikolova, D., ***Kirilova, E.***, Vaklieva-Bancheva, N., Vladova, R., (2021). Optimal design of sustainable biodiesel supply chain using dairy waste scum as a feedstock generated from dairy supply chain, Chemical Engineering Transactions, Volume 88, Pages 577-582.
    https://www.cetjournal.it/index.php/cet/article/view/CET2188096
    https://doi.org/10.3303/CET2188096
    SJR (Scopus):0.254 (Q3)

The rapid depletion of fossil fuels and the increased environmental impact of their combustion make it necessary to find cleaner and more sustainable energy resources. Over the last decades, biodiesel has been introduced as an alternative because of its advantages over fossil fuels. However, the high production cost of biodiesel is one of the main obstacles to achieving its commercial viability. One way to improve the efficiency and sustainability of this process is to use Dairy Waste Scum (DWS), which is a waste product from the dairy industry as a feedstock. Selection of the feedstock used is only a part of the strategy to increase the sustainability of this type of production. The most effective way to achieve this is by optimising the activities across the supply chains (SCs). In addition, the sustainability of the biodiesel production process using

DWS may be influenced by design of optimal product portfolio of the considered dairy SC. This study proposes an approach for optimal design of a sustainable combined dairy and biodiesel/diesel SC using dairy waste scum as a feedstock, generated from dairy SC. It is based on defining mixed integer linear programming (MILP) model of the optimal design of the considered combined SC. The latter includes economic and environmental assessments. The first one is defined as an optimization criterion while the second one is defined as a constraint. The model takes into account key SC activities such as infrastructure compatibility; the production of the dairy products; milk, dairy products and DWS transportation between the regions, carbon taxes, related with all SC activities. The environmental and economic performance of the combined dairy and biodiesel/diesel SC is assessed by the annual operating costs for the combined SC design and greenhouse gas (GHG) emissions of pollutants associated with its operation. The developed approach was implemented on a real case study from Bulgaria. The analysis of the environmental results shown that the total GHG emissions generated by the operation of the SC for all time intervals are mainly due to the production of the products in dairies and utilization of unused DWS for production of biodiesel.

11. ***Kirilova, E.***, Vaklieva-Bancheva, N., Petrova, T., Vladova, R., Varbanov, P., (2021). A MINLP model to optimal design of a sustainable dairy supply chain taking into account preferences of the network actors, Chemical Engineering Transactions, Volume 88, Pages 1045-1050.
https://www.cetjournal.it/index.php/cet/article/view/CET2188174
https://doi.org/10.3303/CET2188174
SJR (Scopus): 0.254 (Q3)

The increase of pollutants generated in the production of dairy products, the increase of the production costs and emerging social problems requires the development of approaches for resilience improvement of the considered product productions. An effective way to achieve this is by optimising all activities across the supply chain: from milk suppliers through the production itself to end-users meeting environmental, economic and social criteria. The other important aspect of solving this type of problems is taking into account the preferences of all actors in the network. The present study proposes a mixed-integer non-linear programming (MINLP) model for the optimal design of a sustainable dairy supply chain (SC) for the production of different dairy products satisfying the preferences of all actors of the network - milk suppliers, dairies and markets. The approach includes models for the production of dairy products along with the economic, environmental and social impact of the considered SC. Three optimization problems are defined and solved at different optimisation criteria representing the preferences of all actors in the SC. The first solution results in the supply of 162,022 kg of two types of milk for the production of 61,758 kg of low and high-fat content products. The latter exceeds the market demands. This is the solution with the largest economic and social costs and lowest production profit of 118,008 BGN. The second solution is related to the production of 60,023 kg of both products. This is the solution with the lowest economic costs and largest production profit of 143,809 BGN. In solution 3, full satisfaction of market requirements was achieved. It is related to the supply of 132,146 kg of both types of milk for the production of 60,057 kg of both products.

12. ***Kirilova, E.***, Vaklieva-Bancheva, N., Vladova, R., Petrova, T., Ivanov, B., Nikolova, D., Dzhelil, Y., (2022). An approach for a sustainable decision-making in product portfolio design

of dairy supply chain in terms of environmental, economic and social criteria, Clean Technologies and Environmental Policy, Volume 24, Pages 213-227.
https://link.springer.com/article/10.1007/s10098-021-02110-2
https://doi.org/10.1007/s10098-021-02110-2
JCR-IF (Web of Science):3.49
SJR(Scopus):0.862 (Q1)

The production of dairy products is related to water and energy costs and generation of large amounts of emissions of pollutants. Full sustainability of these systems can be achieved by optimizing all activities in the supply chain (SC) taking into account not only the environmental and economic aspects, but also the social ones. This study proposes a multi-objective modeling approach for optimal design of three-echelon SC for production of dairy products according to different recipes while satisfying environmental, economic and social criteria defined in terms of costs. The environmental costs are associated with the generated wastewater from dairy production and CO_2 emissions due to energy consumed and transport of raw materials and products. The social ones are related to the employees hired for implementation of the SC activities. It was implemented on a real case study from Bulgaria. Four mix integer nonlinear programming optimization models were defined–one without and three with social impact consideration. They were solved at different values of the environmental and social constraints. The obtain results showed that stricter environmental constraints lead to higher economic costs and lower profit. Conversely, higher environmental constraints result in higher profit and lower economic costs. The greatest share in the environmental impact has the wastewater generated, followed by CO_2 emissions related with energy consumed and CO_2 emissions due to transport. The obtained solutions can be used in the decision-making process in terms of seeking a trade-off between profit, environmental and social impact.

13. ***Kirilova, E.***, Vaklieva-Bancheva, N., Vladova, R., Petrova, T., Nikolova, D., Ganev, E., Dzhelil, Y., (2022). Impact of product demand uncertainties on the optimal design of a sustainable dairy supply chain: A case study of Bulgaria, Chemical Engineering Transactions, Volume 94, Pages 547-552.
https://www.cetjournal.it/index.php/cet/article/view/CET2294091
https://doi.org/10.3303/CET2294091
SJR (Scopus):0.242 (Q3)

Population growth and income, together with urbanization, have caused a significant increase in demand for dairy products. This creates opportunities for increasing the profit from dairy production, but on the other hand, it is associated with the generation of large amounts of pollutants that are released into the air and water and require costs for their treatment and disposal. The presence of fluctuations in the product demands in the markets also influences the sustainable operation of considered supply chain (SC) activities. This study proposes a robust optimisation approach for handling the uncertainty of product demands in a dairy SC to produce different dairy products according to different recipes while satisfying environmental and economic criteria. The latter is associated with the generated wastewater from dairy production and CO2 emissions due to the energy consumed and transportation. The approach has been implemented in a real case study from Bulgaria. Deterministic and robust optimization problems have been formulated and solved under nominal data for the product demands and three different uncertainties levels – 0.2,

0.5 and 1. The obtained results show that the increase in the uncertainty level leads to decreasing profit from the dairy SC with a relatively small standard deviation. The lowest mean value of the SC profit of 232,882 BGN is obtained at the greatest uncertainty level of 1. The results for SC total costs show that they also do not change significantly with an increase in the uncertainty level. The largest value of 154,018 BGN has been obtained at an uncertainty level of 0.5. Given the latter, it can be said that the developed robust optimization model is a sustainable, which leads to obtaining results for the SC profit and costs that do not change significantly with an increase in the uncertainty level of consideration of product demands.

14. Ganev, E., ***Kirilova, E.***, Dzhelil, Y., Vaklieva-Bancheva, N., (2022). Optimal design of a sustainable biodiesel/diesel supply chain using sunflower and rapeseed as feedstock under different scenarios of blending centers, Chemical Engineering Transactions, Volume 94, Pages 55-60.
    https://www.cetjournal.it/index.php/cet/article/view/CET2294009
    https://doi.org/10.3303/CET2294009
    SJR (Scopus):0.242 (Q3)

    Global energy consumption shows a steady upward trend until 2030, with liquid fuels, in particular biodiesel, accounting for a large share of fuel demand for the transport sector. One way to increase its economic and environmental benefits is through optimization of all activities across the supply chain. However, the presence of uncertainties concerning the supply chains parameters may cause to the risk of releasing large amounts of GHG emissions and increasing the total costs and prices of biodiesel on the markets. One way to predict this is by analysing the results obtained by applying mathematical approaches to the design of sustainable supply chains for different scenarios. The study proposes a MILP (mixed integer linear programming) model for optimal design of a sustainable biodiesel/diesel supply chain using different feedstock. It aims to determine the optimal level of the following: arable land and costs for cultivation of feedstock, number, locations, and capacities of biorefineries, transportation network; amounts of feedstock and biodiesel transported between regions while satisfying an economic or an environmental criterion, with the other being set as a constraint. The approach has been implemented on a real case study from Bulgaria. Four optimization problems have been formulated using both criteria for two scenarios - Scenario 1, in which 27 blending centers have been considered and Scenario 2, in which only one blending center has been considered. The obtained results from solving the optimization problems using both criteria for Scenario 1 results in a reduction of the generated GHG emissions with 503 (kgCO2eq/d) and 3,136 (kgCO2eq/d) at both criteria and the total annual costs with 240,576 ($) at environmental criterion. The analysis of the obtained results shows that the decision made regarding the number of blending centers has an impact on the sustainable operating the biodiesel/diesel supply chain.

15. Ivanov, B., Nikolova, D., ***Kirilova, E.***, Vladova, R., (2022). A MILP approach of optimal design of a sustainable combined dairy and biodiesel supply chain using dairy waste scum generated from dairy production, Computers & Chemical Engineering, Volume 166, 107976.
    https://www.sciencedirect.com/science/article/pii/S0098135422003106
    10.1016/j.compchemeng.2022.107976
    JCR-IF (Web of Science):4.13
    SJR (Scopus):0.897 (Q1)

The present study proposes a mixed integer linear programming (MILP) approach for optimal design of a sustainable combined supply chain for the production of biodiesel using as a feedstock dairy waste scum generated from the implementation of optimal product portfolio of dairy supply chain. The latter includes models of economic and environmental impacts of the combined supply, constraints and an optimization criterion in terms of capital and operation costs. The environmental impact is assessed through greenhouse gas emissions obtained through whole life cycle of the products. The proposed approach is implemented on a real case study from Bulgaria. As a result, optimal operating conditions of the considered supply chain, which includes: dairy farms portfolios, dairy plants portfolios, production capacity and location of biorefineries that should be built, performance of biorefineries and transportation routes are obtained. It can be used as a tool for decision-making.

16. Apostolov, A., ***Kirilova, E.***, Vladova, R., Vaklieva-Bancheva, N., Rangelov, T., (2022). Influence of geometry and mechanical load on the delamination in the graphene/ polymer nanocomposite under axial load, Chemical Engineering Transactions, Volume 94, Pages 463-468.
    https://www.cetjournal.it/index.php/cet/article/view/CET2294077
    https://doi.org/10.3303/CET2294077
    SJR (Scopus): 0.242 (Q3)

This paper presents a theoretical study on the influence of the geometry (layer thickness and length) and the magnitude of axially applied tension load on the delamination in a three-layer graphene/PMMA nanocomposite. Two different analytical solutions (Case 1 and Case 2) for the interface shear stress in the middle layer of the nanocomposite structure are obtained, based on the application of a two-dimensional stress-function method and minimization of the strain energy. The theoretical criterion for delamination in the interface layer, which is based on the model interface shear stress, is formulated. The obtained non-linear equation with respect to debond length is solved numerically, for both solutions, at different values of the mechanical load and geometry of the structure layers. For both solutions, it was found that the magnitude of the applied tension load influences strongly the appearance of delamination in the structure. For Case 1 (thinner PMMA layer) the delamination could be observed over 350 MPa external load; for Case 2 (thicker PMMA) it could be seen over 750 MPa. If the structure length decreases, under the above-mentioned conditions, the delamination begins at slightly lower values of the tension load. The magnitude of the applied load influences also the value of debond length. The obtained results could be used for fast prediction of safety intervals of applied loads and geometry design (without delamination) in similar nanocomposite devices to assure their safety working as sensors, nano- and optical electronic devices, energy devices, etc.

17. Petrova, T., ***Kirilova, E.,*** Becker, W., Ivanova, J., (2022). Analytical modeling of graphene/PMMA nanocomposite under hygrothermomechanical loading, ZAMM-Journal of Applied Mathematics and Mechanics/Zeitschrift für Angewandte Mathematik und Mechanik, e202200266**.**
    https://onlinelibrary.wiley.com/doi/abs/10.1002/zamm.202200266
    https://doi.org/10.1002/zamm.202200266
    JCR-IF (Web of Science):2.3 (Q1)

In the present paper, the analytical modeling of graphene/polymethylmethacrylate (PMMA) nanocomposite under hygrothermome chanical loading is performed. The 2D analytical method consists of the use of the stress-function variational method, which was validated with experimental data in our previous paper. Studying the hygrothermomechanical behavior of graphene/PMMA nanocomposites with possible interface delamination along the overlap zone of the structure considered, the parametric analysis is done as well. Three cases of loading–mechanical, thermal (heating/cooling), and mixed (hygrothermomechanical) are considered and compared with mechanical one. All results for the behavior of the axial, peel and shear stresses for all three layers of the structure are illustrated in figures and discussed. Some important conclusions are derived.

18. Petrova, T., ***Kirilova, E.***, Becker, W., Ivanova, J., (2022). Influence of type of adhesive on the interface debonding of a $BATIO_3$/epoxy structure under time harmonic mechanical load and electric field at environmental conditions, Journal of Theoretical and Applied Mechanics, Volume 52, Issue 4, Pages 365-380.
    https://jtambg.eu/issues.php?year=2022&vol=52&issue=4
    https://doi.org/10.55787/jtams.22.52.4.365
    SJR (Scopus):0.187 (Q4)

The study deals with investigation of the effect of the used adhesive upon the interface delamination at adhesively bonded piezoelectric patch/layer structure BaTiO3/Epoxy subjected to time harmonic mechanical load and electric field at environmental conditions. This is needed for a prediction of conditions, at which these type of structures work safely (without failure). For the interface shear stress in the overlap zone of structure, at two different thicknesses of its adherends and three adhesives used, a solution method based on shear lag and Fourier method has been applied. The types of solutions obtained depend mainly on the adherends' thickness, the magnitude and frequency of the applied mechanical loading and the shear modulus of the used adhesive. Based on the analysis conducted it has been shown that with increasing magnitude and frequency of applied mechanical load, the delamination length also increased. The delamination could be avoided if the stronger adhesives and thicker adherends are chosen. The debond length is highly dependent on the magnitude of electric displacement. The analytical equation for resonant frequencies in the considered structure is developed on the base of obtained solutions and they are calculated at all three investigated adhesives.

19. Petrova, T., ***Kirilova, E.***, Becker, W., Ivanova, J. (2022). Two-dimensional stress and strain analysis for graphene-polymer nanocomposite under axial load, Journal of Applied and Computational Mechanics, Volume 8, Issue 3, Pages 1065-1075.
    https://jacm.scu.ac.ir/article_17375.html
    10.22055/jacm.2022.38834.3292
    JCR-IF (Web of Science):3.1 (Q1)

A two-dimensional stress-function method describing the stress transfer in a three-layered adhesive bonded graphene and poly(methyl methacrylate) nanocomposite structure, subjected to axial load is developed and applied. The governing ordinary differential equation of fourth order with constant coefficients for the axial stress in the first layer is obtained minimizing the strain energy in the whole structure and solved analytically. The two-dimensional stresses and strains

(axial, shear and peel) in the structure's layers are expressed and calculated as functions of this axial one and its derivatives and illustrated with graphics. The model graphene strain is compared with experimental data for strain in graphene and shear-lag model results from literature and shows good agreement at 0.4% external strains.

20. Petrova, T., ***Kirilova, E.***, Vladova, R., Boyadjiev, B., Becker, W., Dineva-Vladikova, P., (2022). Modelling and validation of the axial strain distribution in WS_2 flakes at WS2/Epoxy/PMMA nanocomposite under axial load, U. Porto Journal of Engineering, Volume 8, Issue 6, Pages 160-169.
https://journalengineering.fe.up.pt/index.php/upjeng/article/view/2183-6493_008-006_0011
https://doi.org/10.24840/2183-6493_008.006_0011
SJR (Scopus):0.148 (Q4)

In the present study, a two-dimensional stress-function method is applied to model the axial strain distribution in the tungsten disulfide (WS2) flake embedded in an epoxy/polymethyl methacrylate nanocomposite structure subjected to an axial tension load. The analytical model strain distribution along the flake is calculated and compared with experimental and shear-lag model literature data for monolayer flake at an external strain of 0.35% and 0.55%, as well as with results for few-layer flakes at an external strain of 0.55%. The comparison shows good agreement and confirms the applicability of our model method for describing strains in nanocomposite layered structures in the elastic region of applied loads. The presented method is not appropriate for few layers flake at an external strain of 0.55% because of the appearance of relaxation zone and the formation of wrinkles in the flake.

21. Petrova, T., Vladova, R., ***Kirilova, E.*** (2023). A robust optimisation model for the sustainable design of a dairy supply chain under uncertain environmental conditions, Chemical Engineering Transactions, Volume 103, Pages 853-858.
https://www.cetjournal.it/index.php/cet/article/view/CET23103143
https://doi.org/10.3303/CET23103143
SJR (Scopus):0.258 (Q3)

The production of dairy products in the relevant supply chains (SCs) is associated with the generation of significant amounts of pollutants in the wastewater and CO2 emissions into the air, which released into the environment can cause a great risk of its pollution. The presence of uncertainties regarding the released amounts of pollutants further exacerbates the environmental problem. One of the ways to capture these uncertainties and control the environmental risk of pollution is by applying approaches to optimal design of sustainable supply chains operating under uncertainty conditions. The present study proposes a mixed integer non-linear programming approach to the optimal design of a sustainable SC for the production of two types of dairy products with a choice of technology, which includes models of economic, environmental and social impact as well as dairy production. The latter takes into account uncertainties regarding the environmental impact costs for treatment of the generated pollutants in terms of wastewater and CO2 emissions related to the SC activities. The efficiency of the proposed approach has been proved in a real case from Bulgaria, which includes suppliers of two types of milk and dairy plants for the production of two types of dairy products and markets.

22. Vladova, R., ***Kirilova, E.,*** Petrova, T., Kirilov, K., (2023). A sustainable multi-objective optimization model for design of supply chain under uncertain products demands and products prices: a real case of dairy industry, Chemical Engineering Transactions, Volume 105, Pages 385-390.
https://www.cetjournal.it/index.php/cet/article/view/CET23105065
https://doi.org/10.3303/CET23105065
SJR (Scopus): 0.258 (Q3)

Dairy production has a significant environmental impact related with wastewater and air pollution. In addition, it is a large consumer of water and energy. The most effective way to improve its sustainability is through analysis of the food-water-energy nexus, which can be done by optimizing all activities in the supply chain (SC) from the raw materials to the end user while meeting environmental, economic and social criteria. However, the presence of uncertainties regarding the main parameters of the SC would lead to problems related to the implementation of processes and the operating the system as a whole. To solve these problems an implementation of models for optimal design of dairy SCs that handle these uncertainties is needed. The present study proposes an extended version of already developed mixed integer non-linear programming (MINLP) approach to optimal design of a sustainable SC for the production of different dairy products according different recipes under uncertain products demands and products prices. The model has taken into account economic, environmental and social aspects. The obtained results show that the increase in the uncertainty level leads to an increase of values of economic, environmental and social costs as well as the profit, with the standard deviation of the same being the highest at the lowest level of uncertainty, while at the others it is preserved relatively constant. The number of workers employed by the supply centers, dairies and markets is kept constant regardless of the variation in the level of uncertainty of products demands and products prices.

23. Vladova, R., Petrova, T., Nikolova, D., ***Kirilova, E.,*** Kirilov, K., (2023). Robust optimization of sustainable dairy supply chain with products demands uncertainty and environmental impact consideration, Chemical Engineering Transactions, Volume 105, Pages 379-384.
https://www.cetjournal.it/index.php/cet/article/view/CET23105064
https://doi.org/10.3303/CET23105064
SJR (Scopus): 0.258 (Q3)

Milk and milk products are an important part of the daily menu of millions of people around the world. Increasing the efficiency and competitiveness of this type of production is related to the implementation of the strategy of sustainable management of supply chains, which cover all processes from raw materials, through production to end users. The presence of fluctuations in the product demands on the markets also influences the sustainable operation of considered supply chain activities. The present study proposes an application of already developed robust optimization approach for optimal design of a sustainable dairy supply chain operating under uncertain products demands on a new case study from Bulgaria which include three milk suppliers, two dairies and three markets. The considered supply chain is related with a production of different dairy products according to different recipes while satisfying environmental and economic criteria defined in terms of costs. The latter is associated with the generated wastewater from dairy production and CO2 emissions due to the energy consumed and transportation. Several

optimization problems have been formulated and solved under nominal data for the product demands and four uncertainties levels - 0.25, 0.5, 0.75 and 1. The obtained optimal values of the economic and environmental costs show that the optimization approach implementation results in sustainable solutions that do not change significantly with an increase in the uncertainty level of consideration of the product demands.

24. Vladova, R., Petrova, T., ***Kirilova, E.,*** (2024). A multi-objective robust optimization to design a sustainable dairy supply chain under uncertain product demands, economic and social consideration. A real case study from Bulgaria, Bulgarian Chemical Communications, Volume 56, Number 2, Pages 147-158.
https://bcc.bas.bg/BCC_Volumes/Volume_56_Number_2_2024/BCC-56-2-2024-147-158-Vladova-5635.pdf
SJR (Scopus):0.148 (Q4)

The operation of dairy supply chains (DSCs) is associated with the generation of significant amounts of wastewater pollutants and CO2 emissions. The presence of uncertainty regarding various parameters of the considered DSCs has an additional impact on their sustainability. The most efficient way to improve the sustainability of DSCs is by applying mathematical modeling approaches for optimal design of sustainable DSCs operating under uncertain conditions. The present study proposes an optimal model for design of a sustainable DSC for the production of two types of dairy products with a technology selection, which includes economic, environmental and social impact models, as well as dairy production model. The optimization model takes into account uncertainty in products demands, raw materials and products prices and social costs. The effectiveness of the proposed approach is proved in a real case of a DSC from Bulgaria, which includes suppliers of two types of milk and dairy plants for the production of two types of dairy products and markets. The obtained optimal values of the economic, environmental and social costs show that the application of the optimization approach results in sustainable solutions that do not significantly change with an increase in the uncertainty level of consideration of the uncertain parameters.

25. Petrova, T., ***Kirilova, E.,*** Vladova, R., Apostolov, A., Boyadjiev, B., Moravski, A., (2024). Multi-parameter optimization of layered hBN/PMMA nanocomposite under mechanical loading. Bulgarian Chemical Communications, Volume 56, Special Issue 3, Pages 333-341.
https://bcc.bas.bg/BCC_Volumes/Volume_56_Number_3_2024/BCC-56-3-2024-333-341-Petrova-TP-SR.pdf
SJR (Scopus): 0.148 (Q4)

In the present study, a methodology is proposed to find the optimal safe values for the geometry and the magnitude of the axially applied mechanical load for hBN/PMMA nanocomposite, so as to avoid the possibility of its delamination/fracture, by using Genetic Algorithms. First, the analytical solutions for the interface shear stress in the middle layer of the considered nanostructure are obtained, based on the application of the 2D method of the stress
function and the minimization of the strain energy. Second, the theoretical criterion for no delamination in the interface layer, based on the model ISS is formulated, including the structure geometry and loading as parameters. The multi-parameter optimization problem involving this criterion is then defined and solved by the GA. By varying all parameters simultaneously, their

safety intervals (without delamination) in the considered nanocomposite structure are obtained. The magnitude of the applied load was found to mainly affect the magnitude of the ISS. Layer thicknesses mostly affect the type of ISS solution, especially the substrate thickness. The effect of layer length on ISS is weaker than that of layer thickness at fixed load. The obtained results can be used for fast delamination prediction and appropriate design in such nanostructured devices to ensure their safe operation.

II. BOOK CHAPTERS (2 chapters)

1. ***Kirilova, E.***, Vladova, R., Vaklieva-Bancheva, N., Chapter 28 - Multiscenario Approach for Capturing Uncertainties in Energy-Integrated Autothermal Thermophilic Aerobic Digestion Systems, Soft Computing Techniques in Solid Waste and Wastewater Management. Edited by Rama Rao Karri, Elsevier, USA, 2021, ISBN:978-0-12-824463-0, 20, pp.469-489 **https://doi.org/10.1016/C2020-0-01696-8**

This chapter presents an engineering systems approach for the optimal design of a heat-integrated ATAD system under uncertainties in the parameters of the inlet and outlet streams. The approach is based on a heat integration model incorporating heat storage tanks, adapted for inclusion within a two-stage stochastic optimization framework. The stochastic optimization problem is transformed into a deterministic multi-scenario problem using a finite number of scenarios that represent probabilistic combinations of the uncertain system parameters.
An analysis of the heat integration efficiency at the boundaries of the stochastic space is carried out, and the temperature range of the preheated raw sludge after heat integration is determined. For this purpose, a deterministic optimization model is formulated and solved for each boundary scenario using the maximum temperature of the heated sludge as the optimization criterion. The obtained solution defines the lower bound of the integration framework efficiency and is subsequently incorporated as a constraint in the stochastic optimization model.
In the first stage of the optimization, the design variables-heat exchanger areas and heat storage tank volumes-are determined, while the second stage defines the operational variables related to flow rates and heating and cooling times. The objective function accounts for the annual capital costs of the main and auxiliary equipment, as well as the operating costs associated with pump energy consumption.
The formulated two-stage stochastic optimization problem is solved using BASIC GA with an original chromosome structure that incorporates variables from both optimization stages. To evaluate the impact of heat integration on operating temperatures, a simulation study is performed using experimental data collected from a real two-stage ATAD system in Killarney, Ireland, during 15-day winter and summer periods. Artificial Neural Network (ANN) models are developed to predict the TSk temperature, the maximum outlet temperature, and the reduction of volatile solids. The integration of the ANN models with the heat integration model demonstrates a reduction in TSk of 5–6°C, an increase in the inlet sludge temperature of 8-10°C, stabilization of operating temperatures, and an additional reduction of approximately 2 wt.% in the solids content of the two bioreactors.

2. ***Kirilova, E.***, Chapter 6. Artificial Neural Networks: Applications in Chemical Engineering. In book: Modeling and Simulation in Chemical Engineering, Project Reports on Process

Simulation, Editor: Christo Boyadjiev, Springer International Publishing, Book Series: Heat and Mass Transfer, 2022, ISBN:978-3-030-87659-3, 19, pp.127-146
https://doi.org/10.1007/978-3-030-87660-9_6

Traditional approaches to modeling real chemical engineering processes are based on fundamental chemical and physical laws, which include nonlinear algebraic and differential equations. From a computational point of view, these equations have some difficulties with regard to the numerical methods used for their approximation, as well as with the achievement of the desired accuracy of the calculations.

In recent years, there has been a growing interest in the application of the Artificial Neural Networks (ANNs) method to solve a number of problems in the field of chemical engineering related to fault detection, signal processing, modeling, and control of chemical and biochemical processes in which traditional modeling methods have difficulty and it is even impossible to develop physical models with acceptable errors.

Their main advantage is that they work only with data on the input and output values of the process parameters. One model can be used to generate multiple outputs. Once the neural network model is adequately trained and validated, it is able to make predictions for new data about the input values of process parameters that were not used in the development of this model.

This chapter presents the main characteristics of ANNs, the choice of architecture, the process of training and validation of ANN models, as well as several types of ANNs, such as feed-forward nets, recurrent nets and radial basis function nets and combined models with examples of applications in chemical engineering.