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SUMMARY OF THE DOCTORAL THESIS

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The separation of ^{3}He from liquid ^{4}He based on thermomechanical effect

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The doctoral dissertation, entitled "The separation of ^{3}He from liquid ^{4}He based on thermomechanical effect" was done at the Institute of Molecular Physic, Polish Academy of Sciences in Poznań, Department of Low Temperature Physics located in Odolanów, under the supervision of dr hab. Wojciech Kempiński, prof. IFM PAN, and under the assistant supervision of dr inż. Jarosław Poliński. The work is a summary of the research along the PhD course and the program of the National Center for Research and Development – Innotech, realized by the Scientific Consortium: Institute of Molecular Physics of the National Academy of Sciences – PGNiG SA Odolanów Branch– Wrocław University of Technology.

The ^{3}He isotope is used in many fields of science and industry. In the future, the ^{3}He isotope may also play an important role in solving the energy problems of our planet. The ^{3}He world market faces a problem with severe shortages in supplying of this isotope. Currently, the main source of ^{3}He is the storage of radioactive products, including nuclear weapons. The search for this rare isotope has now started also on the Moon. Planets of our system, which do not have a protective magnetic field are also considered as a potential source of ^{3}He. Exploitation of these rich sources of ^{3}He will require enormous financial outlays and a long time. Therefore, in a doctoral thesis the method of acquiring ^{3}He is the cryogenic separation of the ^{3}He/^{4}He mixture below the lambda transition of ^{4}He - temperature 2,18 K has been proposed.

In the theoretical part of the dissertation a general separation process of a two-component mixture is reviewed. Also methods for the ^{3}He isotope separation using cryogenic methods are presented.

The theoretical part describes the introduction to a two fluid Tisza's model and London's law in terms of their use to optimize the separation process. A number of examples methods, which use the term-mechanical effect to enrich 3He can be found in the literature. Based on the presented examples, a thesis was put forward that the modern carbon nanomaterials decorated with Fe_3O_4 and ZrO_2 nanoparticles as well as the YBCO-123 high-temperature superconductor could be used to optimize the ^{3}He separation process.

In the next part of the doctoral dissertation the preparing methods of research materials for the ^{3}He filtration process from the ^{3}He\$^4$He mixture are described. The preparation of entropy filters for mass flow measurements using the thermo-mechanical effect on a double glass dewar, for the enrichment of the ^{3}He \ ^{4}He mixture in the ^{3}He isotope on the 25LHe system test stand and for the enrichment measurements of the ^{3}He \ ^{4}He mixture in the ^{3}He isotope on the industrial separator was discussed.

All three test stand have been characterized in terms of design and the possible enrichment of the ^{3}He \ ^{4}He mixture in the ^{3}He isotope. The procedure for measurement of ^{3}He concentration using a mass spectrometer is presented in the final chapters of the dissertation.

The dissertation presents and discusses results of enriching the ^{3}He \ ^{4}He mixture in ^{3}He isotope for particular entropy filter material. With the laboratory test stand ^{3}He enrichment have been obtained for entropy filters with ZrO_2 decorated carbon nanotubes and for the YBCO-123 high-temperature superconductor. On the semi-industrial test stand the enriching the ^{3}He \ ^{4}He mixture in ^{3}He isotope has been obtained in the continuous ^{3}He separation process with the entropy filter made of compressed carbon nanotubes decorated with magnetic Fe_3O_4.

The dissertation is summarized with number of the conclusions which shown that all the objectives of the work are accomplished and the dissertation thesis is confirmed.

Jakub Wiech