FUKAO Tadashi

"The Pioneering Research on Reactive Power Compensators, High Speed Electric machines and Bearingless Motors"

1. BIOGRAPHY

Date of Birth: May 19, 1940

He obtained the B.S., M.S., and Ph.D. degrees from The Tokyo Institute of Technology , Tokyo, Japan in 1964, 1966 and1969, respectively.

In 1969, he joined the Tokyo Institute of Technology as a Research Associate、from 1977 to 1986 and from 1986 to 2001, he was an Associate Professor and Professor in the Department of Electrical and Electronics Engineering, respectively.

From 2001 to 2006, he was a Professor at the Musashi Institute of Technology (renamed the Tokyo City University, 2009)

2. SUMMARY

In the early days of power electronics technology, he focused on the reactive power and harmonics that would become serious problems when power electronics application equipment become wide spread and he proposed AC/DC converters, static var compensators and power active filters to solve these problems. Also he proposed ultra-high speed rotating machines and bearingless motors , and contributed to the expansion of the application area of rotating machines.

3. RESEARCHE ACHIEVEMENT

The major research subjects and accomplishments are as follows:

3.1 An SCR Power Amplifier[1] and AC-DC converters:

- Bidirectional AC/DC Power Converter[2]
- AC-DC Converter Intended to Improve the Power Factor and Current Wave Form of AC Side[3][4]

3.2 Active filters , Reactive and Negative-Sequence Components Compensators

- Switching filters[5]
- Reactive Power Compensators[6],[7]
- Negative-Sequence Components Compensators[8],[9]

The article(6) earned him the IEEJ Distinguished Paper Award in 1987.

It was pointed out that these researches were difficult to realize at the time of publication, but they were all put into practical use in the 1980s and 90s thanks to the advent of power semiconductor devices with excellent switching performance, and are also used in the AC/DC converter of Shinkansen trains.

3.3 Cycloconverters

- Harmonic Component Analysis[10].[11]
- Direct Digital Controllers [12],

- High-Frequency Cycloconverters [13]-[15]

A patent was applied for the high-frequency cycloconverters presented in the articles[13], [14],and [15], and Japanese Patent 1990-16663 was approved in 1990.

3.4 Super-High Speed Reluctance Machines and Bearingless Motors

- Super-High Speed Reluctance Generators[16]-[23]

At the IEEE Industry Applications Society (IEEE IAS) Annual Meeting held in 1985, Prof. T.A. Lipo showed considerable interests in Prof. Fukao's presentation on a super-high speed reluctance generator and asked Prof. Fukao to serve as a lecturer at the IEEE IAS tutorial course. And Prof. Fukao gave lectures at the IEEE IAS tutorial courses in May 1992[21] and October 1994[22].

-Bearingless Motors[24]-[30]

In 1987, Akira Chiba, a third year doctoral student at the time, discovered the basic principle of a new type of a motor with a magnetically integrated bearing function and this new developed motor was named a "bearingless reluctance motor" [23],[24]. This principle was extended and applied to other types of rotating machines and various bearingless motors, such as permanent magnet type[27], homopolar type[29], and switched reluctance type[30], were proposed.

Articles (29) and (30) earned him the IEEJ Distinguished Paper Awards in 1998 and 2005, respectively.

And 35 Japanese patents including four international PCT patents were granted, the major Japanese patents are as follows:

JP2670986 : Electromagnetic rotating machines (1997.11)

JP2835522 : To provide a radial direction rotating body position control winding electromagnetic rotating machines with radial direction rotating body position control device

JP3524303 : To provide a radial direction rotating body position control device

A Rotor of a bearingless machine is magnetically supported completely non-contact. Therefore, mechanical bearings and their lubricants are no longer required, then bearings and lubricants do not need to be replaced, Bearingless machines are being actively put into practical use and developed for the following applications; 1. High-speed and high-power motor drives, 2. motor drives in outer space, ultra-high and low temperature atmospheres, and also in harsh environment with radiation and poisonous substances where maintenance is difficult, and 3. motor drives for semiconductor manufacturing equipment, food and pharmacy processes that require a high degree of cleanliness.

A bearingless motor with an output of 60kW, rotating speed 37,000r/min (the world largest output at the moment) has already developed in Japan for driving compressors used in air conditioners[31].

These accomplishments earned him the following recognitions from IEEE :

1. IEEE Fellow for " developments of synchronous reluctance motors and generators in super-high speed applications" 1994.1
2. IEEE Industry Applications Society Distinguished Lecturer for "Advanced Power Electronics in

Japan, High-Speed Motor Drives and the Development of Bearingless Motors" 2001.10

3. IEEE William E. Newell Power Electronics Award、with a citation "For contributions to the development of cycloconverters and bearingless drives" 2009.9

4. EDUCATIONAL ACTIVITIES

1969-1977 He relocated and maintained the electrical engineering student laboratory and challenged to improve the electrical and electronics engineering experiments(33).

5. MAJOR ACTIVITIES IN THE IEEJ

1994.5-1995.5 President, Industry Applications Society, IEEJ

1996.5-1997.5 President, Tokyo Branch, IEEJ

1997.5-1998.5 Director, Editorial Affairs, IEEJ

1998.5-1999.5 Vice President, IEEJ

2002.5-2003.5 President-Elect., IEEJ

2003.5-2004.5 President, IEEJ

His oral history appeared in the journal of IEEJ in 2015(34).

6. BOOKS

1. Power Electronics Practice (Shokodo) 1984

2. Magnetic Bearings and Bearingless Drives (Elsevier) 2005

3.Introduction to Electric Machinery (Jikkyo Shuppan) 2007

4. Principles of Electric Machinery and Power Electronics (IEEJ) 2012

7. SPECIAL REMARKS

He was very fortunate to be able to work with extremely talented students and collaborators, including four IEEE Field Award Recipients (Professor Emeritus, Tokyo Institute of Technology, Hirofumi Akagi-2018 IEEE Medal in Power Engineering, 2008 IEEE Richard H. Kaufmann Award etc, Professor ,Tokyo Institute of technology, Akira Chiba-2020 IEEE Nikola Tesla Award, Professor Emeritus, Meiji University Kouki Matsuse [visiting researcher at Miyairi Laboratory in 1975, 96th President IEEJ, a co-author of the paper (8) in the following references]- 2020 IEEE Richard H. Kaufmann Award, and Prof. Feng Zheng Peng, Florida State University, [research associate at Fukao Laboratory from 1992.4 to 1994.3, a co-author of the paper (32) in the following references]-2022 IEEE William E. Newell Power Electronics Award).

8. REFERENCES.

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