Bond of 3+ Decades of an AvH Awardee at RWTH Researching Water Hydraulics

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During the last 34 years, Dr. Shimpei Miyakawa paid several visits to the IHP and IFAS at RWTH Aachen University. Throughout his stays in Aachen and his work in Japan, he gathered profound knowledge of the applications of water hydraulics. In many talks with Prof. Backé and his successor, Prof. Murrenhoff, Dr. Miyakawa discussed the development of water hydraulics and its possible application, especially in the food market. The text gives an overview over his stays in Aachen and how these influenced his personal development of water hydraulics systems.

Keywords: Water hydraulics, history, food market, IFAS, Alexander von Humboldt
Target audience: Anniversary guests

1 Experience as AvH-Visiting-Fellow led to the development of a new technology

From July 1984 to January 1986, Dr. Miyakawa stayed as a visiting fellow at IHP (Institut für hydraulische und pneumatische Antriebe und Steuerungen, established under the direction of Prof. Backé in 1968), RWTH Aachen University. Preparation for this stay started with a preliminary meeting in March 1983. He took a German language training course in Bremen from July to October 1984. In November 1984, he started a research project at IHP. Because of his missing linguistic skills, he attended a German language class held at 18:00 p.m. at the Germanistisches Institut, RWTH Aachen University, taking steps in his linguistic headway. As presented to Prof. Backé in advance during visits in Germany, his research subject was on oil hydraulics, which was a continuation of the research conducted in Japan.

Prior to his return to Japan in January 1986, Prof. Backé asked about a research subject to be undertaken in Japan. This question shaped his future. Based on conversations with Prof. Backé, this article describes his development process of water hydraulics through mentorship and guidance and through the bond with 3 Professors in 33 years in chronological order. His family enjoyed company of Prof. Murrenhoff, then Chief Engineer at IHP. Since the homes were close to Aachen-Laurensberg at that time, the families engaged in regular visits. “Bitburger” was the first German beer Dr. Miyakawa tasted in a local Kneipe. It was a superb experience leading to regular stays at the Postwagen near Aachen’s town hall.

2 Patent application of the new technology and verification of principle and Functions

After returning to Japan in the end of January 1986, he visited Germany several times in the following years to continue the research. Prof. Backé used the opportunities to ask Dr. Miyakawa about his research subjects to be undertaken in Japan. He was working for Ebara Corporation at that time. The company had already withdrawn from the existing oil hydraulic business, which was his area of expertise. He was part of the Ebara’s research institute but had not determined on the research subject yet. On April 1, 1987, he was transferred from research to development and started to explore the research subject. After screening potential subjects, he decided to join the development of water hydraulics to contribute to the company’s water-related business by using his experience in oil hydraulics. When the decision was made, he had 17-year experience in oil hydraulics dating back to April 1970. Being general knowledge that “water and oil never mix” and oil hydraulics having evolved from the fact that it is difficult to drive machines by using water as a working fluid, he recognized that it would be difficult to return to using water as a working fluid. The application of water hydraulics to a machine dates back to the patented hydraulic press invented by the English inventor, J. Bramah in 1795. Even though this was taught in European Universities, it was not public knowledge in Japan at that time and further studies brought him deeper into the subject.

In 1987, applications for water hydraulic servo valve patents were filed. Once again, Dr. Miyakawa learnt a lot with regard to preparatory patent searches in this field. A common practice should always start with searching similar existing patents and papers to be conducted by the company’s intellectual property or patent section. He filed a patent application for a water hydraulic servo valve having in mind that water hydraulic technologies should be smart and intelligent. Since oil hydraulics provides high power density and the key components in...
developing fluid power technologies are pumps, developing a pump seemed to be the first step. However, setting up “intelligent water hydraulics” as a target technology; the first step was a “nozzle flapper control valve incorporating electronic technologies” allowing connection with IT equipment. Not being aware yet of the challenging characters of a pump using water as its working fluid the chance for validation of the originality and novelty of this technology was entirely dependent on the grant of a patent, see /1/.

In the in-house research he started research by verifying functions of the valve technology. In the sliding movement of elements in low viscosity fluid housed in a valve body, the effect of water film cannot be expected. If the structure and principle of the valve could be successfully verified, the development of the technology would be publicly funded by the Research Development Corporation of Japan. The concept of Ebara Corporation was “if the technology is good enough, then public funding should be granted.” In 1989, the principles of the patent were verified, and a fund of 150 million yen (which was paid back in equal installments with free of interest for five years after the development period of three years) was granted. Dr. Miyakawa has strong belief that the industry would be following a path toward the use of freshwater as a working fluid to drive machines, which should be the best choice from the viewpoints of both environment and resources. So he decided to develop washable precision machinery driven by water hydraulics. He was encouraged by the selfish pride as an employee of a leading company in water business already estimating that it would take 20 years to commercialize the technology. On the other hand, he was told by experts that it would usually take 25 to 30 years although this estimation was not made on sufficient grounds. By 1993, all patents including those applied for some advice on German water hydraulic technologies. He introduced him to companies involved in water hydraulics. Germany has a long history of high water-based fluids (HWBFs, HFA) technologies. Germany has a long history of high water-based fluids (HWBFs, HFA) for some advice on German water hydraulic technologies. He introduced him to companies involved in water hydraulics. Germany has a long history of high water-based fluids (HWBFs, HFA). The region located in the Ruhr coalfield (Ruhrgebiet) had many companies offering water hydraulic equipment for safety purposes, including explosion protection in the mines. HWBF or HFA is a special fluid that contains approximately 98 percent water with additives (for lubrication, corrosion prevention, etc.). In a broad sense, HWBF technologies are included in water hydraulics being part of it.

3 Field study of German water hydraulics technologies triggered by Prof. Backé’s statement “Technology development in water hydraulics is difficult” and development of the Japanese market

In September 1988, the First Bath International Fluid Power Workshop (hosted by Prof. Burrows) was held at the University of Bath. During this workshop, a lecture on a water hydraulic pump was given by J. A. Currie, the pioneer of water hydraulic pumps in England (2). Prof. Backé’s questions on 1) friction and tribology, 2) cavitation, and 3) corrosion as well as the application of plastic materials as countermeasures for wear are included in the published proceedings containing the lecture. Dr. Miyakawa realized that solutions for those three points should be keys for the development of water hydraulics. On this occasion, he found the link between Prof. Backé and water hydraulics. In later years, this water hydraulic pump was commercialized and also introduced to Japan.

In March 1989, at the first JFPS (Japan Fluid Power System Society) International Symposium held at the Tokyo Institute of Technology, Prof. Burrows of the University of Bath, who participated in the symposium with Prof. Backé, told him that swash plate water hydraulic pumps have already been put into practical use by a company FE in England. In later years, required for the international standardization of ADS described hereinafter, 1), 2), 3) and the application of plastic materials as described above became basic items to be studied to explain differences from oil hydraulics when a working fluid is changed from mineral oil to freshwater. These items turned out to be the greatest gifts from Prof. Backé.

In 1990, he commenced the study of water hydraulics available in Europe. At the time, proprietary water hydraulic technology was the above mentioned water hydraulic servo valve. No further knowledge regarding other water hydraulics was available. Dr. Miyakawa contacted Prof. Backé at IHP, RWTH Aachen University, for some advice on German water hydraulic technologies. He introduced him to companies involved in water hydraulics. Germany has a long history of high water-based fluids (HWBFs, HFA). The region located in the Ruhr coalfield (Ruhrgebiet) had many companies offering water hydraulic equipment for safety purposes, including explosion protection in the mines. HWBF or HFA is a special fluid that contains approximately 98 percent water with additives (for lubrication, corrosion prevention, etc.). In a broad sense, HWBF technologies are included in water hydraulics being part of it.
In February 1993, Dr. Miyakawa visited the University of Edinburgh to see a water hydraulic robot using a FE’s water hydraulic equipment. To see an all-ceramic seawater pump (a high-pressure positive displacement pump) he also visited a research institute at the University of Hull. To his astonishment, all the parts, including piston and cylinder block, were made of ceramics. He was impressed by the water hydraulic pump of the palm size (6 cc/rev., 16 MPa), which was exactly what he had been looking for. He requested the development of a smaller water hydraulic pump (3 cc/rev., 16 MPa) and started the development of different water hydraulic machines, including a nuclear reactor core cooling device model and a civil engineering machinery as countermeasures against seismic liquefaction in 1994 and a food processing machinery around 1998. Specifically, vane motors with equivalent of electric motor output of 100/200 W (Figure 10) were developed for cutters in meat processing machinery. All the applications were proposed for markets subject to product or machine contamination by oil. In 1997, a partner company of Ebara Corporation concluded a contract for the import and sales of FE’s water hydraulic equipment, which allowed to have priority use of swash plate water hydraulic pumps in Japan. Through progress in technology development and the procurement of components, a new market for water hydraulics in Japan came into sight. Practical accomplishments were also seen.
Dr. Miyakawa had access to papers on low viscosity fluid from Prof. Backé’s archive at IHP, RWTH Aachen University, and learned a lot on technical issues, in particular, cavitation erosion and countermeasures /3-7/. Working fluids used for water hydraulic systems in the papers were HWBFs; however, the effect of viscosity (particularly on cavitation) and the need of corrosion prevention are common characteristics in the case of tap water as a working fluid. Prof. Backé’s words, “Water hydraulics is difficult,” always stayed in his mind. He was eager to know the reason of this statement. To discuss the matter, he needed not only to gain knowledge on water hydraulics but also to master German. Before visiting Prof. Backé for the third time, he had to sum up findings achieved in Germany immediately and ask for his advice. Therefore, after returning to Japan in January 1986, he prioritized to publish the findings in “O+P, Ölhydraulik und Pneumatik”. Thanks to great support from a joint researcher, he finally could publish the findings in the journal /8/. The article was on oil hydraulics.

Prof. Backé’ home for the first time during his stay in Aachen in 1985. At that time, he lived in the mentioned suburb of Aachen. Memories of him are: “I got stage fright and was only able to nod in response to his talk in German, finding it difficult to mention a single word. He spoke German, not English, to me very slowly, which encouraged me to study German harder.” Then, Prof. Backé moved to the city center of Aachen. Considering his increasing age, Dr. Miyakawa began to visit him at home, not his laboratory at the university, to update the progress. His first question was always about progress in the application of water hydraulics to the food sector. He thinks back: “I did not have enough confidence to answer to his technical questions, but his questions were centred in introduction to personal things rather than on technological issues. His wife gave a compliment to me for my achievements in the field different from Prof. Backé’s. He seemed to have significantly changed his opinion on water hydraulics around this point of time. He was eager to listen to my updates on progress in R&D and the introduction of water hydraulic systems to new markets. It is still not certain whether my explanation on water hydraulics with poor German skills was fully understood by the professor. However, one year until the following visit was too short to be prepared for his questions that are getting more difficult to answer. I used twelve hours during the flight back to Japan to plan how to make explanation to him at its next visit in the following year.”

In 2002, Prof. Backé (Photo in Figure 11) gathered parties involved in water hydraulics in Germany to hold a roundtable meeting, the details of which were published in “O+P” /9/. Although his article introducing Dr. Miyakawa’s activities did not fully reflect his scope of work, his mention of the name in public was a honour. Realizing that he was interested in water hydraulics, Dr. Miyakawa read the article with the help of a German dictionary. In later years, he became acquainted with people listed in the journal. At that time, in Germany, VDMA (Verband Deutscher Maschinen- und Anlagengen, Mechanical Engineering Industry Association) played a central role in organizing and operating the committee of water hydraulics. Three lecture meetings on water hydraulics were held in 1998 /10/, 2000 /11/, and 2002 /12/. The proceedings of these meetings helped him greatly in later years. Many researchers and parties involved asked him the reason for its regular visits since 1986 after returning from IHP. Whenever Prof. Backé introduced him to others, he described him as an Alexander von Humboldt visiting fellow from Japan. Since not only Prof. Backé but his secretary and many researchers extended warm hospitality to him, he came along with them on the bases of German learnt. During his stays in Aachen, he waited for Prof. Backé at the entrance of the laboratory to greet him every morning and went out of the laboratory after he left.

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In the Japanese market, specific water-hydraulics-applied products appeared around 1998. A meat processing machine (in 2002) and a semiconductor wafer sealing molding press (in 2002) took the advantages of the patent-filed water hydraulic servo valve. Finally, Dr. Miyakawa succeeded in reaching markets that potentially required water hydraulics and received a good response from the markets. He showed photos of these products to Prof.
Bacé, who seemed to appreciate the situation. In March 1998, Prof. Murrenhoff hosted the first International Fluid Power Conference, IFK. Dr. Miyakawa often got some advice from him mainly in terms of technical aspects. We discussed tribology of water hydraulic pumps using HWBFs. He also showed disagreement on development of water hydraulics using tap water; however, this argument, particularly on durability, became a useful information thereafter. When visiting in 2001, a discussion began on the combination of materials to use. The technical information exchange with Prof. Murrenhoff provided an opportunity to ask about further specific support for development of water hydraulics in Japan. In March 2003, a research group of the Japan Fluid Power Association (JFPA) visited RWTH Aachen University, and a meeting hosted by VDMA was held, in which Prof. Murrenhoff and many engineers involved in water hydraulics in Germany gathered together. Here, the group could learn that the perspective of technology development and intention of markets for water hydraulics in Germany differ from each other. At the same time, he could understand the background of Prof. Bacé’s words, “Development of Water hydraulics is difficult.” On the other hand, market development of water hydraulics in Japan, as stated above, was progressing relatively smoothly. Supported by Prof. Murrenhoff, the outcomes including specific water-hydraulics-applied products, along with the survey results on the market size, were published in “O+P” (13). It was in 2003, the next year when the roundtable meeting on water hydraulics in Germany was held by Prof. Bacé.

In November 2003, the water hydraulics project team in Ebara Research Co., Ltd. was dissolved and Dr. Miyakawa decided to leave the company at the end of March 2004 and told Prof. Bacé about the decision. Prof. Bacé asked him what would happen to the water hydraulics project. He explained to him that a corporation decided to buy related patents and testing facilities of Ebara Research and that the project would be continued at the corporation.

5 Second stay at RWTH Aachen University as AvH-Visiting-Fellow and continuous development of water hydraulics

From May to September 2004, he stayed in Aachen again, supported by the Alexander von Humboldt Foundation. This support was won through the efforts of Prof. Murrenhoff, the successor of Prof. Bacé who was very glad to know that the RWTH Aachen University with the support of the Alexander von Humboldt Foundation took Dr. Miyakawa into care again. In those five months, he could round up water hydraulic technologies developed since 1987.

He started with reporting mainly technical matters to Prof. Murrenhoff. The initial advice from him about the type of hydraulic pumps, pressure specification and the basic structure was always “consider from the academic perspective.” Subsequently, he gave me guidance on water hydraulic pumps using HWBFs (14, 15). The technical details were getting more and more complicated. Around that time, he began to update progress in the development of the water hydraulic business to both Prof. Bacé and Prof. Murrenhoff.

After returning to Japan, the development of water hydraulics and market investigation were continued at the corporation to which water-related patents and facilities were transferred. Dr. Miyakawa’s regular visits to Prof. Bacé and Prof. Murrenhoff also continued.

6 Prof. Bacé no longer mentioned difficulty in development of water hydraulics and Prof. Murrenhoff provided the fundamentals of water hydraulic pumps

In August 2009, to celebrate Prof. Bacé’s 83rd birthday, Dr. Miyakawa and his wife visited him at home together with Prof. Burrows from the University of Bath and his wife. After dinner, he spoke of his personal history, including his birth in Tanzania, Africa, on July 25, 1926, coming to Germany, and establishing IHP (currently IFAS) in January 1968. Two professors and I talked over “the future of fluid power technologies” endlessly until late at night. Dr. Miyakawa was fascinated by the talk of two professors both of whom were the pioneers of oil hydraulics. The research achievement of Prof. Bacé from 1955 to 2009 is published as a book (16). On that occasion, he asked his opinion saying, “Miyakawa is a pioneer of water hydraulics.”

Prof. Bacé was told that his work on the flow force acting on the valve described in his dissertation (17), was of great help in designing a water hydraulic servo valve. He keeps his dissertations with great care. Time passed so fast over the two professors’ talk on “the memories and future of oil hydraulics”. Dr. Miyakawa was more than impressed to share precious time with them. Two professors suggested to continue the talk with their successors, Prof. Murrenhoff and Prof. Plummer (in the UK); however, unfortunately, this part has not been realized yet.

For the applications of water hydraulics, the efforts focused on the marketing of food processing machinery, which was discussed before. He said, “This direction turned out to be right,” to Prof. Bacé; he smiled and said, “Good.” That was the moment my efforts began to bear fruit. Then, again in “O+P”, an article on the historical background of water-based working fluids and the technological differences and market size of systems using tap water as a working fluid was published (18).

Around 2010, the team set out the commercialization of food processing machines for a specific market, which was funded by an organization associated with the Ministry of Agriculture, Forestry and Fisheries of Japan (Figure 16). In Japan, there has been increasing awareness that our water hydraulic system, Aqua Drive System (ADS), is an effective driving method for machines subject to HACCP (Hazard Analysis and Critical Control Point) which will be applied to exported and imported products to support “safety and reassurance of food”. ADS allows cleaning of food processing machines and components immediately after operation; therefore, attention was drawn to its improved productivity and hygiene as well as ease of maintenance. Then, ADS evolved into an integrated structure of a forming press for frozen meat and a meat slicer, which was publicly announced.
In 2013, on the occasion of Prof. Murrenhoff’s 60th birthday party, Prof. Backé presented a working-fluid-filled champagne bottle, which made the guests excited. Dr. Miyakawa felt that this witty expression of expectation and affection to his successor could be because of Prof. Backé’s special nature. At this instant, something came to his mind remembering the Great East Japan Earthquake, which occurred in September 2011. On the way to home from work going down the stairs of a train station his cellphone rang in the pocket. He took the phone and placed it to his ear. It said, “Prof. Backé am Apparat. Dr. Miyakawa?” he was surprised.

He continued “Are you all right? How can I donate?” It was early evening, in the crowded station. I can never forget this.

On some other evening, Dr. Miyakawa had an opportunity to visit Prof. Backé at home. There, he updated the progress of introduction of water hydraulics to the market. He no longer repeated his previous statement, “Technology development in water hydraulics is difficult.” Therefore, Dr. Miyakawa felt, that he finally admitted the advantages of water hydraulics. It was the moment when concerns over technology development in water hydraulics turned into reassurance.

From 2010 to 2015, outcomes of commercialization and basic research of ADS were presented in international symposiums in Aachen (Germany), Tampere (Finland), Linköping (Sweden), Bath (UK), and Japan [19-24].

During one of his regular visits in August 2014, Prof. Backé had his 85th birthday. His secretary told Dr. Miyakawa that it might not be easy for him to listen to his updates because of his gradually decreasing physical strength. Therefore, he called him directly for an update. He answered clearly and was far from being frail. Dr. Miyakawa was relieved to see him eating a huge cake baked by his wife. He talked smoothly and listened to the updates. Then, he inscribed on a gift copy of what he described as “his last publication” [25]. Seeing “Herrn Prof. Miyakawa”, I told him, “I am not Prof. but Dr.-Eng.” He answered, “You are Prof. because you are a pioneer of water hydraulics,” and his wife took a picture of Prof. Backé presenting the inscribed copy to me at his home.

I reported to him that we had finally achieved the introduction of water hydraulics to the market. Again, he pointed out, “It must be the food market.”
Dr. Miyakawa immediately showed a resin protective film forming press for chip-sized devices adopted in a semiconductor process, which was put into practical use in 2002. He seemed to be satisfied with the food and semiconductor fields as markets that potentially require water hydraulics and nodded, “Right.” He told him that the product machines functioned, but also said, “The optimization of hydraulic energy transfer has not been achieved yet.” The performance and energy consumption of water hydraulic systems still need to be addressed.

Prof. Backé advised him the importance of the balance of hydraulic energy consumption in each component. It was the moment Dr. Miyakawa felt certain that the standardization of water hydraulics would be critical sooner or later.

7 International standardization of ADS unreported to Prof. Backé

Dr. Miyakawa told Prof. Backé the purpose of a visit in 2016 as “the international standardization of ADS”. He conveyed him its intention of proceeding the market development and standardization of ADS in parallel. He was thinking of visiting him earlier than usual. However, without hearing the outline of “the international standardization” from me, Prof. Backé passed away one week before the planned regular August visit. When he received the news, strength was suddenly gone from his legs and his head dazed. In an e-mail to Prof. Murrenhoff, he mentioned nothing but “great sorrow.”

At the end of 2016, Dr. Miyakawa left KYB Corporation to start working for the Japan Fluid Power Association (JFPA). While engaged in industry-wide activities related to water hydraulics, he was assigned as the Chairman of ADS Technical Committee. Then, aiming at the international standardization of ADS, he visited standardization-related organizations in Europe and the U.S. At these organizations, he met researchers who studied under Prof. Backé. This provided him with psychological support.

Although his wish to tell Prof. Backé in person was not fulfilled, he would like to express that ADS was originated during his stay at RWTH Aachen University, Germany and the development of ADS was carried out through mentorship under Prof. Backé, Prof. Murrenhoff and his successor, Prof. Schmitz, as well as support of German water hydraulic equipment manufacturers.
The ISO TC131 meeting was held in San Antonio on May 18, 2017. To his regret, the presentation of “Proposal for Standardization of ADS” was not made. At the meeting, German VDMA members actively expressed their opinions. However, he hopes this work for standardization to be advanced as a Japan-Germany joint work.

Thirty-four years have passed since he met Prof. Backé for the first time in 1983. With the support from many people, ADS (a new water hydraulic system) has been put into practical applications. Dr. Miyakawa gained knowledge enormously from the three outstanding professors as well as German companies involved in water hydraulics and through books on water hydraulics in the RWTH Aachen University’s library. Likewise, he would like to thank users in Japan for their understanding for ADS as well as JFPA (Japan Fluid Power System Society) and companies involved in ADS for their great support, and hopes ADS become widely used around the world through international standardization. He strongly wishes that ADS contributes to the growth of diverse industries.

Acknowledgements
Finally, deep appreciation goes to Prof. Murrenhoff for providing this special opportunity at the 11th IFK to talk about 33 years of career with water hydraulic development. This is the precious gift in my life. I would also like to express my sincere thanks you to Jutta and people in the secretary office of IFAS for their hospitality especially during my long-term stays.

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