UTILISATION OF HIGH-EFFICIENCY SYSTEMS FOR GENERATION AND STORAGE OF HYDROGEN FOR STAND-ALONE POWER SUPPLY

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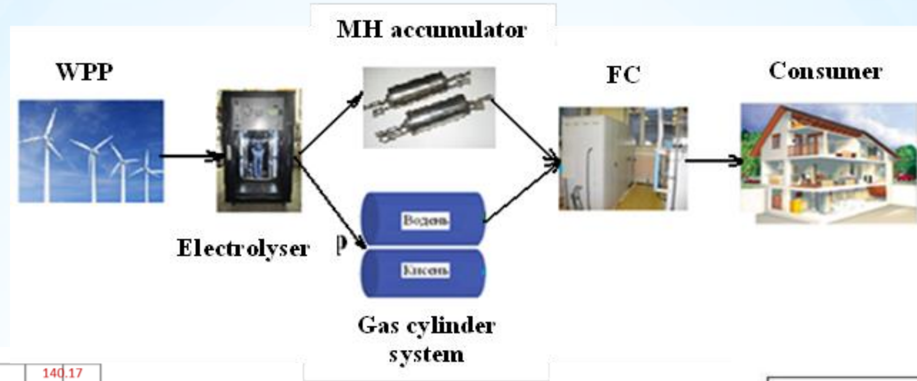
The purpose:

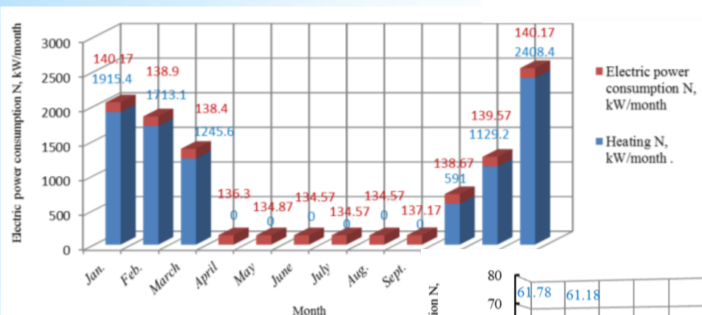
To develop of scientific and engineering solutions to improve the reliability of power supply of stand-alone systems and mitigate the environmental burden by using hydrogen technologies for energy storage.

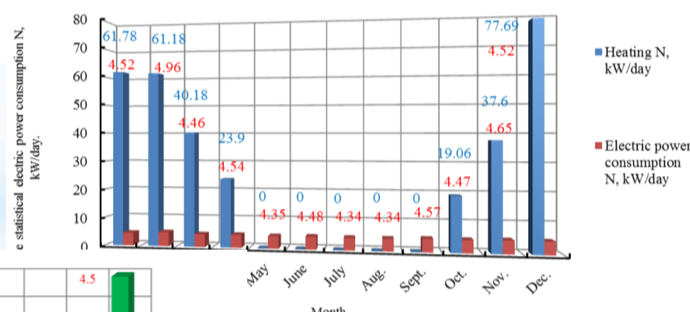
To achieve project goals it was planned to determine the required amount of hydrogen for the operation of fuel cells; determine the optimal operating modes of the metal-hydride hydrogen storage system in accordance with its specified characteristics; to develop the design of a metal-hydride accumulator and to synchronize its dynamic characteristics with the operating mode of the fuel cell.

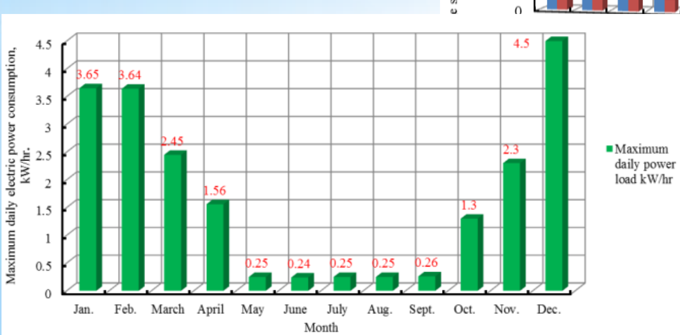
Thermodynamic analysis of a system "Metal-Hydride Hydrogen Storage - Fuel Cell"

SCHEME OF AN AUTONOMOUS POWER PLANT

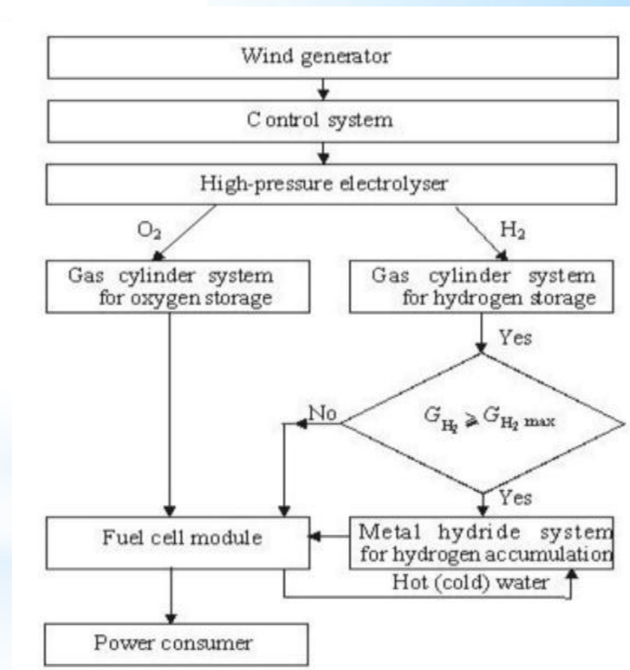








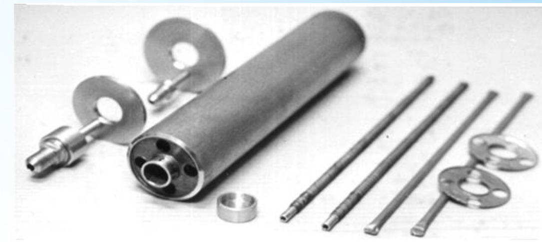
Estimated maximum electric power load in a stand-alone house



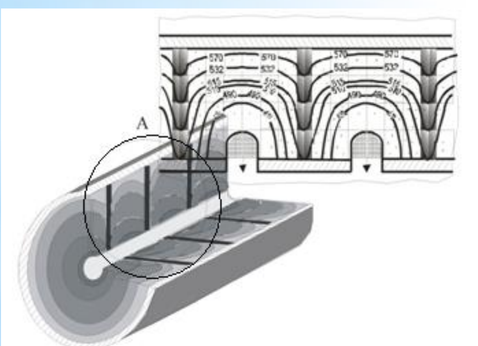
Generalised algorithm for design of a stand-alone energy supply system

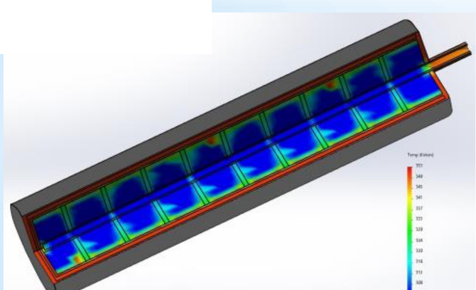
Synchronization of the operation of the Metal-Hydride Hydrogen Storage System and the PEMFC

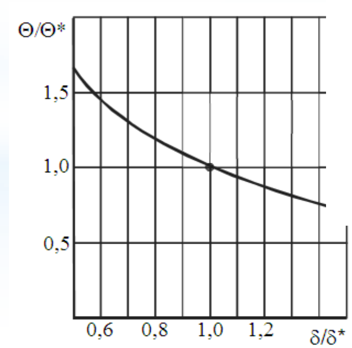
METAL-HYDRIDE HYDROGEN STORAGE SYSTEM

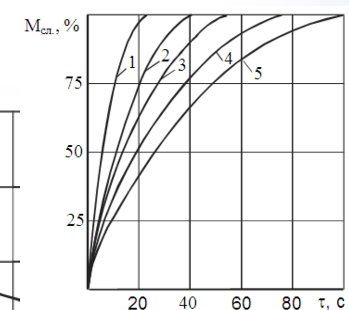


SIMULATION RESULTS

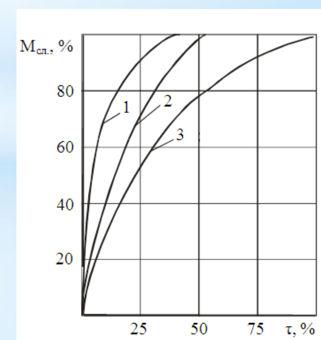








1 – l = 0,001 m; 2 – l = 0,003 m; 3 – l = 0,005 m; 4 – l = 0,007 m; 5 – l = 0,01 m



Formation of a rational design of metal hydride cells of a hydrogen accumulator

CONCLUSION

1 An analysis of the operation of a fuel cell with a proton exchange membrane with a metal hydride hydrogen storage system is carried out. A regularity has been obtained between the amount of heat taken from the fuel cell during hydrogen desorption with its subsequent use to increase the power of the fuel cell and the throughput of the consumer's network.

2 The offered mathematical model of thermal sorption interaction of an MH with hydrogen allows for calculating the transfer potentials (temperature, pressure and specific hydrogen mass content) of the sorption process in a GS for any time interval. Experimentally this is impossible. At the stage of designing the GS structure, the model allowed selecting its geometric and operating parameters to ensure effective hydrogen compression and quantitatively estimate exergy loss. The results of testing the developed experimental GS prototype with the technique offered have proved the declared cost-effectiveness characteristics of the metal hydride system.

3 On the basis of detailed calculations of the design of a hydrogen accumulator with a diameter of 0.046 m, in which the heat transfer matrix is made of copper plates, the influence of changes in the geometry of the internal ribbing of the accumulator on the process of heat and mass transfer in the MG is investigated. It was found that for the selected design of the hydrogen accumulator, the most preferred thickness of the ribbing of the plate is = 1.0×10^{-4} m in the range of thickness variation within 20 %.

4 When studying the effect of the distance between the plates on the hydrogen desorption process, it was found that with a decrease in the distance between the plates, the process intensifies. However, an increase in the number of rib plates per unit length of the accumulator leads to a reduction in the useful volume of the MG and, as a consequence, to a decrease in the hydrogen content in it (up to 13%). For the chosen design of the hydrogen accumulator, the distance between the ribbing plates with a thickness of = 1.0×10^{-4} m should not exceed 5.0×10^{-3} m.

5 Recommendations have been developed for synchronizing the operation of a metal hydride hydrogen storage system and a fuel cell as part of a power plant for autonomous power supply of a residential building.

PUBLICATION

1. Chorna N.A. Application of Mathematical Modeling for the Improvement of Mass and Size Parameters of Metal-Hydride Installations / N.A. Chorna, V.V. Hanchyn // Journal of Mathematical Sciences. – 2022. – Vol. 263, № 1. – P. 185–194. https://doi.org/10.1007/s10958-022-05916-7.(Scopus)

2. N.A. Chorna. Prospects for application of hydrogen technologies for autonomous power complexes based on renewable energy sources. *Scientific and Applied Journal Vidnovluvana energetika*, 2021, № 3(66), Pp. 18-32. https://doi.org/10.36296/1819-8058.2021.3(66).18-32. (Scopus)

3. N.A. Chorna. Research of the efficiency of fuel cell as part of autonomous power plants. *Journal of Mechanical Engineering*. – 2021. – Vol. 22, №. 4. – pp. 48–52. https://doi.org/10.15407/pmach2019.04.048. (Scopus)

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5. A. Avramenko, N. Chorna. Adaptation of metal-hydride hydrogen storage technologies for autonomous power supply systems based on fuel cells // *XVI International Conference «HYDROGEN MATERIALS SCIENCE AND CHEMISTRY OF CARBON NANOMATERIALS»* (ICHMS '2019), Kiev, September 23–30, 2019. – 2019. – Pp. 88–89.

6. Chorna N., Shliakhov M. Use of Mathematical Modelling for Development and Creations of an Effective Design of a Metal-Hydride Hydrogen Accumulator. *MATERIALS OF 9 TH INTERNATIONAL FORUM «LITTERIS ET ARTIBUS»*, NOVEMBER 21-23TH, 2019, LVIV, UKRAINE. – Pp. 183-186.

7. N.A. Chorna , V.V. Ganchin Use of mathematical modeling to improve the mass and dimensions of metal-hydride plants. *Mathematical methods and physical and mechanical fields*. 2019. Vol. 2. № 3. Pp. 159–167.