Nakada Takashi (1908-2000) "Pioneering Research of Profile Shifted Gear"

中田　孝　「転位歯車に関する先駆的研究」

1. Biography

<Career>

Nakada Takashi
中田　孝

Born in 1908 in Asakusa Ward, Tokyo City. After graduating from Kyoka Junior High School, he entered the Tokyo Technical High School, since he was good at mathematics. He studied under Yaekichi Sekiguchi in the Department of Mechanical Engineering. He graduated from Tokyo Technical High School in 1928 and proceeded to Tokyo Institute of Technology (now Institute of Science Tokyo) as a first-year student. In 1932, he graduated from the Department of Mechanical Engineering, Faculty of Engineering and became a laboratory assistant in the Department of Mechanical Engineering.

In 1939, he became an assistant professor at Research Laboratory of Precision Machinery and Electronics (RLPME), Tokyo Institute of Technology, Professor of RLPME in 1944, and received Doctor of Engineering. In 1953, together with Professor Masao Naruse of Tohoku University and Professor Akira Waguri of Kyushu University, he received the Japan Academy Prize for his research on gears.

1958 Visiting Professor at Purdue University (Fulbright Program). 1961 Director of RLPME at Tokyo Institute of Technology. 1962 President of the Japan Society of Precision Machinery. 1963 President of the Japan Society of Mechanical Engineers.

1964 Visiting Professor at Georgia Institute of Technology (National Science Foundation). 1966 Director of RLPME at Tokyo Institute of Technology (reappointed) and Director of the International Society for Automatic Control Engineers (IFAC). 1967 President of the Society of Instrument and Control Engineers. 1968 Retired, Professor Emeritus at Tokyo Institute of Technology, Representative Director of Tokyo Seimitsu Sokki Co., Ltd. 1982 Chairman of the Board of Directors of Tokyo Seimitsu Sokki Co., Ltd. 1986 Advisor to Nishijima Iron Works Co. 1988 Member of the Japan Academy.

<Awards>

* 1959 Japan Society of Mechanical Engineers Paper Award
* 1964 Okochi Memorial Technology Award
* 1973 Honorary Member of the Society of Instrument and Control Engineers
* 1973 Honorary Member of the Society of Precision Machinery
* 1973 Honorary Member of the Japan Society of Mechanical Engineers
* 1983 Machine Tool Technology Promotion Paper Award
* 2000 Society Award and Achievement Award from the Society of Instrument and Control Engineers
* 1953 Japan Academy Prize
* 1964 Tokyo Governor's Award
* 1978 Order of the Rising Sun, Third Class
* 1988 Member of the Japan Academy
* 2000 Order of the Sacred Treasure, Second Class

2. Achievement

Takashi Nakada's research topic is gear engineering. Gears are mechanical devices used to transmit power, and their role is to (A) transmit rotational motion with equal angular ratios from one axis to another, and (B) reliably transmit continuous rotational motion from one axis to another[1].

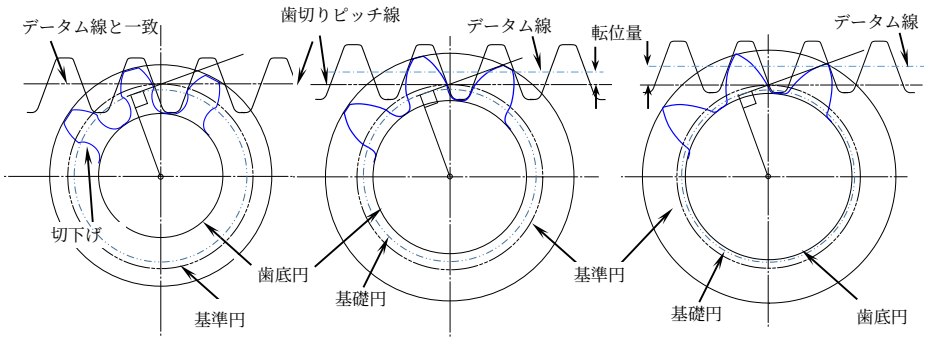
Gears were described by Aristotle of Greece before 300 BC, which is said to be the oldest in the world. They were apparently used in China before 200 BC. In 1765, L. Euler of Switzerland proposed involute gears. The teeth are made of involute curves, and they mesh well regardless of geometrical deviations. In 1908, M. Maag of Switzerland announced the profile shifted gear. This added diversity to the design and manufacture of involute gears, and Maag started a company to manufacture gear cutting machines.

Nakada learned about profile shifted gears from a book by Siebel[1] given to him by Shigeo Sasaki, who was the director of RLPME where Nakada was appointed as an assistant professor at the time and began his research. Profile shifted gears are gears made by shifting the position of the rack to be cut (a) toward (c) or away from (c) the gear to be cut when cutting an involute gear, as shown in Figure 1. This was just before World War II, and numerical analysis of involute curves was not easy, and manufacturing was done by trial and error based on experience.

Nakada came up with creative analytical methods, such as a method of generating involute tooth profiles using diagrams and a design method using an involute slide rule. With these methods, he was the first to elucidate the characteristics of the gear profile of involute profile shifted gears and the problem of gear meshing vibration, as well as the fluctuations in transmitted rotational force during high-speed operation [1].

Furthermore, he proposed and proved a theory of correlative inference between the dynamic characteristics that emerge when this gear is in use and the static characteristics that can be predicted in advance through analysis, etc., and presented a transition gear and its design method that allows selection of gears that can achieve higher operating performance depending on the purpose of the gear.

He also expanded this theory to the field of gear manufacturing technology and discovered a design method that can produce gears with a variety of different characteristics by simply moving the mounting position of the tool on the gear cutting machine, under conditions where the same standard gear cutting tool is used.



a) $x = 0$, 切下げ　　b) $x = 0.6$　　c) $x = 0.8$, 歯先が尖る

Fig. 1: A group of profile shifted gears made with the same rack-type tool [1] (This diagram is by Haruo Houjoh)

This ingenious cutting method for profile shifted gears has made it easy to manufacture high-performance profile shifted gears. This calculation method is widely used both domestically and internationally. As another application of this theory, he has developed a new method of tooth profile analysis that can analyze and clarify the various factors that are the basis for the design of gears whose tooth profile curves are unknown [1], [2]. This method has also been widely adopted internationally.

He has provided a function table of transcendental function expressions for profile shifted gears, and even included approximate algebraic formulas for simplified design. For these series of achievements, which were at the forefront of gear research in the world, he was awarded the Japan Academy Prize in 1953.

Fig. 2 The image of profile shifted gears[2] Corresponding to (a) and (c) in Fig.1

At RLPME, the mechanical and electrical engineers of the Laboratory led by Nakada, created Japan's first numerically controlled machine (NC). The NC machines in which Japan currently leads the world had already been made in the United States during World War II, but Nakada and his team at the institute created the NC machines themselves (1957). In the process, they granted the right to commercialize to Fujitsu (Vice President: Omi Hanzo), which cooperated by providing parts. This was turned into a company by Inaba Seiemon, who later became the president of FANUC, and it later developed into a large corporation. Due to these engineering contributions, Nakada was elected as a member of the Japan Academy on December 12, 1988.

(This part references a portion of the report[2] on Nakada's achievements made by Suzuki Hiroshi, a member of the Japan Academy, at the Japan Academy General Assembly in January2000 and the Tokyo Institute of Technology Museum[3].)

3. Important Notes

Nakada Takashi had an extremely wide range of hobbies, excelling at playing the flute and leaving behind many enjoyable, small Western-style paintings that are all uniquely elegant. He enjoyed playing tennis outdoors and bridge indoors, soothing the fatigue he shared with his laboratory staff and graduate students and refreshing himself to face his research again. He was the epitome of "learning and playing as one."[3] Nakada Takashi was one of the pioneers in gear engineering, and in particular his discovery of new methods for the design and manufacture of transfer involute gears made a major contribution to the development of Japan's machinery industry, particularly the automobile industry. He also led the laboratory team in realizing Japan's first numerically controlled (NC) machine tools, making a major contribution to the industrialization of the machine tool field.

Papers and Books

[1] Takashi Nakada: “Shifting Gears”, Seibundo Shinkosha, 15th edition, Feb. 20 (1965) (first edition published on October 20, 1949)
[2] Takashi Nakada: “On Some Analytical Methods of Involute Gears”, Journal of the Japan Society of Mechanical Engineers, vol. 6, No. 30, pp.61-77, Oct. 27 (1941)

References

1) A. Schiebel; Zhanrädar 1, Julius Springer, 1930.
2) “Learning and Playing as One: The Colorful Life of Engineer Takashi Nakada”, Takashi Nakada Memorial Publishing Committee, June 20 (2002)
3) “Gear Research Combining Theory and Practice”, Nakada Ko Tokyo Institute of Technology Museum, May 31 (2021)

(2025-01-28 Lectured by Kenichi Iga)