

7.15 The cost of air pollution control technology

7.15.1 Changes in plant and equipment investment capital

Fig.7.15.1 shows changes in previous years air pollution control countermeasure equipment cost (based on expenditure). During a period of about 30 years from 1966 to 1995 the cost based on expenditure of air pollution control countermeasure equipment was a total of ¥4.7 trillion. The gross total cost in 1990 was ¥6.6 trillion yen (\$46.7 billion, at \$1=¥142).

The cost breakdown was:

- dust collector: ¥2.3 trillion (\$ 16.2 billion)
- flue-gas desulfurization equipment: ¥1.4 trillion (\$ 10.2 billion),
- heavy and light oil desulfurization equipment: ¥880 billion (\$ 6.2 billion)
- flue-gas denitrification equipment: ¥440 billion (\$ 3.1 billion)

Dust collector formed the base of air pollution control countermeasures and covered about one-third of all expenditure. Historically, investment in air pollution control countermeasure equipment has increased since the mid-1960s. At first, the main emphasis was on dust collection and heavy oil desulfurization and then later on high stacks. In the 1970s flue-gas desulfurization commenced and in the mid-1970s flue-gas denitrification was introduced.

7.15.2 Sulfur Oxides Countermeasures

In the early 1960s, in Japan's heavily polluted areas direct combustion of crude oil with a small sulfur content was undertaken. From 1967 heavy oil desulfurization technology which removed the sulfur content in crude oil during refining was introduced. Investment in heavy oil desulfurization plant and equipment began in 1966 and in the decade 1967~1976 increased to around ¥585 billion. Through this about 45% of the sulfur content in heavy oil could be removed. With the introduction of heavy oil desulfurization, the sulfur content in heavy oil which averaged 2.6% in 1966, decreased to 1.93% in 1970, and then markedly to 1.43% in 1973.

But due to the technological limits of heavy oil desulfurization in decreasing the sulfur content in heavy oil, it was necessary to introduce flue-gas desulfurization to reach the appropriate environmental standard. Also, at the same time natural gas began to be imported in 1969.

In response, significant investment in plant and equipment for flue-gas desulfurization started in 1970. The annual expenditure was a substantial ¥146.7 billion in 1974, ¥95.2 billion in 1975, and ¥98.0 billion in 1976 and in the early 1980s annual expenditure was ¥30~40 billion. In the 1990s, expenditure increased significantly again as Japan entered a period of reequipping equipment that had been put in place in the 1970s. (refer to Fig. 7.15.1)

In addition, in the 1990s investment in plant and equipment for heavy and light oil desulfurization, which had decreased in the 1970s, began increasing.

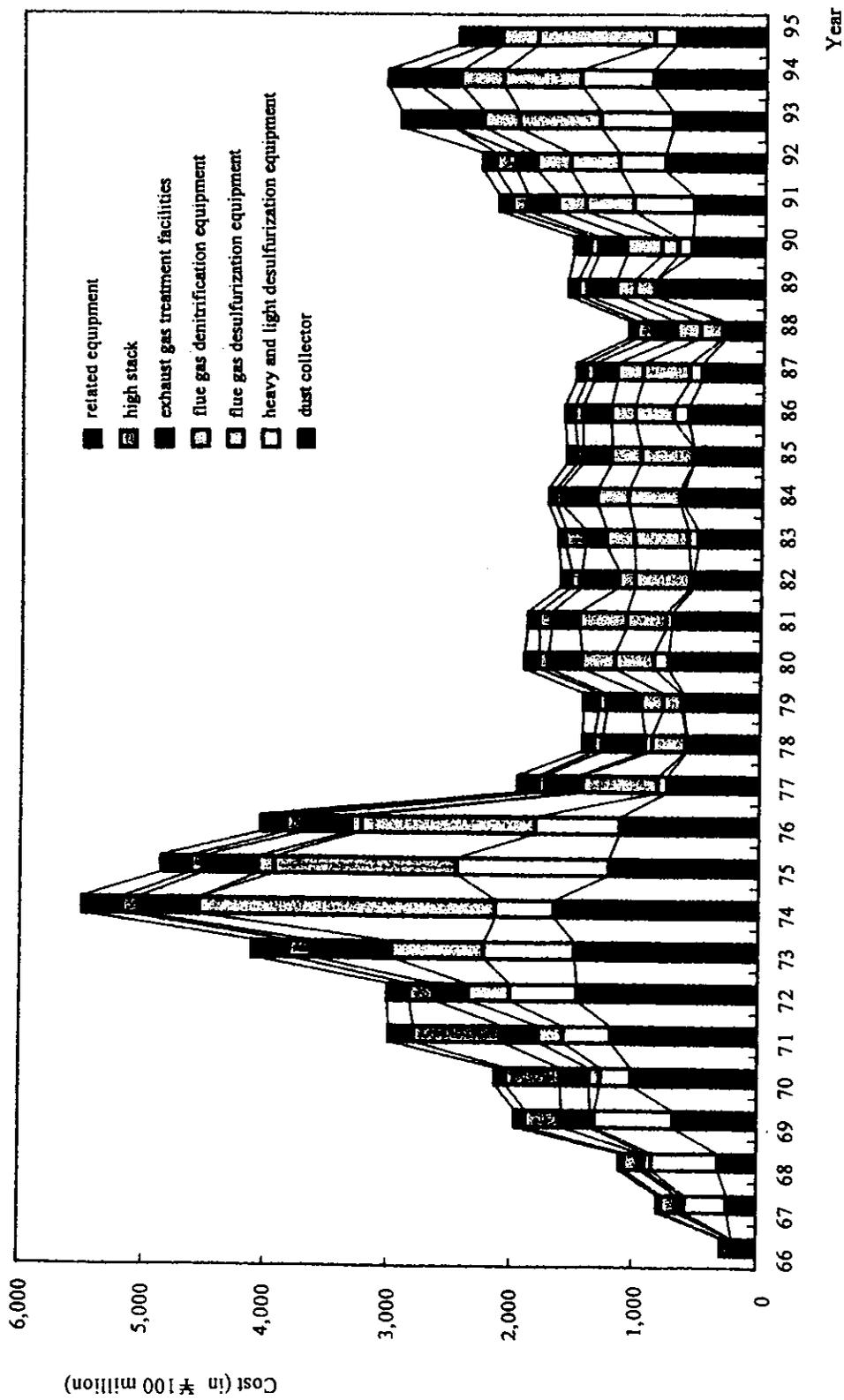


Fig.7.15.1 Changes in the cost of air pollution control countermeasure equipment (at 1990 prices)
 (made from the documents of the Japan Society of Industrial Machinery Manufacturers)

7.15.3 The countermeasure cost of individual investment– the example of heavy oil power plant

From the above, it is possible to get an overall understanding of equipment installation costs for sulfur oxides countermeasures from a macro-economic viewpoint. On the other hand, for a micro-economic analysis running costs must be added to construction cost (ie, the cost of plant and equipment investment). For these calculation examples I refer to the ideal model (Nishijima) of a thermal power plant (a heavy oil power plant with a power generation capacity of 300 MW, and a 1million m³ volume of emitted gas). If the SO_x concentration in flue gas is desulfurized from 2,000 to 200 ppm using the lime gypsum method with heavy oil as fuel, the cost is estimated to be ¥2,600 per ton of heavy oil consumed. In 1993 the wholesale price of C-type heavy oil was around ¥19,000 per kℓ and so desulfurization costs were more than 10% of its price. And if the concentration of sulfur content in the heavy oil is set at around 1.5%, the cost of sulfur removal is a high ¥200,000 per 1 ton of sulfur content.

In the trial calculation the total cost of countermeasure costs, including not only flue gas desulfurization but also dust collection and flue gas denitrification, were ¥1.35 per KW of generated power. At current prices the cost of thermal power generation by power plant is around ¥10 per 1 KW, which means countermeasure costs are 13% of the total cost of power generation per KW. However, this is only one example of a trial calculation.

7.15.4 The economic influence of sulfur countermeasures

As I indicated above, in Japan when fossil fuel with a sulfur content is combusted the cost must be calculated according to the sulfur content volume and the cost is 10~20% of the fuel price. In macro-economics terms, this is the equivalent influence as an increase in the fuel price. The changes of the wholesale price of C-type heavy oil show a remarkable increase from ¥9,100 per kℓ in 1973, to ¥19,300 in 1974 and a peak of ¥61,400 in 1982. In the 1990s it has been at a lower level of around ¥20,000 per kℓ. The economic influence of the cost of sulfur countermeasures was in large part absorbed by the changes in oil price resulting from the oil crisis.

(7.1) Literature cited

- 1) Shinbo, Motoji; Can Production be in Harmony with the Environment pp.165~168, The Nikkan Kogyo Shinbun Ltd (1973)
- 2) Urano, Kohei; The New Environmental Safety Control System of Chemical Substances, Registration of Emissions and Movement of Environmental Contaminant Substances (PRTR), Kagaku Kogaku, 61, 50~53 (1997)
- 3) Kamaya, Shinzen et al (translators); Differentiation of AIDO Modern Chemical History: Two Professional Areas, pp.448~449, Misuzu Shoho Publishing Co, 1979
- 4) Oba, Hideki; Environmental Issues and World History, pp.191~202, Association for Environmental Pollution Control Inc. (1979)
- 5) Tsuchide, Atsushi et al; The Ideas of the Chemist Ryutaro Tsuchida, pp.99~112, Kagakudojin Publishing Company, (1979)
- 6) Himi, Yasuji; Air Pollution Countermeasures in Japan and Other Asian Countries, Inorganic Materials 1, Nov. (No. 253) 67~76 (1994)
- 7) Himi, Yasuji; What Direction should Researchers go in Thinking of the Researchers at the Research Institute of Regional Pollution Examinations From an Engineering Viewpoint., *Journal of Environmental Laboratories Association*, 11, 109~123 (1986)

(7.4) Literature cited

- 1) Under the Supervision of the Ministry of International Trade and Industry, Environmental Protection and Industrial Location Bureau. Technology and the Laws and Regulations of Pollution Control (Atmosphere Edition) p.86 (1990)
- 2) Edited by the Energy Conservation Center, Japan.; Energy Conservation Combustion Technique, p.208 (1984)
- 3) Edited by the Energy Conservation Center, Japan.; Energy Conservation Combustion Technique, p.220 (1984)
- 4) Edited by the Energy Conservation Center, Japan.; Energy Conservation Combustion Technique, p.2 (1984)
- 5) Under the supervision of Norio, Arai.; The Emission of Combustion Products and Control Technology, p.417 (1997)

(7.5) Literature cited

- 1) Kanagawa Prefecture Government, Environmental Department, 1979 Report on Research; Report on the Emissions of Hydrocarbon Species Substances, pp.6~44 (1980)
- 2) US Department of Health, Education, and Welfare, Public Health Service; Atmospheric Emissions from Petroleum Refineries, A Guide for Measurement and Control (1960)
- 3) Himi, Yasuji; The Current State of Pollution and Countermeasures, (VI), *Gypsum and Lime*, No.125, 31~37 (1973)
- 4) Kanagawa Prefectural Secretariat for Environmental Pollution Countermeasures; Research Report Relating to

the Vaporization Control of Hydrocarbon Species Substances in Kanagawa Prefecture (1975)

(7.6) Literature cited

- 1) Under the Supervision of the Ministry of International Trade and Industry, Environmental Protection and Industrial Location Bureau; Technology and the Laws and Regulations of Pollution Control (Atmosphere Edition, 4th edition)
- 2) Industrial Research Center of Japan Inc, Production Goods Work Station; Encyclopedia of Air Pollution Control (1995)
- 3) Iitani, Koichi; New Trends in Filter Dust Collection Technology, *Industrial Pollution Control*, 18, (4), 304~310 (1982)
- 4) Toray Research Center Inc.; New Developments in Gas Filters (1994)
- 5) NTS; The New Technology System for Energy, edited by the Heat Transfer Society of Japan, (1996)
- 6) JISB9909; Ways of Expressing in Manuals for Dust collector
- 7) The Association of Powder Processing Industry and Engineering, Japan (Dust Collection Branch), The Society of Powder Technology Japan (High Heat Dust Collection Group Meeting) 1993 Regular Meeting
- 8) The Society of Powder Technology Japan (High Heat Dust Collection Group Meeting) 1994 1st Regular Meeting
- 9) Kaneoka, Chizuo and Tamori, Ikuo; The Development and Movement of High Temperature Ceramic Filters, *Solids Handling and Processing Industry*, 20, (2), 57~64 (1988)
- 10) Oya Yoshio and Emi Jun and Mori; Early Stage Collection Efficiency of Electric Filters and the Stability of Dust Collecting Operations, *Kagaku Kogaku Ronbunshu Collection of Chemical Engineering Essays*, 18, (1) 29~36 (1992)
- 11) Nagata, Masayuki; High Speed Electric Dust Collection Equipment, *Industrial Machinery*, 517, 27~30 (1993)

(7.7) References

- 1) Edited by the Environment Agency; The 1996 Environmental White paper (all theses) p.49 (1997)
- 2) Arai, Mitsubishi; Heavy Industries Technical Review, 27, (4) 303 (1990)
- 3) Ogawa; *Sulfuric Acid and Industry* (9), 161 (1991)
- 4) Ikeno et al.; *Ishikawajima- Harima Engineering Review*, 30, (3), 183 (1990)
- 5) Yoshii et al., Mitsubishi Heavy Industries Technical Review, 29 (1) 60 (1990)

(7.8) Literature cited

- 1) Ando, Junpei; Global Flue Gas Purification Technology, The Coal Mining Research Center, Japan, p.170 (1990)
- 2) Takahashi, Yoshiro et al, Mitsubishi Heavy Industries Technical Review, 17 (6) 929 (1980)
- 3) Nakamachi, Ichiro; *Combustion Research*, no.98, 51 (1994)

(7.9) Literature cited

- 1) Kido, Nobuo; The Basics of Gas Purification Technology; New Energy Technology for the Environment and Energy Conservation, NTS, pp.395~401 (1996)
- 2) Environment Agency Official Air Pollution Control Division, Air Quality Bureau; The Actual Conditions for setting up Smoke and Soot Treatment Equipment, *Environment and Measurement*, 22, (2) 4~7 (1995)
- 3) Edited by the Environment Agency; The 1996 Environmental White paper (all theses) p.35 (1997)
- 4) Ando, Junpei; World Flue Gas Purification Technology, The Coal Mining Research Center, Japan, p.141 (1990)
- 5) Kido, Nobuo; The Current State of Air Pollution Control Technology in Japan, *Industry and Environment*, (285), 31~34 (1996)
- 6) Electric Power Development Co.; The Dry Process Activated Carbon Method and Simultaneous Desulfurization and Denitrification, Environmental Technology to Protect the Earth, #94 of a 100 piece selection, pp.414~417 (1994)
- 7) Doi, Yoshitaka et al.; A Corroborative Evidence Test of Coal Generated Power Station Flue Gas Treatment by Electron Beam, *Ebara Engineering Review*, (166), 56~64 (1995)

(7.10) References

- 1) Kato, Seitaro; General Summary of Pollution Control Countermeasures (Atmosphere Edition) Japan Environmental Management Association for Industry
- 2) Mizushima, Kiyoshi; *Chemical Engineering* (7), 81 (1994)
- 3) Daikin Document, EDX-10b
- 4) Igumo, Masanori; *Pollution and Countermeasures*, 21, (12), 46 (1985)

(7.11) References

- 1) Environment Agency, Air Quality Bureau; Environmental Measures towards Automobiles in Japan, July 1996 (1996)
- 2) Japan Automobile Service Promotion Association.; Automobile Exhaust Gas Countermeasures, 1993 Edition (1993)

(7.12) Literature cited

- 1) Hirose, Yasuo; Combustion Emission Substances, *Industrial Heating*, 18, (3) 65~71 (1981)
- 2) Tsuji, Masaichi; A General Outline of Pollution Control Combustion Technology, Association of Japan Heat Energy Technology (1973)
- 3) Ando, Tamotsu; Current HC Control in Yokohama City, *Journal of Japan Society for Atmospheric Environment*, 13, 382~386 (1978)
- 4) Kashimura, Hiroaki and Suyama, Yoshiaki and Saiki, Yoshio and Yamamoto, Akio and Nagami, Yasuo; The Emission Volume of Hydrocarbon Species during Automobile Gasoline Refuelling, *Journal of Japan Society for Atmospheric Environment*, 18, 432~438, 1983

- 5) Environment Agency, Air Quality Bureau; Manual for Hydrocarbon Species Emission Control (1981)
- 6) Japan Chemical Industry Association, Emission Control Technology of Offensive Odors and Hydrocarbon Species (2) (1977)
- 7) Environment Agency, Internet Homepage (1997)

(7.13) Literature cited

- 1) Kawasaki, Shinichiro and Takishima, Mitsuru; Treatment by Activated Sludge Aerated Deodorisation in Sewerage Facilities, *Journal of Odor Research and Engineering*, 24, 141~145 (1993)
- 2) Ishiguro, Tatsuyoshi; The Basics and Implementation of Odor Countermeasures, Ohmsha Publishing Co, (1997)
- 3) Editorial Committee for the Encyclopedia of Environmental Pollution Control; Encyclopedia of Air Pollution Control, Industrial Research Center of Japan Inc (1996)
- 4) Offensive Odor Law Study Group; New Handbook of the Offensive Odor Control Law, Gyosei Corporation (1996)
- 5) Okada, Hisayuki; Research into the Treatment of Offensive Odor from Emission Gas including VOC by Adtech Thermal Storage-Type Deodorization Equipment, *Journal of Odor Research and Engineering*, 27, 189~191 (1996)
- 6) Yamada, Hideo; The Thermal Storage-type Combustion Deodorization Method, *Journal of Odor Research and Engineering*, 27, 192~199 (1996)
- 7) Osako, Masaharu and Higuchi, Takeshi and Tanaka, Masaru; Technical Appraisal of the Biological Deodorization Method based on Survey Research, (the 3rd), *Journal of Odor Research and Engineering*, 25, 310~313 (1996)
- 8) Morita, Yoichi; Emission Gas Treatment using Microscopic Organisms, General Research Center for Resource and Environmental Technology, the 10th Research Conference Document, 48~53 (1996)

(7.14) Literature cited

- 1) Yokohama City; Outline for the Construction of a Coastal Industrial Area in Negishi Harbor, Yokohama City (1965)
- 2) Yokohama City Port and Harbor Bureau Southern Coastal Area Development Department; Reclamation of Yokohama City, pp.40~101, Gihodo Shuppan Co. Ltd (1992)
- 3) Himi, Yasuji; Environmental Technology Transfer to Developing Countries, (1) *Journal of Life and the Environment*, 38, (6) 72~76 (1993)
- 4) Nippon Oil Co. Ltd, Nippon Petroleum Refining Co. Ltd History Editorial Department; A Thirty Year History of Nippon Petroleum Refining, Nippon Petroleum Refining Co. Ltd (1982)
- 5) International Center for Environmental Technology Transfer; Pollution in Yokkaichi City and Steps Towards its Environmental Improvement (1992)
- 6) Yoshida, Katsuki; Air Pollution in Yokkaichi City and Particulars, The 24th Air Pollution Conference Summary, pp.63~73 (1983)

7) Nippon Kokan 70 Year History Editorial Department; A 70 Year History of Nippon Kokan K.K.

(7.15) References

- 1) Nishijima, Yoichi; Engineering the Earth's Environment, Japan Productivity Center for Social Economic Development
- 2) Japan Society of Industrial Machinery Manufacturers; A Record of the Actual Sales of Environmental Protection Equipment