Technological Research for a Better Future

The 4th Research Forum between
Changzhou University and Satakunta University of Applied Sciences

Marina Wikman (ed.)

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Foreword

The fourth research forum between Changzhou University (CZU) and Satakunta University of Applied Sciences (SAMK) was held in spring 2016.The universities alternate in organising the forum. This time it was SAMK's turn, and the location was Pori, Finland.

The research forum provides the researchers at both universities an international platform to present their research, and also to learn about studies conducted at the other university. It also enables networking with other researchers.

This publication contains summaries of the presentations given by researchers in the forum. The contributions are diverse, ranging from environment to care technology. The summaries are evidence of both universities and researchers aiming to work towards innovation, and, thus, to accelerate progress and positive development in their respective fields.

As both universities have a strong focus on industry and industrial co-operation, the presentations addressed mainly topics, which cover a wide variety of technology, which can benefit both industry and society today and in the future.

The contributions of the presenters are greatly appreciated, and we are convinced that reading the summaries provides a worthwhile insight into future possibilities in research.

Satakunta, August 2016
Marina Wikman, Editor

SAMK's profile: Industrial University

Juha Kämäri, Adjunct Professor, President and CEO,
Satakunta University of Applied Sciences

SAMK is a versatile, multidisciplinary, internationally and professionally oriented university with some 6000 students and 450 staff members. Satakunta region is characterized by maritime and offshore industry, energy production, heavy engineering, process industry, ports and logistics services as well as diversified food industry. The University is the region's key actor in advancing innovations, entrepreneurship and internationalization.

SAMK's ideology for matching the needs of the work life is to cooperate closely with enterprises, public service providers and various development organizations. How to do it; every year we carry out several hundred joint projects, mostly involving students, together with companies and public organizations. In addition, more than 1000 theses per year are prepared by graduating students, supporting the economic life in multiple ways. Moreover, annually more than 1000 professionals participate in further education provided by SAMK. Finally, around 20 new companies are formed every year with the help of SAMK's own *Enterprise Accelerator*, offering mentoring service to student entrepreneurs.

At the present time SAMK has started the negotiations with the Ministry of Education and Culture for the next agreement term for the years 2017-2020. The Ministry has requested the universities to have high ambitions in defining their profiles and in carrying out structural measures in order to enhance their strengths and emerging areas.

SAMK has defined its profile to be an *"Industrial University"* indicating the important role of SAMK in supporting the industrial life of the region by focusing its activities on renewal of the industries, on export business skills and on supporting the performance of labor. The renewal of industries is understood by turning the focus to modern ways of doing business, e.g. digitalization and Internet of Things.

We have defined six strategic focus areas for the agreement with the Ministry. Three of these areas were defined as strengths: i) automation, ii) seafaring, iii) services for aging population, and the other three as emerging areas: i) logistics, ii) new energy and water technologies, and iii) tourism business. These focus areas together with the regional strategies drive the development of the research and development activities of the University. Presently there are 13 research groups at SAMK with a main interest to develop tangible cooperation with companies and public organizations. This working strategy leads to rapid utilizations of the research results.

Let us also highlight the new vision of our university: Every student of SAMK becomes employed. By this we aim at education that has been tailored by the needs of the region, we aim at wide company level cooperation between SAMK and the employers of the region, and finally, we aim at providing an entrepreneurial attitude for all students of the university. By these steps we provide the students the means to become employed.

The two Universities, SAMK and CZU, have a well-established partnership that has resulted in successful student and faculty exchange programs as well as research forums. The research forum between CZU and SAMK offers an operational platform for faculty and researchers to share ideas and discuss cooperation. The first forum was held in Changzhou in 2010, the second in Pori in 2011, and the third in Changzhou in 2014. In this publication, the deliberations of the fourth distinguished Research Forum of Changzhou University and Satakunta University of Applied Sciences are presented.

Looking into the future, there is to be seen a great potential for extending the collaboration even further, into project based research and development work in several possible areas, for example those presented and SAMK's focus areas, services for aging population, and automation. The main objective of the planned projects is to help companies from Finland and China to establish partnerships and customerships.

The Development Path of Education-Research-Industry at Changzhou University

Chen Qun, Professor, President of Changzhou University

Founded in 1978, Changzhou University (CZU) has changed its name four times and in 2010 got its current name after the city. The University is committed to developing an open, harmonious, progressive, and prosperous community and aims at becoming a leading university with high level and distinctive characteristics in the local.

CZU has developed from an engineering institute to a comprehensive university with over 15000 undergraduates, 1600 postgraduates and about 1000 teaching staff. The 15 faculties offer 67 Bachelor's Degree programs covering most academic fields in science, engineering, management, economics, laws, medicine, agriculture, etc. A wide-range of Master's Degree Programs are offered in areas such as Chemistry, Chemical Engineering, Petroleum and Natural Gas, Material Science, Environmental Engineering, Safety Engineering, Mechanical Engineering, Computer Science, Software Engineering, Management, Art Design, and PhD programs in Photovoltaics.

CZU is well equipped with up-to-date research facilities: one key national laboratory (under construction), two national simulation experiment centers, seven key provincial laboratories and many other fundamental laboratories. In recent years, the University has won four national science and technology awards. During 2013-2015, the University was granted 126 National Natural Science Fund projects, and 22 National Social Science Fund projects, and 1722 articles in SCI EI and CPCI-S journals. Its technological inventions and patents increase rapidly and rank among top 50 among Chinese universities.

CZU has close links with the petrochemical industry and the local community. The University has established long-term cooperative relations with over 40 large enterprises such as Lenovo Group, China Chemical Group, Sinochem. In 2011, the University won a joint grant by Jiangsu provincial government and three biggest Chinese petrochemical corporations which are Sinopec, Petrol China, and China National Offshore Oil Corporation. The University also pays great attention to technological service for local enterprises. It has established 30 centers for research and development with local companies and governments which contribute to the development of local small-and-medium sized enterprises.

CZU emphasizes international cooperation and has established close links with universities and research institutes in Europe, North America and South-East Asia. The University especially values the collaboration with SAMK in Finland. The student and faculty exchange program, which started in 2008, has closely bound the two universities together. The research forums between CZU and SAMK, which have been held four times, also offers a convenient platform for faculty and researchers from both sides to share ideas and discuss cooperation. In 2016, the two universities have been discussing double degree programs and nursing projects. We will continue to give full support for the collaboration between our two universities and look forward to a closer relationship and more collaborative programs and projects.

SME Innovation Targeted Technology Transfer

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Kati Katajisto, MSc (Tech), R&D Manager, Seinäjoki University of Applied Sciences

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Introduction

The traditional, linear technology transfer between enterprises and higher education institutes (HEIs) has reached the end of the road. Today the collaboration between universities and enterprises is much more diversified, open innovation targeting and based on clear needs. The universities must create their own, regional technology knowledge transfer models with more impact in order to foster collaborative innovations. The main goal of this research is to develop functioning ways of technology knowledge transfer between HEIs and SMEs (Small and Medium-sized Enterprises), to identify the best practices and to model them. (Bradley et al. 2013)

This research is conducted as a technology knowledge transfer process between three higher education institutions and 16 enterprises. This paper presents the research project, the created transfer model as well as the evaluation and the conclusions of all these.

Background

Earlier technology transfer was based on linear models, where universities created and transferred technologies based on their research results (Harmon et al. 1997). This kind of traditional technology transfer between universities and enterprises has focused mainly on IP rights, patents, licensing and commercialization of the research results, whereas the modern technology knowledge transfer means much wider actions with different operation channels and mechanisms (Perkmann and Walsh 2007).

Today there is need for nonlinear and regionally engaged technology transfer models which are based on interaction and knowledge sharing. This means that the universities have to adjust their technology transfer models from only push type to both push and pull type models. (Leino et al. 2015)

Satakunta is a region with quite traditional manufacturing industry and its SMEs need their own technology knowledge transfer model. The first steps of the model creation were taken with 6 SMEs in 2008-2009 and later with 7 different SMEs in 2009-2011. These developing processes indicated that there is distinct need for developing the model also with other universities of applied sciences as well as with a larger research group and with a wider sample group. (Laine et al. 2015)

Research Implementation

SMEs were chosen as the target organisations of this research because particularly SMEs do not usually have enough resources or background knowledge to search and utilise newest technology information. As one solution for this, a wide-ranging group of experts coming from three universities worked together in technology transfer. These experts have multifield, versatile expertise and at the same time they have the technology, research and pedagogy competences to filter and interpret the technology knowledge in ways that the SME representatives may utilise in their work. The experts' disseminative capacity is widely exploited with the 16 technology enterprises participating in the research. With this set-up the goals for the research project were:

1. To develop a technology transfer model suitable especially for the UASs
2. To increase knowledge competences of the universities and SMEs
3. To create a multiregional model for wide-ranging university experts' cooperation

In creation of regional technology transfer model there are three main features to be taken into consideration. How to make sure that the SMEs can assimilate the knowledge? Which are the most effective ways to disseminate the technology knowledge? And how to implement the cases as effectively as possible? First, absorptive capacity is found to be a prominent threshold factor in the effectiveness of university-industry interaction. Absorptive capacity means the ability of an enterprise to recognize the value of new, external information, assimilate it, and apply it to commercial ends (Cohen et al. 1990). Disseminative capacity, on the other hand, is the counterpart of absorptive capacity and it is a competence of the knowledge source. Kuiken et al. (2011) define dissemination capacity as the capacity of an organization or institute to transform its knowledge into value for other actors in its network with a commercial and/or learning purpose.

In this research the technology transfer modelling is based on case studies where UAS (University of Applied Sciences) experts were finding solutions for the technology needs recognised in the participating SMEs. The theories of design science research are used as guidelines in case execution in order to find the most effective results. Design science research is a research method based on problem solving paradigm. Design science research processes focus on innovative results that rise from design and construction creativity of humans and have clearly recognized needs. (Hevner and Chatterjee 2010)

In this research the knowledge search was executed iteratively in two phases. The first phase was wide-ranging with the focus on new innovations, technological changes, standard changes and in suitable events, seminars and conferences. The focus of the second phase was on deeper and more precise cases which were sifted from subjects of the first phase. Both phases contained many actions performed interlocked. Especially in the second phase the modus operandi was iterative as the specific knowledge search was executed in cycles. After every search cycle there was a knowledge transfer point where the enterprise representatives could assimilate the information and identify more precise knowledge needs. (Leino et al. 2015)

A continuing and focused dialog between experts and enterprise representatives was the base for productive knowledge search. That way the potential information channels and knowledge transfer methods were tested. All the 14 cases and 25 subcases were executed through multidisciplinary communication. The technology knowledge transfer modelling was done by executing these cases. The existing action models, experimented selected models and evaluated realised actions were studied. This way the best practices for knowledge transfer were identified.

The cross-sectional study of all the case studies and best practices led to the development of the Innovation oriented model for technology knowledge transfer in HEI-SME collaboration (Figure 1).

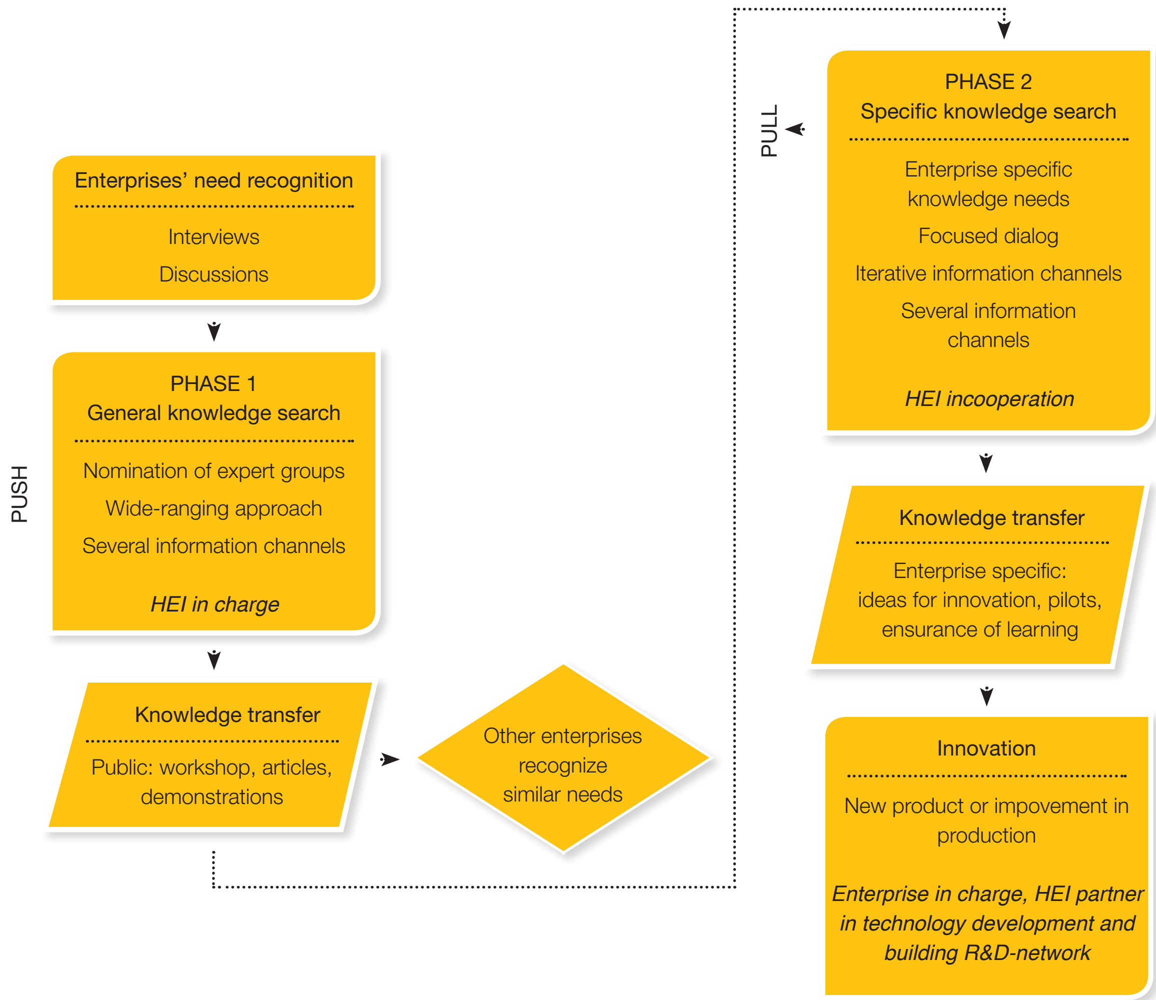

Figure 1. Innovation oriented model for technology knowledge transfer in HEI-SME collaboration (Leino et al. 2015)

The key element of successful HEI-SME cooperation is to understand the business environment of SMEs from their perspective. The model is highly based on need recognition carried out in the enterprises. When the needs are evident, the technology transfer process proceeds in two phases. In the first phase the university is in charge of knowledge search on a more general level. After the first phase the knowledge transfer, such as demonstrations and pilots, lead to recognition of more specific needs, which are then fulfilled in cooperation with the university and the enterprise. Finally, in successful cases, the results are new innovations.

Evaluation of the Model

The innovation-oriented model for technology knowledge transfer in HEI-SME collaboration is a new approach for need- and dialogue-based technology knowledge transfer. The model is focused especially on small and medium-sized enterprises (SMEs). It is non-linear with need recognition and many iterative cycles. It is not just about searching and disseminating knowledge passively but also combining existent knowledge with new searched knowledge, demonstrating the possibilities of the technologies based on searched and interpreted technology knowledge and piloting the technologies in real cases of the enterprises, as well as transferring the knowledge interactively and iteratively in order to find answers and new innovations. This model deepens the collaboration between the HEIs and the SMEs while the model actions proceed, and it increases the responsibility of the enterprises and supports push to pull transformation of the technology knowledge transfer. The model takes the absorptive capacity of the enterprise into account by demonstrating and piloting the technologies based on the needs and on the absorptive capacity of the enterprise, and by transferring the technologically interpreted and analysed knowledge by the experts with dissemination skills.

Conclusion

Developing of the innovation oriented model for technology knowledge transfer was influenced by design science research. The model was created by studying existing action models, experimenting with selected models as well as evaluating realised actions and identified best practises used in the technology knowledge transfer cases. In the evaluation of the whole research process the success of the case studies could easily be detected on the grounds of the large amount of subcases risen from the case studies.

There are some limitations for this research. The model is created for collaboration between Finnish universities of applied sciences and SMEs in their region. It may not be generalised to other fields of collaboration. There may be differences between SMEs' entrepreneurialism and approach. The model was created and tested with traditional fields of industry so it takes no stand on collaboration with start-ups, for example. The model is highly applied in the context.

The future research interests in this field cover testing with start-ups and other modern fields of industry. The model should also be piloted in other fields of operation like on the field of well-being enhancing technologies or in more service-oriented areas of business.

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Embracing a Green Future with Ultra-low Emission Technologies of Coal-fired Power Plants in China

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Introduction

In recent years, more attention has been paid on the air pollution caused by the frequent severe haze events in some regions in China. Based on the source analysis, reducing NOx, SO_2 and particulate matter emissions from coal combustion, as the important secondary aerosol precursors, will contribute for PM2.5 controlling (Huang, Zhang, et al. 2014). According to the latest Air Pollution Control Act issued by the Chinese government in August 2015, the total coal consumption amount will be controlled and stricter measures will be taken on reducing the coal combustion emission (Chinese State Council, 2015). At present, the revised emission standards for coal-fired power plants were issued by the Ministry of Environmental Protection and some local governments. Promoted by the policy and social pressure, the power enterprises are taking efforts on the further retrofitting projects for the emissions deep removal using different technical routines, and the completed retrofitted projects showed good operation performance. Being on the initial development stage, the whole coal-fired power industry will still face several technical and economic challenges.

Status and Challenges in Coal-fired Power Industry

In recent years, with the decrease of the growth rate of energy consumption, the total amount of the energy consumption is about 4.3 billion TCE in 2015 in China (National Bureau of Statistics of China, 2015), and China remains the world's largest energy consumer, importer and producer. With the continuous improvement of the energy structure, coal still plays the dominate role in China, accounting for 66% of the total energy consumption in 2014 (Petroleum B, 2015). For a long time, coal-fired power generation has accounted for the total power generation and coal consumption with about 75% and 50% respectively. By the end of 2015, the total installed power generation capacity and the coal-fired power capacity is 1.51 and 0.88 billion kW respectively (China Electricity Council, 2016). Rapid growth of the installed coal-fired power capacity brought the severe air pollution challenges. In 2014, the total SO_2, NOx and particulate matter emission from coal-fired industry reached 6.2, 6.2 and 0.98 million ton (Chinese State Council,2015). Eleven severe haze events took place in the last two months in 2015 in China. The latest research indicates that the globe's most polluted regions include the east-central China (Cheng, Luo, Wang, et al,2016). Since the mid-1980s, the Chinese government has formulated many policies and regulations to control air pollution and improve environmental quality (Zhang, Zhang & Bi, 2015). The latest emission standard for coal-fired power plants was issued in 2011, named GB-13223-2011, and has been carried out since 2012. More efforts were being taken for promoting the refitting projects by the state and some local governments.

Technical Routines for Multi-pollutants Simultaneous Removal Strategy

Toward the traditional pollution control strategy, a single pollutant was controlled by single equipment. In fact, there are coupled relationships among the emission pollutants, and multi-pollutants can be removed through optimization process design and using novel control devices. Many developed countries focus on controlling emissions of multiple pollutants simultaneously, and some studies indicate that multi-pollutant control strategy may yield benefits that outweigh compliance costs (Zhang, Zhang, & Bi, 2015; Nakayama, Nakamura, Takeuchi ,et al,2011). According to the different flue gas characteristics, boiler type and power generation capacity, the various technical routines will be adopted by the enterprises. The key technologies focus on the optimization process design and combination of the novel cleaning devices, including ESP, FGD, and SCR etc. Based on the flue gas composition and emission limits, different kinds of ESPs were widely applied, including the electrostatic-bag precipitator, low-temperature ESP, rotating electrode ESP and wet ESP. Through the integrated novel structure design of the SCR and wet FGD device, an ultra-low NOx, SO_2 and PM emission level can be obtained (Zhang, 2015). As shown in figure 1, the retrofitted demonstration project using the multi-pollutants removal strategy at a 1000 MW coal-power plant showed an ultra-low emission level compared with the state limits.

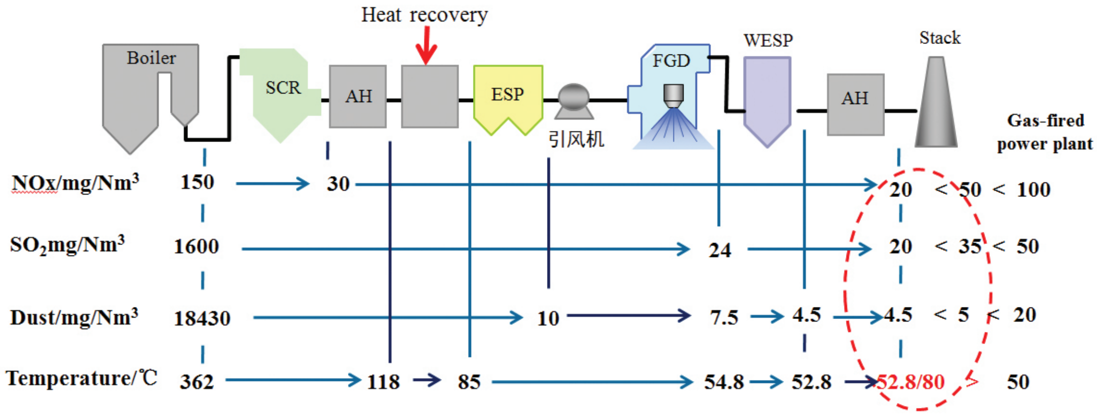

Figure1. Multi-pollutants' simultaneous removal strategy application at a 1000MW coal-fired power plant

Future Challenges and Prospects

According to the latest emission limits, multi-pollutants simultaneous removal strategy will be expected to be carried out for a wide utilization for the coal-fired power plants in China. Nowadays practice for deep pollutants removal is undergoing the initial development stage in China. The adopted technologies are not mature and the scientific evaluation should be carried out toward the finished retrofitted projects, including the actual system performance, investment cost, device operation stability, etc. Based on the actual operation practice and emission data collected by the CEMS (Continuous emissions monitoring system), the integrated cleaning system design needs further update. Also the power unit capacity, coal parameters, boiler type and the coupled relationships among the different cleaning devices should be taken into consideration on the multi-pollutants removal strategy. Future technical innovation for coal-fired power plants needs an interdisciplinary cooperation from the different fields, including e.g. the coal power industry, the local governments, research institutes or universities, the environmental protection enterprises.

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Boosting Circular Economy in SMEs: International Experiences from fhe Case Cradle To Cradle®

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Introduction

There is a growing business movement toward the circular economy, where resources and products will be kept continually in use. The innovative Cradle to Cradle® (C2C) design concept has been developed in the 1990s by the German based Internationale Umwelt-forschung GmbH (EPEA, Environmental Protection Encouragement Agency) by Michael Braungart and William McDonough. EPEA works with clients worldwide to apply the Cradle to Cradle®-methodology to the design of new processes, products and services. By the Cradle to Cradle® design concept materials become nutrients that move within metabolic cycles and waste does no longer exist. C2C design allows recycling capability of products that are economically successful, beneficial to the environment and healthy for the consumer. C2C minimizes the need for new inputs of materials and energy, while reducing environmental pressures linked to resource extraction, emissions and waste. The key principles of Cradle to Cradle are: material reutilization, material health, renewable energy, water stewardship and social fairness. The C2C concept has successfully been implemented in large companies with more than 1,500 C2C products on the market. For small and medium sized enterprises (SMEs) the application of C2C has so far been non-existent. Since the SMEs represent 99% of all the enterprises in the European Union, it was important to address sustainability and circular economy concepts in the form of C2C to them.

Cradle to Cradle Project

The project Improvement of *Skills in the Green Economy through an Advanced Training Program Cradle to Cradle* (C2C in SMEs) was created to benefit SMEs to implement Cradle to Cradle ideology in their products or production environment. The project was coordinated by the Hanseatic Parliament together with the Baltic Sea Academy. Project partners from Finland, Germany, Hungary and Poland implemented the Erasmus+ programme co-financed project from 1.9.2014 to 30.8.2016. This project contributed to the Europe 2020 strategy for growth, jobs, social equity and inclusion, as well as the aims of the European Union's strategic framework for education and training.

The primary target groups were entrepreneurs, managers and employees of small and medium sized enterprises, basically from all fields of business. The objective was to raise the C2C awareness among the SMEs and enable them through a customized training programme to use the C2C and discover new fields of activity. It also qualified personnel of partnering enterprises to meet future requirements of the labour market and to provide skills which are important for successful business. Besides enterprises the C2C project benefitted the personnel of the universities and chambers of commerce to train well-qualified instructors for SMEs as well as competent consultants for individual support of the SMEs in the application of the C2C.

Contents of the C2C Project

The C2C project had several work packages:

- Development of the C2C concept to SMEs
- C2C projects in SMEs
- Development of training, curricula and materials for the Train the Trainer programme and for the training in enterprises
- Evaluation of the Train the Trainer programme
- Testing and evaluation of C2C trainings and concepts in Schwerin in Germany, in Wroclaw in Poland and in Budapest in Hungary
- Dissemination of the results in workshops and in the Hanseatic Conference in 2016.

EPEA together with universities and chambers developed materials and C2C training programmes (Train the Trainer programme and Training in Enterprises programme) to meet the specific conditions of SMEs. The core contents included the key aspects on the Cradle to Cradle® Design Concept, the principles, philosophy and methodology, and how to develop it towards the SME sector in different fields. The experts from EPEA trained participants to use C2C and coached the C2C projects in the SMEs. SAMK was responsible for pedagogical lectures and evaluation of all training packages. Based on the evaluation results the C2C programme will be further developed in August 2016.

Train the Trainer Training Programme

The first step in the Cradle to Cradle® transfer process was to organize the Train the Trainer programme for experts, who put the Cradle to Cradle® design concept into practice in SMEs. A two-day Train the Trainer programme was arranged in June 2015 in Gdansk, Poland. The Train the Trainer programme was planned for professors from universities, teaching staff from chambers and institutions providing further education, consultants to chambers and other SME funding agencies. During the training days participants gained knowledge on the Cradle to Cradle® concept and pedagogical issues related to its implementation in SMEs. Upon completion of the Train the Trainer programme participants were able to supervise projects in SMEs. The following themes were discussed: C2C philosophy and principles, C2C methodology and criteria, case studies, interactive session: asking the right questions, Pedagogical methods: principles of effective teaching and effective training, and C2C toolbox and C2C roadmap.

Training in Enterprises

Training in enterprises had three stages as shown in Figure 1.

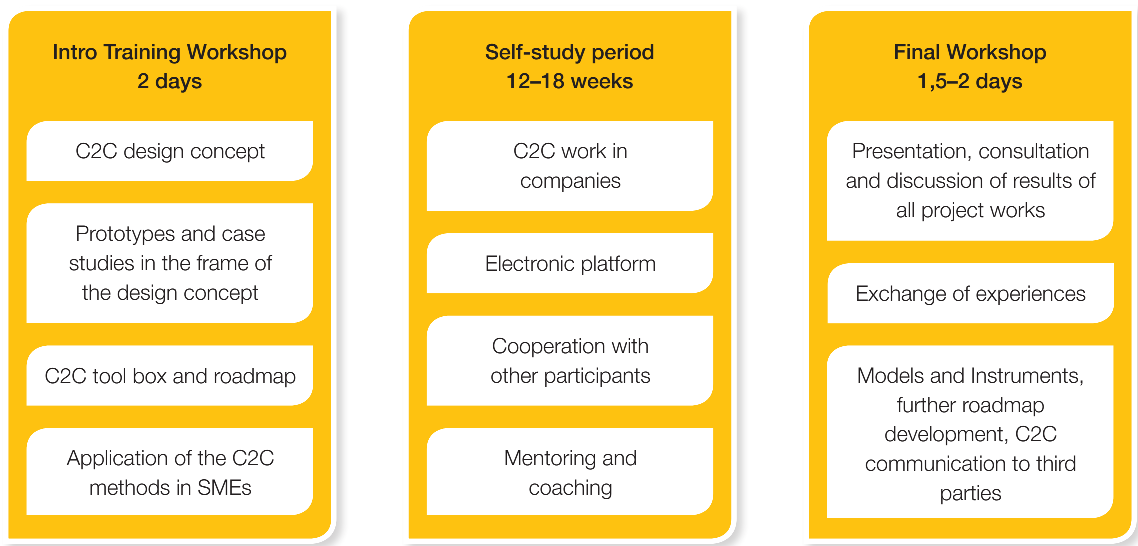

Figure 1. Structure and contents of the training organized in enterprises.

Evaluation of the Cradle to Cradle Project

SAMK was responsible for the evaluation of all phases of the training programme. The Train the Trainer programme evaluation was done by a questionnaire addressed to the participants, interviews with the lecturers and observations during the training sessions. The Intro Training Workshops evaluation methods included a questionnaire to the participants, and a lecturer's self-evaluation form. After the self-study weeks lecturers made a very short face-to-face interview with the participants. The Final Workshop evaluation included questionnaires for the participants and lecturers. All questionnaires were standardized: they had 15 statements, which were evaluated with the grading scale (Strongly disagree, Disagree, Neither disagree or agree, Agree or Strongly agree) and three open questions. The evaluation forms were translated to Hungarian, German and Polish languages, so the participants could use their mother tongue when giving their feedback. Answers to open questions were later translated to English. The type of the evaluation followed standard course evaluation methods, i.e. formative, process and outcome evaluation, the latter being only partial.

Conclusions from Train the Trainer Programme Organized in Gdansk, Poland in June 1-3, 2015

At the time of the China-Finland Forum 2016 only the evaluations from the Train the Trainer programme were received and analyzed. Table 1 describes the mean values of all statements, the grading scale being Strongly disagree (1), Disagree (2), Neither disagree or agree (3), Agree (4) or Strongly agree (5)).

Table 1. Grading of the Train the Trainer programme June 1-3, 2015 in Gdansk, Poland. Grading scale: 1 – 5 (Strongly disagree – Strongly agree).

Statement	Mean grade
The aims of the training were clear.	3,8
Ratio of theory and practice was good.	3,2
The course linked previous knowledge and practices well.	3,7
The training methods supported learning.	4,3
There were enough practical examples.	3,4
The training materials were interesting and informative.	4,0

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The lecturers could convey the topic well.	4,5
The lecturers facilitated group work and other participant activities well.	4,1
During the training working atmosphere was positive.	4,3
Discussions were active and experiences were shared with others.	3,8
The course premises, facilities and equipment were well suitable for the needs of the training.	4,2
The training course met my expectations.	3,4
The course has motivated me to apply the topic in my daily work.	3,9
I feel prepared to perform tasks in guiding C2C in companies.	3,2
I was able to reflect the contents of the course with my previous experience.	3,7
The course inspired me to study more of the subject.	4,1
The course increased my ability to train others.	3,9
I was satisfied with the working speed.	3,7
I participated actively in the discussions	3,9
I participated actively in the group activities.	3,9
I was satisfied with the organization of the training.	4,1
Overall grade	3,6

In the open-ended questions the highest values were given to the C2C definitions and pedagogical lectures, while the lowest values were given to non-existent cases from SMEs and missing real cases for group activities. Participants also indicated that the programme should be developed so that the ratio of theory and practice is balanced and real cases from SMEs should be presented. These remarks will be taken into account, as well as other remarks from trainings in enterprises, in the further development phase of the programme. The training programmes will be transferred to 15 universities as well as to the training institutions of the 50 chambers in the Baltic Sea Region.

FURTHER INFORMATION OF CRADLE TO CRADLE®

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Electrosorption of Lead Ions by Nitrogen-Doped Graphene Aerogels via One-Pot Hydrothermal Route

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Introduction

We present an efficient Pb^{2+} electrosorption by nitrogen-doped graphene aerogels (NGAs) prepared by one-pot hydrothermal synthesis of nitrogen-doped graphene hydrogels (NGHs) followed by freeze-drying treatment. Graphene aerogels (GAs) and reduced graphene oxide (rGO) were also used in the electrosorption as control experiments. The whole process of NGAs synthesis and application in the electrosorption of Pb^{2+} is illustrated in Figure 1.

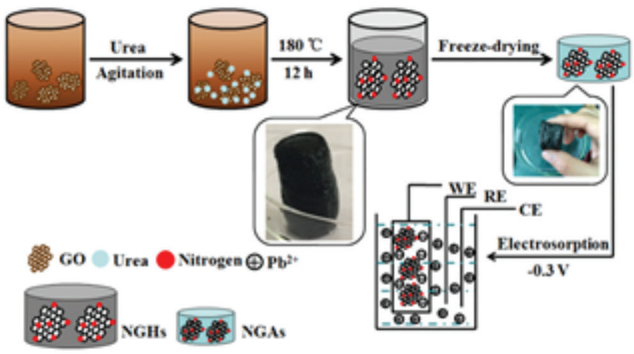

Figure 1. Schematic illustration of the whole process for NGAs synthesis and application in the electrosorption of Pb^{2+}.

Characteristics

The characteristics of GAs and NGAs were analyzed through SEM, TEM, FT-IR, XPS and BET.

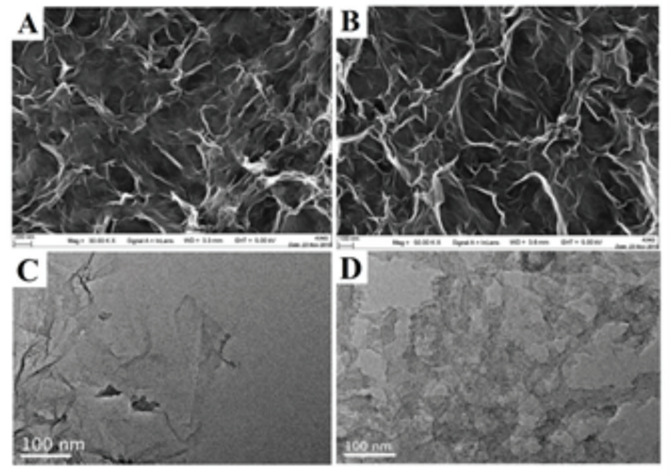

Figure 2. SEM and low-resolution TEM images of GAs (A, C) and NGAs (B, D).

The SEM and TEM of the obtained NGAs as well as GAs are shown in Figure 2. It can be seen that both of the two samples exhibit a porous and multilayer structure with extensive stacking and folding. The GAs nanosheets are randomly compact and stacked together as in Figures 2A and C, exhibiting a morphology of crumpled silk veil waves similar to that of graphene. As shown in Figures 2B and D, defective structures are clearly observed for NGAs, and this morphology is attributed to the presence of doped nitrogen atoms (Meyer, Geim, Katsnelson, Novoselov, Booth, & Roth, 2007).

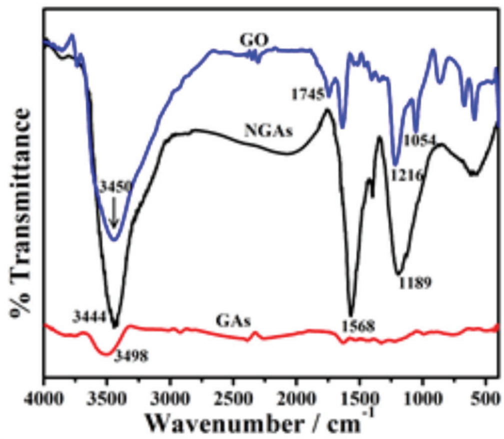

Figure 3. FT-IR spectra of GO, GAs and NGAs.

The doping of nitrogen atoms into NGAs during the hydrothermal process is further confirmed by the FT-IR spectra shown in Figure 3. The peaks are at 1568 and 1189 cm^{-1} on the spectra of NGAs, corresponding to the functionalities of C=N and C-N, respectively (Wang, Yin, & Yao, 2014). This result implies that nitrogen atoms are doped into GAs successfully in the hydrothermal process.

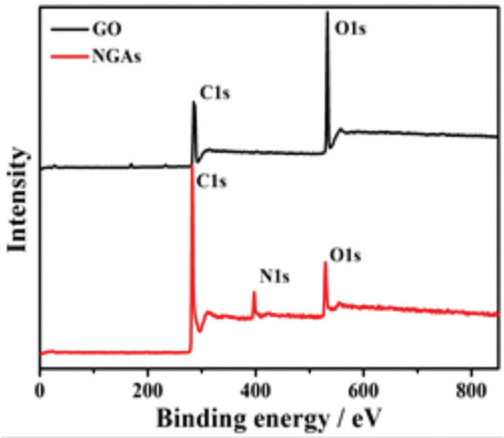

Figure 4. General XPS spectra of GO and NGAs.

In order to further confirm the doping of nitrogen atoms, XPS measurements are carried out. As shown in Figure 4, the XPS spectrum of GO shows only the presence of C 1s (284.4 eV) and O 1s (532.2 eV). After nitrogen doping using urea, the intensity of O 1s decreases significantly, and a new N 1s peak at 400.0 eV (Wu, Ma, Yadav, Yang, Zhang, Vajtai, Lou, & Ajayan, 2015) appears at the XPS spectrum of NGAs, demonstrating the removal of most oxygenated functionalities and incorporation of nitrogen during the hydrothermal process.

Also, the Brunauer-Emmett-Teller (BET) specific surface areas of rGO, GAs and NGAs are measured to be 16.9, 393.4 and 434.4 m^2 g^{-1}, respectively. The total pore volume of NGAs is 0.19 cm^3 g^{-1} with a corresponding pore-size distribution of 4.86 nm determined by the Barrett-Joyner-Halenda (BJH) method.

Experiment

The as-prepared NGAs, GAs and rGO paper electrodes were used for the electrosorption of Pb^{2+}, the results are shown in Figure 5.

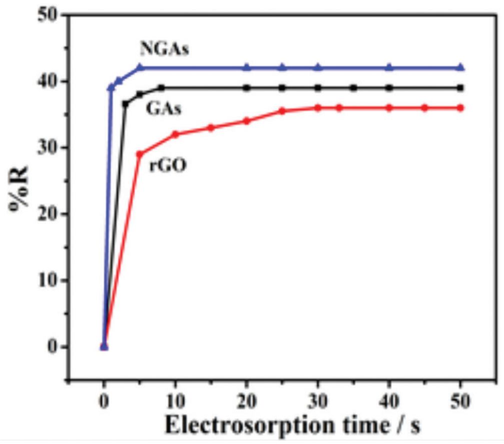

Figure 5. Electrosorption of 1 mM Pb^{2+} (pH 4.2) on NGAs, GAs and rGO paper electrodes at an applied potential of –0.3 V.

From Figure 5, we can see that Pb^{2+} can be effectively removed by the as-prepared paper electrodes at an applied negative potential, the NGAs exhibit the highest removal ratio (%R) of Pb2+ and the shortest adsorption equilibrium time. The removal mechanisms include (1) electrostatic attraction derived from external electric field, (2) electrostatic attraction caused by intrinsic charges on NGAs and Pb^{2+}, (3) large specific surface area of NGAs, and (4) coordination between doped nitrogen atoms and Pb^{2+}.

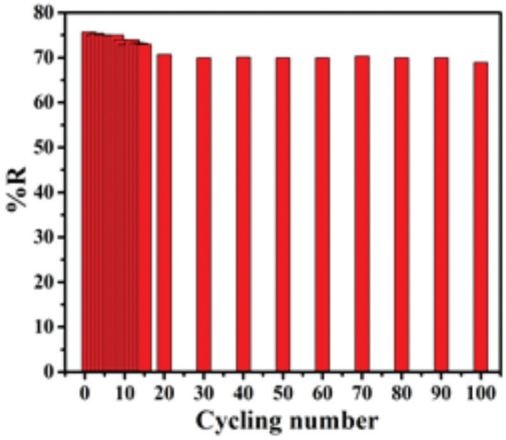

Figure 6. Successive electrosorption/electro-desorption cycle for the treatment of 80 mL 0.2 mM Pb^{2+} at the same NGAs paper electrode at an applied potential of –0.3 V.

More importantly, after a simple and convenient electrodesorption treatment, the NGAs exhibit promising performance in recyclable electrosorption, and the removal ratio (%R) of Pb^{2+} decreases only 5% after successive 100 cycles as indicated in Figure 6.

Measurement and Control Solution for Retrofitting Industrial and Domestic Equipment

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Introduction

Industrial and domestic systems have grown to complex ensembles of devices from various manufacturers. Extending the lifespan of these devices plays a key role in maintaining industries' cost-effectiveness. Older equipment does not necessarily meet the needs of modern industry, such as more accurate measurements or control abilities. Modern needs also require systems and components to communicate with each other without depending on a certain form of communication or manufacturer. The solution developed handles the interfaces between communication methods or devices and thus enables more modern industrial or domestic applications to be used in to some extent outdated devices. Due to the simple structure, it also provides a cost-effective way to implement intelligence in devices in which it has not been worthwhile before, especially for SME's where the ability to invest in new equipment varies from the ability of larger companies.

Need

The need for the developed solution started from work on optimizing and adapting solar energy systems into the built environment in Finland. Research has shown that efficient operation of solar energy systems is challenging because solar energy is diurnal and seasonal. This results in solar energy systems being part of a hybrid energy system in most areas of the globe, where energy should be able to be used and retained soundly. In the future this development will lead into a situation, where different parts of a home area network (HAN) will be controlled by gateways and control boxes, resulting in a complete home energy management system (HEM). For the end user, all this should be as easy as electric heating, with reasonable investment cost, and with technology which makes it possible for the consumer to get real time data about the consumed and produced amount of energy. It should be equally easy to use the gained data to control operations towards efficient use of energy. (Mayank A. et al., 2012)

In industrial perspective, interfaces are required to be more open and compatible with each other, as different IoT solutions make production more efficient. Every technology and every branch of industry will be moving towards system intercommunication. Production needs to be more precise and more efficient, therefore measuring and monitoring will have to scale up. Monitoring and measuring are already up-to-date on several new installations, environments and devices but these tend to be expensive and updating old equipment, or often obtaining new, can have a serious impact on the economy of the company in question. More so, even when these modern solutions have provided almost everything, they tend to lack one important aspect required for future industry: intercommunication. Also, adding transducers or measurement devices, if the need arises, can be extremely difficult when dealing even with a moderately closed system. Therefore, an interface solution with capabilities of communicating with all ongoing processes and procedures during the manufacturing process, gathering data, analyzing and summarizing the data will be a necessity in the future for gaining the competitive edge on the escalating market of manufacturing industry. (Manyika J. et al., 2015)

Principle of Solution

A single system consists of a single server and of one or more clients. Both server and client are a collection of software blocks. A client is a combination of configuration files; a TIM (Transducer Module Interface), FunctionBlocks and a TransducerBlock. The core functionality of the client relies on the TransducerBlock and this is one of the common factors among all clients in a system. It is the engine that wraps together the desired FunctionBlocks and the TIM as well as takes care of the basic functionality of the client. This functionality is fully configurable via its configuration file.

TIM-Block (Transducer Module Interface) is the interpreter between the transducer or the target device and the server. It translates the data and the messages from the device into standard messages. This works both ways; when the control functionalities on the server send a command to the target device via NCAP (IEEE 1451), TIM is the block that translates that command into a format that the device understands and can react to, and then sends it to the desired location.

FunctionBlocks are the functionalities embedded in the system. They are completely modular and therefore can be added and/or removed easily depending on requirements. FunctionBlocks contain most of the analysis-properties, control functionality and the overall logic of the system.

User management and other high-level aspects are mainly done within the user interfaces, separate from the system, allowing even simpler implementation of the system on various targets and environments of various degrees. Modularity is one of the key concepts of this solution. Forming of different individual blocks, each separate but yet connected, there are practically no limitations on how this system can be configured, what it can be harnessed to do or how big or small it can become. In industry, it is often not required for different parts of the production chain to be able to communicate with each other. Sometimes it is even regarded a necessity considering security reasons. In this scenario, this particular system can be configured to work simultaneously as a man-in-the-middle, a filter and a firewall. Information can be gathered from each system separately and all information can be filtered so that no unnecessary or harmful packages can reach other systems.

Retrofitting and Connecting Various Systems in Research Cases

Retrofitting is in most cases the best option in companies where investment ability varies, especially in the case of SMEs. Companies may have invested in equipment that is not at the end of its lifespan, but need somehow be connected to new or existing equipment. The developed solution has the ability to add lifetime to past investments by doing this. Connecting "old" equipment to automation systems or adding intelligence is one of the core capabilities of the developed interface solution.

The first research case of the system was done at Satakunta University of Applied Sciences. The structure of the connected system can be seen in figure 1. The solution in this case reads 47 measurements per minute. From this case, it was soon discovered that more systems were required to be connected. A hybrid renewable energy laboratory was being built at SAMK during the same period. Through these research cases, it was soon discovered that the developed solution is not limited to energy systems and can be down or up-scaled, based on the need of the current case. By connecting multiple different systems to the existing photovoltaic system, the amount of measurement per minute rose to more than 400, proving the ability to scale up multiple times. The developed solution was connected to the logic of the extended laboratory and it has been proven to work being in charge of external communication, data measurement and -collection, high-end control and overall monitoring.

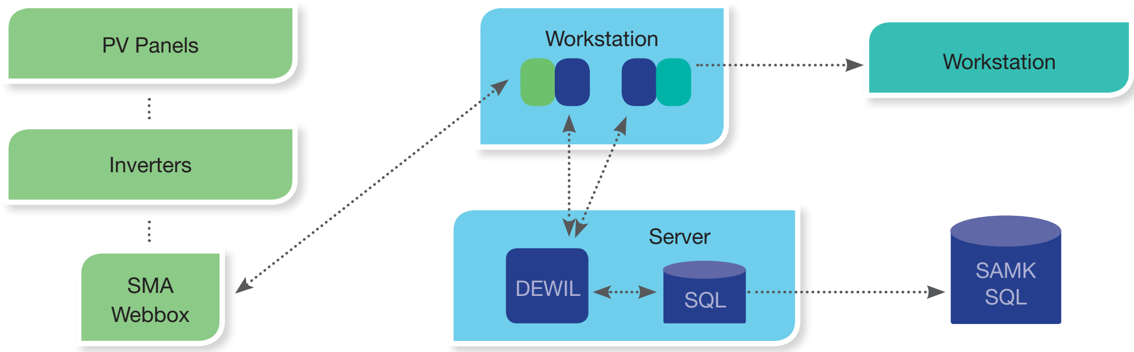

Figure 1. Structure of a solution developed around the basic core of DEWIL for solar energy production and weather condition measurement.

Conclusion

The development of the software is not restricted to energy efficiency matters. Features such as intelligent residence HVAC, security and lighting control, industrial equipment measurements and controls can be added as a result of the software's modularity and scalability. The application is designed to be easily installed, implemented and light-weight in order to create a cost-effective solution. Requirements for the installation are only a standard PC and cables required for connecting almost any kind of new readable device. Therefore, the installation of old and new devices and interfaces is simple and straightforward compared to existing solutions. Intelligent, modular and scalable structure of the application offers the possibility to expand any system to practically limitless extents.

Data gained from the software has been used to optimize performance of a public swimming complex that uses solar energy as a part of its energy production. The data has also been used by designers while planning new solar energy installations. In the future, the software will be tested and developed further if current results of being connectable to virtually anything will prove to be right.

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Experimental Study on PMMA Combustion Restraining by Ultra-Fine Water Mist in Confined Space

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Introduction

Due to the environmental protection and high efficiency advantages, the superiority of water mist fire extinguishing technology has become the main alternative technology of halon fire extinguishing agent and it has got a wide range of applications in many fields. In all kinds of fire accidents, solid combustible materials occupy a leading position, and the quantity of them determines the spreading speed and the final size of fire.(Cao et al., 2015; Feng, Li, & Qin, 2015; Liu, Zhu, Zhao, & Liang, 2013; Pei, Yu, Chen, Zhu, & Yang, 2016; Yu, Yang, Jia, Lu, & Lu, 2009; Zhu, Liang, & Liu, 2014) Furthermore, PMMA is one kind of the normal solid combustible materials. Avoiding the fire from spreading further by discharging ultra-fine water mist, not only has important practical significance, but also has the typical technology advantage and good application prospect. This paper will construct a simulation experiment platform of ultra-fine water mist, inhibit the effectiveness of limited space PMMA fire, summarize its influence factors. In order to provide a theoretical basis and data supporting to the ultra-fine water mist suppression system, this article would build a simulation platform for studying the validity of the ultra-fine water mist suppression system and would sum up its impact factors.

Experimental Platform and Working Condition

Experimental apparatus and test systems mainly contain ultra-fine water mist fire extinguishing system, smoke analysis system, digital temperature acquisition device, computer workstations and other equipment. Experimental units diagram is shown in Figure 1.

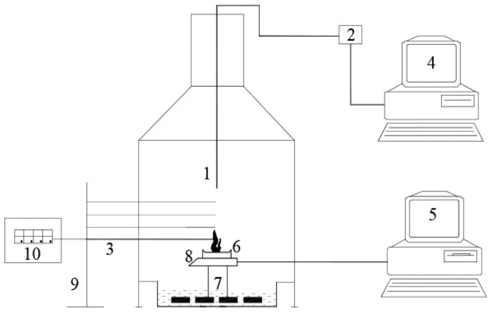

Figure 1. Schematic of the experimental compartment: 1.Smoke analyzer probe; 2.Smoke analyzer; 3.Thermocouple tree; 4.Smoke analyzer workstation; 5.Quality change acquisition workstation; 6.Burning containers; 7.Atomization pool and atomizer; 8.Electronic scale; 9.Thermocouples stent; 10.Digital temperature acquisition instrument

By changing the mist flux, preignition time, discharging time, the experimental cases are shown in table 1.

Table 1 Tested Cases

Case Number	fuel quantity (g)	discharging or not	mist flux (ml/min)	preignition time (s)	discharging time (s)
1	367	N	–	–	–
2	240	Y	150	25	50
3	240	Y	150	65	50
4	330	Y	50	65	55
5	330	Y	150	65	55
6	342	Y	150	80	40
7	342	Y	150	80	80
8	367	Y	200	50	60

Results and Discussion

The experimental ultra-fine water mist droplet size was 5 ~ 40 μm, far less than the value. So, when ultra-fine water mist was discharged at an early time, it would be taken to the upper part of the flame region by a fire plume. Under the influence of a high temperature smoke layer, it would evaporate rapidly. Because the droplet size was smaller than normal fine water mist, the specific surface area was big and the heat absorption was also large. Once a high concentration water vapor layer was formed outside the flame region, O_2 would not spread into the flame region, and the PMMA combustion would consume a great deal of O_2, the oxygen content decreased rapidly. With the decreasing of the flame temperature, small size ultra-fine water mist also gradually entrained into the flame region, thereby the flame temperature was effectively lowered, the thermal radiation feedback of smoke layer also significantly reduced, ultimately, PMMA heat release rate decreased. In addition, on one hand, the combustion of coal consumed part of O_2, on the other hand, ultra-fine water mist rapidly diffused in the confined space, and the living space of O_2 was compressed, thus the concentration of O2 decreased faster than without discharging ultra-fine water mist. In the pre-25s, the PMMA still be able to burn fully, and the generation of CO_2 showed a slight increase in the graph. Along with the decrease of temperature in the confined space, ultra-fine water mist gradually entrained into the flame region, the PMMA could not burn completely, the concentration of CO_2 gradually decreased.

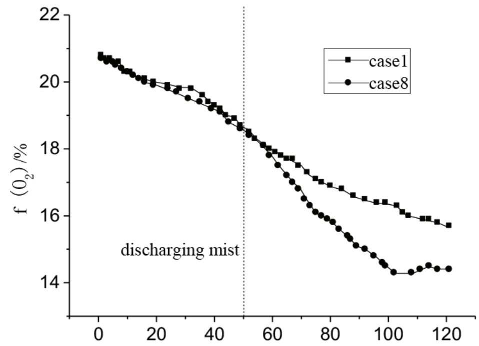

Figure 2. Oxygen volume fraction variation curve with and without ultra-fine water mist

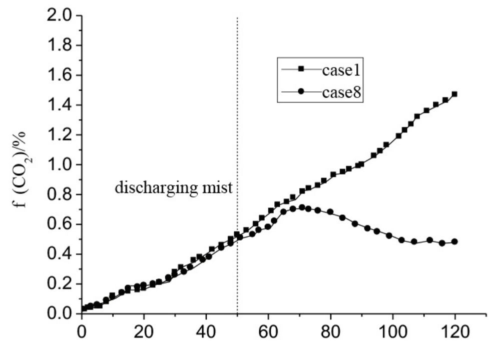

Figure 3. Carbon dioxide volume fraction variation curve with and without ultra-fine water mist

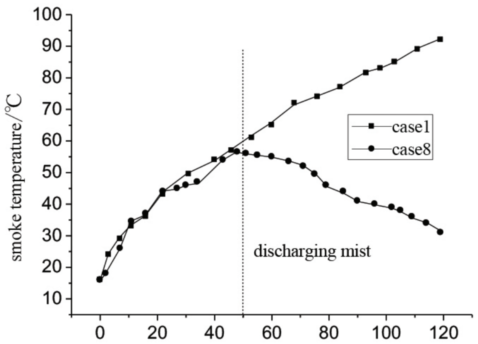

Figure 4. Smoke temperature variation curve with and without ultra-fine water mist

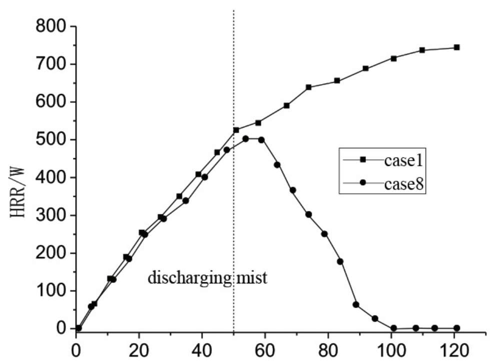

Figure 5. Heat release rate variation curve with and without ultra-fine water mist

As the application of fine water mist in the other occasions, it is more effective to discharge the ultra fine water mist in the early time of PMMA combustion.

Taking case 2 and case 3 as the example, the heat release rate of fire source and the temperature of smoke layer are illustrated in Figure 6 and Figure 7. In the experiment, the mist flux was 150ml/min and the discharging time was 50s. In case 2, the ultra fine water mist was discharged at 65s while the smoke temperature reached 67s. Comparing to case 3, although the mist flux in case 2 was big enough to reduce the smoke temperature and heat release rate, the descending rate of the smoke temperature and heat release rate decreased obviously. It was seen that the flame length was longer than that in case 3. In case 3, the ultra fine water mist was discharged at 25s when the flame length was short, and the shortest flame length appeared at 59s.It showed that the preignition time played an important part in the ultra-fine water mist suppression system.

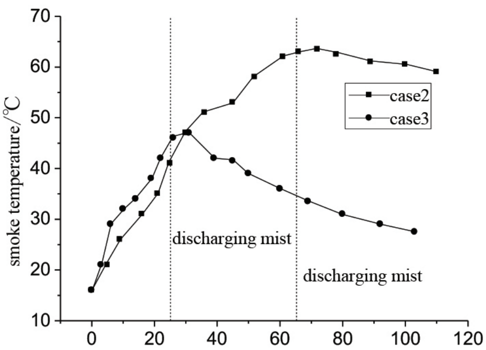

Figure 6. Smoke temperature variation curve at different preignition time

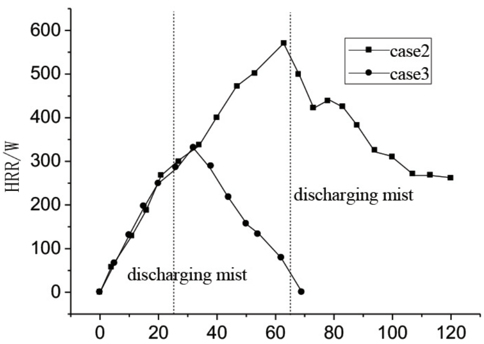

Figure 7. Heat release rate variation curve at different preignition time

When the fire source power, discharging time and the preignition time were invariable, the volume flux determined the inhibiting effect of PMMA combustion. The mist flux can be stated by the ultra-fine water mist flow rate. The more the flow rate was, the greater the mist flux was.

Taking case 4 and case 5 as the example, the preignition time was 65s and the discharging time was 55s. The smoke temperature and the fire source heat release rate are compared in Figure 8 and Figure 9.

From the figure, the smoke temperature and the heat release rate have barely changed after discharging the mist for 55s under the flow rate of 50ml/min in case 4. However, for case 5 when the flow rate was 150ml/min, the flame length of PMMA became shorter.

Meanwhile, the descending rate of the smoke temperature and the heat release rate decreased significantly. It indicated that the flow rate of 150 ml/min can restrain PMMA combustion effectively. It showed that sufficient mist flux was a key factor in the ultra-fine water mist suppression system.

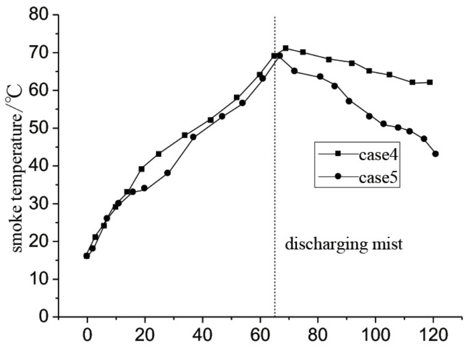

Figure 8. Smoke temperature variation curve at different mist flux

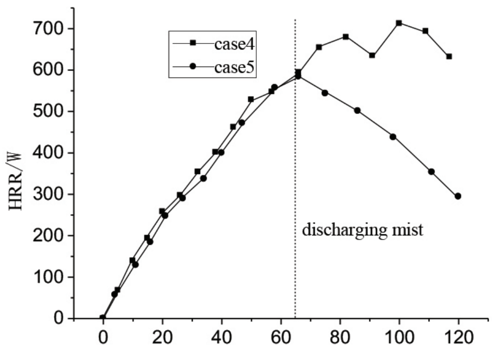

Figure 9. Heat release rate variation curve at different mist flux

The experiment also discovered that different discharging time may lead to different suppression effects. Taking case 6 and case 7 as an example, the smoke temperature and the heat release rate were described in Figure 10 and Figure 11. In the first 40s, after discharging the ultra fine water mist, the PMMA combustion can be suppressed under two cases. In case 6, the ultra fine water mist was stopped discharging at 120s. Because the evaporation and heat absorption function disappeared, the smoke temperature stayed the same. However, in case 7, the discharging of ultra fine water mist was continuative, the smoke temperature kept downtrend. Along with the increase of time, the ultra fine water mist was accumulated on the surface of the PMMA. Compared to case 6, the heat release rate decreased obviously. It was seen that the discharging time was another factor to affect the function of ultra fine water mist suppression system.

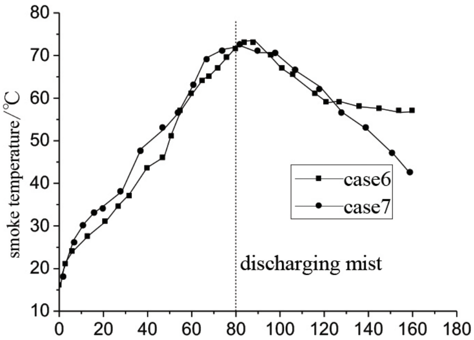

Figure 10. Smoke temperature variation curve at different discharging time

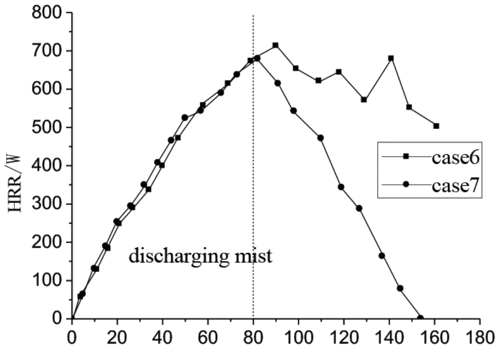

Figure 11. Heat release rate variation curve at different discharging time

Conclusion

By the function of ultra fine water mist, the concentration of O2 in the smoke decreased continuously, the concentration of CO2 decreased slowly until becoming stable. Along with the extinguishment of the flame, the heat release rate decreased, and finally, it became zero. The ultra fine water mist suppression system was related to the preignition time, the mist flux, the discharging time and so on. In order to suppress the PMMA combustion, the mist flux should be big enough. For the sufficient mist flux, the shorter the preignition time was, the better to suppress the PMMA flame. When the preignition time and the mist flux was feasible, the more the discharging time was, the better to extinguish the PMMA flame.

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Studies on the Magnetic Water Treatment in New Pilot Scale Drinking Water System and in Old Existing Real-life Water System

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The link to the article:
http://www.sciencedirect.com/science/article/pii/S2214714416300125

The Application of Ferrate(VI) in the Treatment of Pharmaceutical and Personal Care Products (PPCPs)

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Introduction

Every year, a huge number of medicines belonging to various therapeutic groups are taken by human beings and animals to cure illness. However, certain levels of the taken drugs are excreted out of bodies without changes in their structures or only being transformed to their primary metabolites (Glassmeyer et al., 2005). In this way, many pharmaceutical compounds as well as personal care products enter the domestic sewer system. Besides, household disposal of unwanted or expired pharmaceuticals into the toilet is also a main pathway for the occurrence of pharmaceuticals in the influent of WWTPs (Bound & Voulvoulis, 2005). In these pathways, pharmaceutical and personal care products (PPCPs), a group of emerging micro-pollutant, enter the aquatic environment undesirably, and have been widely detected in the aquatic environment at trace levels (usually in ng/L–µg/L) since 1990s (Ternes, 1998).

Potential risks on human health and the eco-system do exist associated with the presence of PPCPs in the environment. Many studies regarding the acute and chronic toxic of PPCPs have been carried out recently. Despite a few non-harmful results (Bruce, Pleus, & Snyder, 2010), the chronic effects from the long-term exposure to PPCPs in the environment, e.g. disruption in the endocrine system, cannot be neglected (Yergeau, Lawrence, Waiser, Korber, & Greer, 2010). A new finding that diclofenac, naproxen and ibuprofen were detected in the organ of wild fish caught in the down flow of a WWTP proved the accumulation effect of such persistent micro-pollutants and possible risk to the food chain of human beings (Brozinski, Lahti, Meierjohann, Oikari, & Kronberg, 2013).

Ferrate(VI) and Its Application in the Treatment of PPCPs

Wastewater treatment plants (WWTPs) play a very important role during the transportation of PPCPs from their sources to surface waters (Carballa et al., 2004). However, in conventional WWTPs, many PPPCPs were discharged without reduction, while some PPCPs were only partly removed by the adsorption on sludge (Hyland, Dickenson, Drewes, & Higgins, 2012). Therefore, one important step in tackling the issue of such micro-pollutants is to upgrade or build WWTPs with advanced treatment units.

Potassium ferrate(VI) (K_2FeO_4) is a stable iron (VI) derivative and a powerful oxidant, with its redox potential even higher than ozone under acidic conditions (V. K. Sharma, 2002). Besides, the reduction products of ferrate(VI) are ferric ions or ferric hydroxide, which is a common type of coagulants used in water treatment (Jiang & Lloyd, 2002). Therefore, ferrate(VI) plays a role as a dual-functional chemical in a single treatment unit. Such unique property has made ferrate(VI) a promising and attractive technology in various water treatment processes, such as disinfection, degradation of organic compounds and inorganic compounds, and sludge treatment (Jiang, 2007).

Recently, several researches on the treatment of PPCPs by ferrate(VI) have been carried out focusing on the rate constants and degradation products. Similar to ozone, ferrate(VI) also has good performance in treating pharmaceutical compounds with ERMs, e.g. ciprofloxacin, with removal efficiencies higher than 85% (Lee, Zimmermann, Kieu, & von Gunten, 2009). The second-order rate constants between ferrate(VI) and pharmaceuticals were up to 10^3 M^{-1} s^{-1} (for sulfamethoxazole and triclosan), and showed clear pH dependence (Virender K. Sharma, Mishra, & Ray, 2006). In the basic area, decreasing solution pH could significantly increase the oxidation of most compounds by ferrate(VI). However, current studies on ferrate(VI) treatment of pharmaceuticals gave little information on the optimisation of operating conditions in terms of solution pH and ferrate(VI) dosage, which would be helpful to the full-scale application of ferrate(VI) in treating real wastewater.

Conclusion

To date, no regulatory guidelines for WWTPs regarding the discharging limits of PPCPs have been established, which may be caused by two reasons. Firstly, the long-term and chronic influence of drugs in the environment lacks scientific and firm conclusion. Secondly, the emission limit of these products is difficult to decide, which not only depends on their harm to the environment but also the economic conditions of available treatment techniques. However, based on the precautionary principle, to prevent the entry of PPCPs into the aquatic environment via WWTPs is necessary.

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RFID-based Sensing in Health and Care

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Introduction

In the healthcare and well-being industry, technology applications answering the future challenges are gaining more and more interest. For example, the lack of nursing personnel and resources is a significant problem. The current trend is to encourage people to take more responsibility for their own health and well-being, and to assist and support people with limited capability to function, to live independently at home instead of caring homes. Thus, the role of care technology is becoming especially significant. This article introduces possibilities of passive ultra-high frequency (UHF) radio frequency identification (RFID) technology applications in healthcare and well-being contexts, especially in remote sensing.

RFID Technology

RFID technology was designed for automatic identification or tracking of objects and people. The widespread use of RFID in other industries has resulted in attempts to introduce applications in the healthcare environment as well, such as to increase patient safety by RFID-based automatic patient identification, which enables reliable and real time patient information. RFID also has a lot of potential in tracking and identifying important equipment in care environments. The technology can also be further developed and applied to other purposes, such as wearable wireless sensing, which also has versatile possibilities in healthcare and well-being contexts. This article focuses on passive UHF RFID technology in which the simple tags used do not have any power source on them and thus have almost unlimited life-time and low price. Use of passive RFID technology requires wirelessly readable electronic tags consisting of a microchip and an antenna (carrying identification data), readers (powering of tags, communication with tags and background system), and a background system (data use, processing, storing, and sharing). (Dobkin 2008)

RFID-based Sensing in Health and Care Related Applications

The use of propagating electromagnetic waves in the UHF frequency range enables rapid interrogation of a large number of tags through various materials, and the tag can be read from distances of over 10 meters. UHF RFID tags are promising candidates to work as energy-autonomous wireless sensors that exhibit low complexity and cost. There are two types of passive UHF RFID sensor tags: 1) RFID tag with a traditional sensor attached as a part of the tag or integrated into the tag microchip, 2) RFID tag in which the sensing ability is integrated into the tag antenna structure. In the former type, the RFID tag antenna is typically used in power supply and data transfer, and in the latter the tag antenna performs the sensor function itself (Merilampi et al., 2012). In the latter type, it is possible to establish maintenance free sensors without external sensors or onboard electronics by using a passive UHF RFID tag antenna as the sensing element. Antenna-based sensing provides integration of many kinds of sensing capabilities in passive RFID tags with a minimal increase in the overall complexity and power consumption of the tag. These types of simple tags can also be integrated into clothes for wireless wearable sensors and they are now further discussed.

An RFID tag's response can be manipulated according to the prevailing circumstances, such as mechanical changes in the tag or presence of certain materials, e.g. water. The changes in the antenna or antenna substrate affect the impedance matching of the tag antenna and the microchip as well as the gain of the tag antenna. Through these they also affect wirelessly measureable parameters, such as the transmitted threshold power, the power on the tag, and the backscattered power of the tag. Several prototypes of RFID sensor tags have been presented and interesting applications have been suggested in versatile fields (see Occhiuzzi et al., 2011; Virtanen et al., 2011, Merilampi et al., 2011; Babar et al., 2012; Qiao et al., 2013, Yi et al., 2014, Long et al., 2015). In this article we will now introduce two different self-sensing tags: **strain sensor tag and perspiration sensor tag**.

Wearable strain sensors will allow remote monitoring of physiotherapy exercises, posture, and flexibility during normal everyday tasks. Also, they can be used to provide real-time feedback to neurological patients undergoing motor rehabilitation. After further development, **strain sensor tags** could be used in various healthcare applications, for example in monitoring the movement of healing limbs (to warn about too large a movement) or in monitoring chest movements (breathing). Other applications could be found in rehabilitation and in exercising to prevent diseases. An example of passive UHF RFID strain sensor response is presented in Figure 1. As seen in Figure 1 the backscattered signal power is dependent on the strain applied.

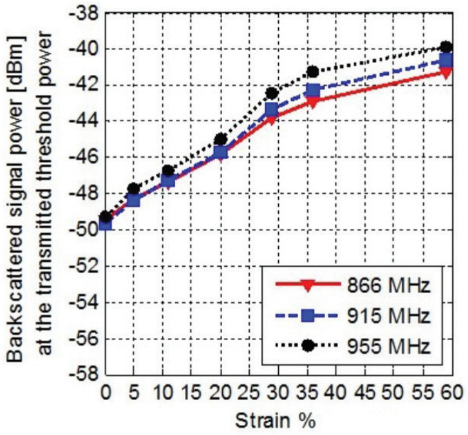

Figure 1. The response of a strain sensor tag as a function of strain (Merilampi et al., 2011).

Also perspiration and other body fluids can be sensed with passive UHF RFID technology. These offer various possibilities in sports applications (e.g. body hydration level analysis), seizure detection as well as identifying blood or urine in textiles. We have been investigating a perspiration sensor tag made of silver ink on stretchable fabric substrate. Figure 2 illustrates that the difference in tag response, caused by applied human sweat, is noticeable through the entire measurement frequency range.

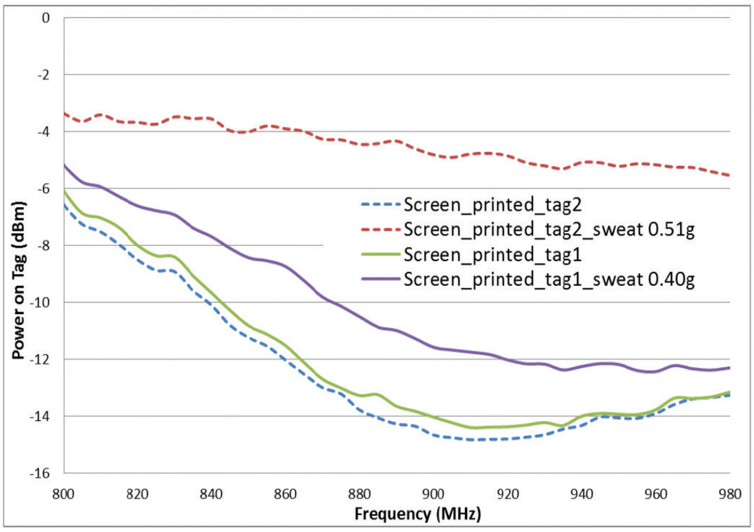

Figure 2. Power on tag as a function of frequency, screen printed textile tags. (Merilampi et al., 2016)

Although passive UHF RFID technology provides many possibilities, the use of this technology for sensing is still in early stages. There are still challenges to overcome, such as optimization of sensor designs, development of efficient fabrication methods and optimized materials, as well as ensuring the reliability in actual fields use (e.g. effect of human body on the measurement result, development of a calibration system to eliminate the dependence of the measurement result on the distance and on the surrounding conditions).

Conclusion

RFID technology can be utilized in the healthcare and well-being industry. The most common applications are identification and tracking systems of assets and people. However, other applications are emerging as well. RFID-based wearable sensors have enormous potential and versatile future applications. Two prototype sensor-tags were introduced in this article. Despite promising results, more work is required to further develop the tags and the technology for on-body sensing.

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This publication contains summaries of the presentations given by researchers in the 4th research forum.

The contributions are diverse, ranging from environment to care technology. The summaries are evidence of both universities and researchers aiming to work towards innovation, and, thus, to accelerate progress and positive development in their respective fields.

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