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Co-chairs

V.V. Kozlov, Member of the Russian Academy of Science, Russia

N.A. Kudryshov, Head of department of Applied Mathematics NRNU MEPhI, Russia

O.V. Nagornov, Head of department of Higher Mathematics of NRNU MEPhI, Russias

Program committee

V.V. Kozlov, Member of the Russian Academy of Science, Russia

N.A. Kudryshov, Head of department of Applied Mathematics NRNU MEPhI, Russia

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Section "Mathematical modelling"

the defects (or, equivalently, for any initial damage) numerical simulations have shown that dependences of the healed and the damage from the time will not be different of order, we calculate these dependences in the regions of integration, consisting of one or few representative elements. Positions of microcracks relative to each other, their shape and distance between its does not affect on the dependences of the healed and the damage from the time under the treatment of current pulse. These changes are affected by the value of initial damage only. The dependences of the healed and the damage from the time will be practically the same for all different shapes and mutual positions of microdefects, provided that the initial damages are equal for these different mutual positions of defects. Based on the simulation results, the approximate piecewise-linear dependences of healed and damage from time and the initial damage are obtained. It follows from the dependencies that up to the certain moment in time all the microcracks in the material (regardless the initial damage) does not heal and damage of the material is not changed under the current. After this moment in time it will start the process healing of microcracks. Thus, under the action of the current the damage of material is decreased over time at the constant rate (independent of the initial damage) over time, while the healed is increased over time at a rate inversely proportional to the initial damage of the material. The work was supported by the Russian Foundation for Basic Research (Grant No. 15-08-08693).

The construction of the SDE for modeling wind speed for wind power plants

D.S. Kulyabov[1,2,a)], M.N. Gevorkyan[1,b)], A.V. Demidova[1,c)], A.V. Korolkova[1,d)], L.A. Sevastianov[1,3,e)]

[1] *Peoples' Friendship University of Russia (RUDN University)*
6 Miklukho-Maklaya St, Moscow, 117198, Russian Federation
[2] *Laboratory of Information Technologies Joint Institute for Nuclear Research*
6 Joliot-Curie, Dubna, Moscow region, 141980, Russia
[3] *Bogoliubov Laboratory of Theoretical Physics Joint Institute for Nuclear Research*
6 Joliot-Curie, Dubna, Moscow region, 141980, Russia

This work considers the problem of modeling evolution of wind speed in the area of of wind turbines farm. As the statistical data we use the table of turbine performance, wind speed and direction from the wind farm on the territory of Republic of Poland. We use Weibull distribution to approximate wind speed. Parameters of Weibull distribution were calculated by the method of maximum likelihood. We also have calculated the autocorrelation coefficient for the entire data range and have proved the local exponential decrease nature. After that, we built a stochastic differential equation and solved it with stochastic numerical methods.

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[a)]Email: kulyabov_ds@rudn.university
[b)]Email: gevorkyan_mn@rudn.university
[c)]Email: demidova_av@rudn.university
[d)]Email: korolkova_av@rudn.university
[e)]Email: sevastianov_la@rudn.university

Introduction

Popularity of alternative renewable energy sources increases constantly. One type of such sources is the farm of wind turbines. Its main disadvantage is the strong dependence on metrological conditions, particularly wind speed. Therefore, the modeling of the evolution of the wind speed in time is essential for predicting the efficiency and profitability of wind turbines.

In this paper we build a stochastic model based on data obtained from one of the wind farms located on the territory of the Republic of Poland. We used model building mythology from articles [1, 2]. Also we use Python with NumPy, SciPy and [3], Matplotlib [4] libraries with interactive shell [5].

Approximating distributions

In the first phase of work on the basis of statistical data was constructed frequency histogram. From visual analisis of that histogram we fined out the possibility to use distributions with heavy tails for the approximation of the available data. We used method of maximum likelihood to compute the parameters of the four distributions: lognormal, gamma, Weibull (three parameter each) and beta (four parameter). For the analysis of the results we plotted frequency histogram and distributions PDF function graph on the same axis. Also we plotted quantile-quantile graphs for all four distributions. The analysis allowed to conclude that the optimal choice for the approximation is the Weibull distribution, which is consistent with the results known from the literature [6, 7]

SDE constraction

The method described in the article [1] implies exponential decrease of the autocorrelation coefficient $e^{-\alpha\tau}$, where α — some coefficient, and τ — autocorrelation lag. The coefficient α plays a significant role bocouse it is included as a parameter in the resulting equation.

The calculation of the autocorrelation coefficient based on the data available to us and plotting its values in graphical form allows to verify the exponential character of decrease, at least for the initial values of the lag. To calculate α coefficient we use least squares methods.

As soon as we know parameters of Weibull distribution and the coefficient α we are able to construct stochastic differential equation, whose solution is a stochastic process, approximately the evolution of wind speed changes in time and in each moment of time has a Weibull distribution.

To solve stochastic differential equation we use stochastic numerical Runge-Kutta methods, implemented and described in our earlier [8, 9] paper. The nature of the resulting numerical solution reflects a qualitative picture of the available statistical data. Numerical solution reflects the properties of empirical data — such as sharp jumps to extreme levels with the further sharp return to the averages values.

Conclusion

As a further direction of research is planned to verify the model built based on statistical data of larger size, which we plan to get in future. We also planning to include in the model along with the wind speed also the performance of the wind turbine.

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Nonlinear mathematical model for spatial periods of micro- and nanogratings formation in framework of universal polariton model of laser-induced condensed matter damage

V.S. Makin[1,a) , R.S. Makin[2,b)
[1]*NII OEP*
[2]*NRNU MEPhI*

[a)]Email: makin@sbor.net
[b)]Email: rmak@sai-net.ru