Joint project of KNUCA and Zhejiang Yuexin Inspection Technology Co., Ltd.

Mykhailo Sukach[1], Jin Hangfei[2]

[1] Kyiv National University of Construction and Architecture
Povitroflotsky Avenue 31, Kyiv, Ukraine, 03037
msukach@ua.fm, orcid.org/0000-0003-0485-4073
[2] Zhejiang Yuexin Inspection Technology Co., Ltd.
Liangta West Road 135, Taozhu Street, City
Zhejiang Province, yuexndt@163.com

Received 18.07.2022, Approved 18.09.2022
https://doi.org/10.32347/tit.2022.51.0201

Abstract. Every year, international scientific conferences are held in China, dedicated to the search for high-class talents, the attraction of innovative technologies, the creation of joint ventures in various fields of science and production. One of the organizers of such events was the Ukrainian-Chinese Silk Road Center, which, as part of the "One Belt, One Road" program, regularly conducts online video road shows between Chinese and Ukrainian specialists. This time, projects from several branches of production, including mechanical engineering and robotics, were presented. The best works are selected for the preparation of grant applications for research funding in laboratories and research groups in China, as well as for participation in the country's production activities.

One of the successful applications was a joint project of the Kyiv National University of Civil Engineering and Architecture and the pipeline diagnostics company Zhejiang Yuexin Inspection Technology Co., Ltd. Doctor of Technical Sciences, Professor M.K. Sukach took part in it as the technical director of the project., specialist in deep-sea technology. The Chinese side was headed by the project's chief manager, company director Jin Hangfei. The project became one of those selected by the Ukrainian-Chinese Center and nominated for a state grant. He won the support of the Beijing High-Tech Exchange and government funding for joint research. In addition to the scientific component, it provides an educational program for student training, PhD training and advanced training of specialists in the relevant field.

Mykhailo Sukach
Doctor of Technical Sciences,
Professor at the Department of construction machinery

Jin Hangfei
Company director

Keywords: measuring equipment, sensing, non-destructive testing, magnetic flux, intelligent technology.

INTRODUCTION

At the international conference "China Weihai International Talents, Innovation and Entrepreneurship Conference", which took place in the city of Weihai, Shandong province (China), the reports entitled: "Identification of working processes of deep-water equipment" by professor M.K. Sukach [1] and "Magnetic flux leakage detection technology in pipeline", by the di-

rector of the company, Jin Hanfei [2] were presented. They related to the joint program with Chinese scientific and industrial facilities for the development of marine deposits, diagnostics of pipeline transport by determining the leakage of magnetic flows during operation [3 − 5], assessment of countries' readiness to develop non-traditional types of mineral resources. Necessary steps and staging of seabed study for excavating systems, methods and equipment for deep-sea research, as well as underground and underwater pipelines integrity diagnosing questions have been discussed [6 − 9].

The conference was organized by the Human Resources and Social Security Department under the patronage of the Municipal Bureau of Human Resources and Social Security. Representatives of many Chinese organizations and several Ukrainian specialists in educational and industrial spheres took part in the conference. Having discussed real production needs, several works, which attracted attention by their technical achievements, have been selected from among numerous available options. Having determined the list of experts and projects of the road show, the organizers of Ukrainian-Chinese Center provided recommendations regarding preparation work for China's "One Belt One Road " grant program applications, which opens up new opportunities for Ukrainian-Chinese cooperation [10].

PROJECT TEAM

According to the "Overseas Talents Program", a joint project of Kyiv National University of Construction and Architecture and Chinese oil industry military-civilian enterprise Zhejiang Yuexin Inspection Technology Co., Ltd., became one of the nominees, as a part of the "Shaoxing" (2020) long-term project. The project under the working title: "Industrialization of pipeline magnetic flux leaks internal testing technology" is aimed for diagnostics of the pipelines, that are being designed and also those, which are currently used.

The international team of the project included: Mykhailo Sukach (KNUCA, Kyiv) – technical director responsible for the general planning of research and development work and technological development of project products; Jin Hangfei (Zhejiang University of Technology) as a general manager, responsible for the day-to-day work of the entire innovation team; Zheng Li (Harbin Engineering University) as a project researcher and State Council special scholarship nominee, responsible for solving various problems during the production process; Chen Ming (Northwest Institute of Telecommunications Engineering) as a researcher responsible for product manufacturing and on-site management; Fang Feizhong (Nanchang Aviation University) as a senior engineer responsible for the experimental equipment application.

Information about the leader of the project: M.K. Sukach is a Department of Construction Machinery professor at Kyiv National University of Construction and Architecture. He is engaged in teaching and scientific research in mechanical engineering and measuring technology, an expert in converting and storing magneto-electrical signals of pipe-laying robots. He published more than 650 scientific and methodical works, including 20 monographs, 340 articles, 40 manuals and textbooks, 30 author certificates and patents for inventions (Fig. 1). He is a current member of the Academy of Engineering Sciences of Ukraine, a member of the National Committee on Theoretical and Applied Mechanics, a member of the Presidium of the Academy of Construction of Ukraine, a foreign member of the Polish Academy of Sciences. Awarded the medal of the Ministry of Defense of USSR "Excellent in military construction", has a certificate of honor of the Ministry of Education and Science of Ukraine, the silver medal of the Academy of Construction of Ukraine for the best publication in the field of construction science (2015), the winner of KNUCA competition "Best in professional and scientific activities" (2017), certified as high-level talent, category A (Zhejiang, China, 2022).

2020年绍兴“海内外英才计划”创新长期项目

管道漏磁内检测技术产业化项目

申报人：米哈伊洛·苏卡奇
Mykhailo Sukach

申报单位：浙江越新检测技术有限公司

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创新人才基本情况

米哈伊洛·苏卡奇
Mykhailo Sukach

基辅国立建筑大学　机械工程　技术科学博士
曾任基辅国立石油天然气大学机械工程系　教授

从事智能检测机械方面的教学、科研工作。是管道机器人磁电信号相互转化、储存方面的专家。

曾发表了600余篇科学和方法论著作，包括15部专著，310篇文章，37本手册和教科书，28份版权证书和发明专利。

个人荣誉：
2017 KNUBA竞赛“最佳专业和科学活动”优胜者证书
2015 乌克兰土木工程学院“建筑科学领域最佳出版作品”银奖
2014 乌克兰教育和科学部荣誉证书
2013 乌克兰建筑科学院院士
2010 波兰科学院外籍院士
2006 乌克兰工程科学院院士
2005 乌克兰理论与应用力学国家委员会成员
1981 苏联国防部“卓越军事建设”勋章

创新人才基本情况

教育经历：

起止时间（年/月）	国家	学校	专业	学位
1971. 09-1976. 06	乌克兰	基辅工程建设学院	自动化与集成机械化	电气工程师（硕士）
1989. 09-1992. 12	乌克兰	基辅工程建设学院	自动化与集成机械化	博士
1999. 09-2003. 01	乌克兰	基辅国立建筑大学	机械工程	技术科学博士


创新人才基本情况

工作经历：

起止时间（年/月）	国家	工作单位	职位或职称
1976. 07-1986. 12	乌克兰	基辅国立建筑大学	初级研究员
1987. 01-1994. 09	乌克兰	基辅国立建筑大学	高级研究员
1994. 10-2000. 09	乌克兰	基辅国立石油天然气大学	助理教授
2000. 10-2020. 05	乌克兰	基辅国立石油天然气大学	机械工程系教授
2020. 06-2025. 05	中国	浙江越新检测技术有限公司	技术总监

创新人才基本情况

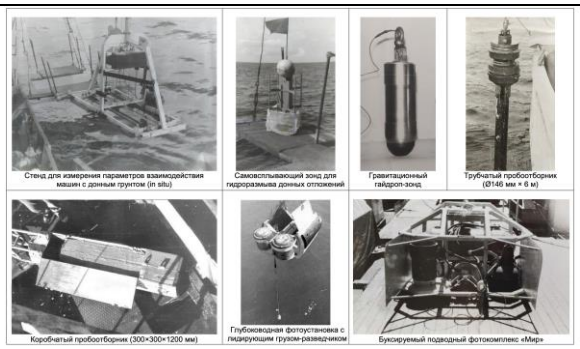
领导参与过的项目——领导实施了多个项目，研发经费共1200万元

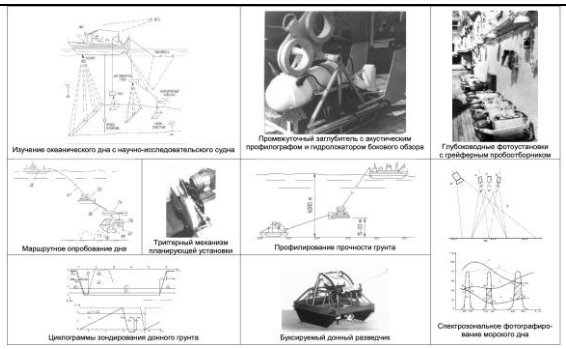
起止时间（年/月）	项目性质和来源	经费总额	参与人数	申报人的具体职位和任务
2018.02-2019.05	磁场测量设备的研发	150万	5	项目负责人，开发用于磁场测量设备的传感器
2017.07-2019.10	沿河底敷设管道技术的发展	400万	10	项目负责人，河床底部管道的特殊水下设备，使用新技术创建传感器系统
2016.04-2018.06	管道圆周磁场信号与传感器位置的阶梯算法	350万	6	项目负责人，正确提取了不同位置的传感器信号
2015.09-2017.04	深海管道检测机器人的创新工作	300万	12	项目负责人，为深海管道检测机器人开发高压密封技术和地磁导航技术

创新人才基本情况

代表性论著——拥有**600**多份印刷的科学论文，其中与管道相关的论文就有200余篇。

发表时间	论著（论文）名称	发表载体	论著（论文作者）
2019	教科书：《电子信息技术基础》	Kiev, Lira-K Publishing House, 318 pp.	Mykhailo Sukach
2016	教科书：深海机械设备	Kiev, Lira-K Publishing House, 408 p. https://doi.org/10.26884/mks-lirak.01	Mykhailo Sukach
2015	专著：“漏磁场的阶梯算法”	Kyiv, MP Lesya, 106 pp., Https://doi.org/10.26884/mks.m1512	Mykhailo Sukach
2014	专著：“管道检测创新技术转让”	Saarbrucken, Germany, Palmarium Academic Publishing, 482 pp.	Mykhailo Sukach
2004	专著：“机器人对海底管道的缺陷检测”	Kiev, Naukova Dumka, 364 pp.	Mykhailo Sukach





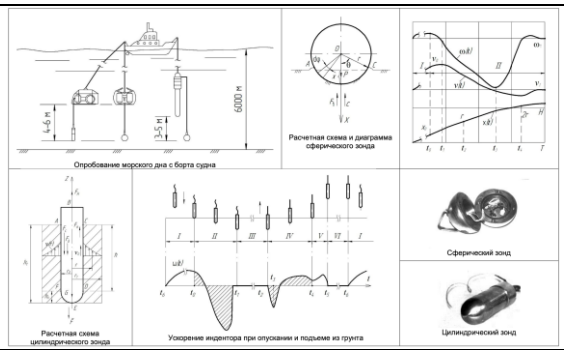


Fig. 1. Information about the leader of the project (begin)

Fig. 1. Information about the leader of the project (end)

He graduated from Kyiv Engineering and Construction Institute with a degree in electromechanical engineering, defended his candidate's and doctoral theses, received the title of associate professor and professor at the department of construction machinery of KNUCA, where he works till now. He currently performs the duties of the technical director of the project entitled: "Industrialization of pipeline magnetic flux leaks internal testing technology".

Here are some of his main publications: Working processes of deep sea machines (monograph, 2004), Trench excavator for opening underground pipelines (patent of Ukraine No. 42389), The method of laying cables along the bottom of rivers and shallow reservoirs (patent of Ukraine No. 67382), Transfer of innovative technologies (monograph, 2014), Modernization of a two-section chain trencher (monograph, 2015), Construction machines and equipment (textbook, 2016), Fundamentals of technology transfer (textbook, 2020) etc.

The base production facility of the project is Zhejiang Yuexin Inspection Technology Co., Ltd, which is located in the beautiful ancient capital of the Yue Kingdom and the ancient city of Xishi − Zhuji, bordering Hangzhou in the north, Shaoxing in the east, and Yiwu in the south. This is a professional enterprise that specializes in the detection of underground space and non-destructive testing.

This company is positioned as a professional enterprise for non-destructive testing and intelligent transformation of oil depots. Its technical scope includes: services for detecting underground spaces, services for internal inspection of MFL main pipelines, four services of conventional non-destructive testing (RT / UT / MT / PT), as well as services for conversion and modernization of digital oil fields and intellectual oil storages (Fig. 2).

The company cooperates with the Aerospace Science and Technology group and the 35th Research Institute of the Aerospace Scientific and Industrial group. In cooperation with these groups, they established the Zhejiang Yuexin Research Institute of Underground Research, an engineering laboratory for the detection of magnetic flux leakage in the pipeline and other technical support. Zhejiang Yuexin Inspection Technology Co., Ltd is a growing Chinese military-civilian integrated enterprise. Currently they have 125 workers, 85 of them have relevant certificates (12 of them have certificates of non-destructive control special equipment of

Fig. 2. Certified technologies of Zhejiang Yuexin Inspection Technology Co., Ltd

the third level, 48 of them obtain certificates of non-destructive control of the second level). The company has 35 sets of X-ray machines, 10 sets of ultrasonic flaw detectors, 5 sets of magnetic powder flaw detectors for detecting magnetic flux leaks in pipelines and other auxiliary devices.

DETECTION OF PIPELINE DEFECTS

Problem. Magnetic flux leaks detecting technology is the most widely use d method of oil and gas pipelines research [11 − 14] (detection of magnetic flux leaks of terrestrial pipelines has 95% of the market share, while ultrasonic and sonar detection has only 5% of the market share). Currently, domestic and foreign inspections of pipelines rely mainly on the detection of magnetic flux. The magnetic flux leakage detector is sensitive to such defects as narrow cracks, which are perpendicular to the pipeline, but can not effectively detect narrow cracks, whic are parallel to the pipeline. At the same time, the distance between the defect and magnetic pole, level of magnetization, speed of operation and distance of the sensor ads – all these factors may directly affect testing results.

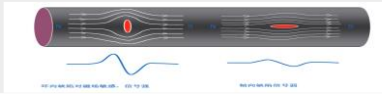
Main contents. On the basis of axial type magnetic flux leaks detection technology [15 − 19] we proposed a circular technology of magnetic flux leaks internal detection. It is based on the magnetic circuit finite element modeling technology. This circular magnetic flux leakage detection method relies on a magnetic field, which is distributed along the pipeline (in circles). It has potential advantages for detecting and quantifying axial defects [20 − 23]. Finally, the technology of detecting magnetic flux leaks in the axial mode and the technology of detecting magnetic flux leaks in circular mode are combined to form a two-way composite technology of detecting magnetic flux leaks, which realizes comprehensive detection of pipeline defects (Fig. 3).

Idea of the project. Choosing proper magnetization parameters is the key to a successful application of circular type magnetic flux leaks detection technology. Finite element modeling technology is used to study the correlation between the distance between the defect and magnetic pole and the magnetic leakage signal, generated by this defect, in order to determine the permanent magnet size parameter. In addition, the magnetic flux leakage signal is calculated using the calculation, in order to overcome the problem of magnetic flux leakage signal, caused by magnetic field coverage defect close to magnetic poles zones. The technology for magnetic flux leaks circular detection is optimized for the structure of toroidal magnetizer. Electromagnetic yoke receives 4 groups of symmetrical ring structures. Generated magnetic field lines are perpendicular to the axial direction of the pipeline, each line forms independent loop.

项目产品情况介绍

现有问题：

漏磁检测技术是油气管道检测中应用最广泛的检测手段（陆地管道检测中漏磁检测占95%市场份额，超声和声呐检测因介质问题只占5%市场份额），目前国内外管道内检测装备主要采用轴向漏磁检测技术，轴向漏磁检测器对垂直于管道的铁管裂纹等缺陷敏感，但对平行于管道的铁管裂纹等缺陷，无法有效识别。同时缺陷距磁极的距离、磁化水平、运行速度和传感器的间距都直接影响检测结果。

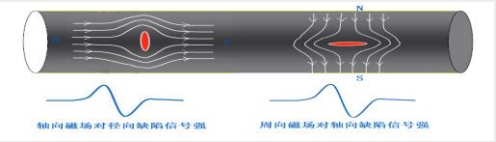


项目产品情况介绍

项目产品情况介绍

主要内容：

在轴向漏磁检测技术的基础上，加入了一种基于磁路有限元仿真技术的周向漏磁内检测技术。周向漏磁检测方法依靠环绕管道（周向）分布的磁场实现检测，对于检测和定量评价轴向缺陷具有潜在优势。最终使轴向漏磁检测技术和周向漏磁检测技术相结合形成双向漏磁复合检测技术，实现对管道缺陷全方位检测。

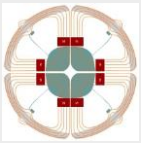


项目产品情况介绍

创新设计1：

周向漏磁检测技术应用的关键是选择合适的磁化器参数。利用有限元仿真技术研究缺陷距磁极的距离和缺陷产生的漏磁信号之间的关系来确定永磁体的尺寸参数。并且漏磁信号经微积分计算来克服临近磁极区域背底磁场覆盖缺陷产生的漏磁信号的问题。

周向漏磁检测技术在环向磁化器结构上进行了优化，轭铁采用4组对称的环形结构，产生的磁力线垂直于管道轴向，各自形成独立回路。

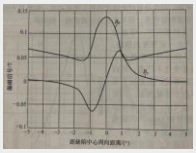


周向漏磁磁场分布

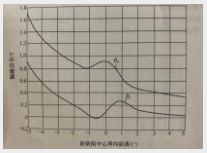
项目产品情况介绍

创新设计2：

双向漏磁检测智能数据分析技术：其难点在于两向不同励磁方式以及物理差异形成的多数据融合以及特征决策算法，需结合两向磁路形成的双三轴数据、双位置差等多维信息实现数据特征转换提取，融合抽样、隐函数关系建立、模糊集决策等算法实现高可信度缺陷反演。



位于两个磁极中心处的漏磁信号



领近磁极的缺陷处的漏磁信号

团队和现有工作基础

团队情况：

姓名	毕业院校	性别	职位
Mykhailo Sukach 米哈伊洛·苏卡奇	基辅国立建筑大学	男	技术总监 负责项目产品的总体研发策划及技术开发
金杭飞	浙江工业大学	男	总经理 负责管理整个创新团队的日常运作
郑莉	哈尔滨工程大学	女	研究员，国务院特殊津贴获得者 负责解决生产过程中出现的各种难题
陈铭	西北电讯工程学院	男	研究员 负责产品生产，现场管理
方飞忠	南昌航空大学	男	高级工程师 负责项目应用研究

团队和现有工作基础

企业简介：

浙江越新检测技术有限公司是一家专门从事地下空间探测和无损检测服务的专业化企业。公司拥有特种设备检验检测漏磁检测（MFL）资质、四项常规（RT/UT/MT/PT）检测资质和优秀的服务团队。与航天35研究所，共同建有浙江越新智能检测技术军民融合研究院、管道漏磁检测工程实验室，集研发、制造、服务于一体，是一家检测行业中冉冉升起的军民融合企业。

工作设想和预期目标

计划安排

2020.06-2020.12	2021.01-2021.12	2022.01-2022.12	2023.01-2023.12	2024.01-2025.05
实现漏磁检测磁路的仿真建模设计，实现产品的优化设计。	通过实测验证检测的有效性，最终得到工程实际应用，实现销售。	设备继续改良，国内、国际项目推广。	优化升级改造磁化器结构，改进传感系统。	继续新产品研发、技术革新，进行技术推广应用。

时间	2020年06月-2020年12月	2021年01月-2021年12月	2022年01月-2022年12月	2023年01月-2023年12月	2024年01月-2025年05月	合计
新增销售（万元）	0	3000	5000	7000	12000	27000
利税（万元）	0	500	800	1200	2200	4700
本项目研发投入（万元）	700	500	400	400	400	2400
专利情况（个）	3	5	6	6	8	28

工作设想和预期目标

周向漏磁检测技术是跨入国际市场的门槛，这项技术的成熟应用可以打破国外垄断，开拓国际检测市场。同时还大大提升了我国现有和在建的管道运营的安全性，为防止我国海底地形地貌和管道位置泄密发挥不可替代的作用，具有广阔的市场应用前景。

	原油管道	成品油管道	天然气管道	管道长合计（万公里）	管道内检测市场（亿美元）
亚太	4.35	2.87	17.05	24.27	29.12
中东及非洲	5.7	4.4	10.4	20.5	24.6
俄罗斯及中亚地区	7.5	1.9	20	29.4	35.28
欧洲	2.6	2.3	23.1	28	33.6
北美	15.29	17.91	51.3	84.5	101.4
拉丁美洲	2.2	1.36	4.4	7.96	9.55
合计	37.64	30.74	126.25	194.63	233.56

2019年全球油气储运管道长度

谢谢

敬请各位评委专家提出宝贵意见！

Fig. 3. Pipeline magnetic flux leakage testing

Implementation of the project. Intelligent data analysis technology for two-way detection of magnetic flux leaks: the complexity lies in the algorithm of data registration and processing, consisting of two-sided different methods of excitation and physical differences, which must be connected to the two-sided magnetic circuit using double triaxle data, double position signal difference and other multidimensional information. Data transformation and feature extraction, fusion sampling, establishing implicit functional relationships, fuzzy set decision making, and other algorithms to achieve high-fidelity defect inversion (Fig. 4).

Fig. 4. Implementation of the technology for detecting magnetic flux leaks in pipelines

Work planning. Project work stages are as follows: implementation of simulated modeling of the design of magnetic circuit for detection of magnetic flux leaks and implementation of optimized product design (06.2020 – 12.2020); application and verification of the effectiveness of diagnostics by actual measurements and implementation through the sale of product design solutions (06.2020 – 12.2020); application and verification of the effectiveness of diagnostics by actual measurements and implementation through the sale of product design solutions (01.2021 – 12.2021); improvement of equipment and advancing of domestic and international projects (01.2022 – 12.2022); optimization and renewal of the magnetizer structure, improvement of the sounding system (01.2023 – 12.2023); continuing research and development of new products, technological innovations and promotion and application of new technologies (01.2024 – 05.2025). The project budget is 270 million RMB.

Application potential. According to 2019 data, the length of global oil and gas storage and transportation by region is: in the Asia-Pacific region 242.7 thousand km, in the Middle East and Africa 205.0 thousand km, in Russia and Central Asia 294.0 thousand km, in Europe 280.0 thousand km, in North America 845 0,000 km, in Latin America 79,600 km. Total - 1946.3 thousand km. At the same time, the market for internal diagnostics of pipelines is $23.356 billion.

CONCLUSION

The technology of detecting circular leakage of magnetic flux is the threshold for entering the international market. Wise application of this technology can destroy foreign monopolies and open up the international testing market. At the same time, it will significantly improve the safety of existing and under-construction pipelines, play an indispensable role in the prevention of underwater pipeline leaks, and will also have broad prospects for application in the market as a whole.

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Совместный проект КНУСА − Zhejiang Yuexin Inspection Technology Co., Ltd

Михаил Сукач, Цзинь Ханфей

Аннотация. Ежегодно в Китае проводятся международные научные конференции, посвященные поиску высококлассных талантов, привлечению инновационных технологий, созданию совместных предприятий в различных отраслях науки и производства. Одним из организаторов таких мероприятий выступил Украинско-китайский центр Шелкового пути, который в рамках программы «Один пояс, Один путь»

регулярно проводит онлайн-видео роуд-шоу между китайскими и украинскими специалистами. На этот раз были представлены проекты из нескольких отраслей производства, в том числе машиностроения и робототехники. Лучшие работы отбирались для подготовки грантовых заявок на финансирование исследований в лабораториях и исследовательских группах Китая, а также для участия в производственной деятельности страны.

Одной из успешных заявок стал совместный проект Киевского национального университета строительства и архитектуры и компании по диагностике трубопроводов Zhejiang Yuexin Inspection Technology Co., Ltd. Доктор технических наук, профессор Сукач М.К. принял в нем участие как технический руководитель проекта, специалист по глубоководной технике. Китайскую сторону возглавил главный менеджер проекта, директор компании Цзинь Ханфэй. Проект стал одним из номинированных украинско-китайским центром на государственный грант. Он получил поддержку Пекинской биржи высоких технологий и государственное финансирование совместных исследований. Кроме научной составляющей, предусмотрена образовательная программа подготовки студентов, аспирантов и повышения квалификации специалистов соответствующего профиля.

Ключевые слова: измерительное оборудование, зондирование, неразрушающие испытания, магнитный поток, интеллектуальная технология.