Issues in Factory Improvement and Production Efficiency in the Chemicals Industry

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Abstract: The purpose of this paper is to suggest factory improvement and production efficiency of Sumitomo Chemical Co., Toray Industries, Inc, and Teijin Ltd., representative firms of Japanese chemicals industry. We examined the financial statements and history of these companies, and interviewed managers in order to show changes over time by economic conditions and technological innovation such as petroleum-crisis and evolution of industrial structure.
Keywords :Chemicals industry, factory improvement, reengineering, comparison and analysis

1. Introduction

The purpose of this paper is to suggest restructuring of Sumitomo Chemical Co., Toray Industries, Inc, and Teijin Ltd., representative firms of Japanese chemicals industry. We examined the financial statements and history of these companies, and interviewed managers in order to show changes over time by economic conditions and technological innovation such as petroleum-crisis and evolution of industrial structure.

2. Reengineering

Reengineering is reorganization of work process internally to move effectively create its products or services by, changing workers responsibilities and tasks and altering relationships among them. In this paper, we surveyed the labour-serving by examples, which streamline the business process by integration of plants and by making use of outsourcing, alternate of product-mix and improvement in manufacturing process.

3.1 Sumitomo Chemical

3.1.1 Sumitomo Chemical Ehime Factory

The Ehime factory (Ehime Works) is the core factory of Sumitomo Chemical. We researched and interviewed the managers of the factory, which is in Niihama-city Sobiraki 5-1. Built in 1913, the Ehime Factory is the very cornerstone of Sumitomo Chemical's manufacturing operations. At this plant, sulfuric acid and calcium superphosphate were produced from sodium dioxide gas generated during the refining process of copper ores excavated from the Besshi Copper Mine. Starting off with the production of fertilizers, the plant expanded its operations into related basic industrial chemicals and in 1958 entered the petrochemical field by commissioning the first low density polyethylene plant in Japan. In recent years, Ehime Factory's core business is basic chemical production. For example, Sulfuric acid, Nitric acid/ Aniline, Acrylonitrile, Caustic soda, Methacrylic resins, Alumina, High purity alumina, Alumina fibre, High purity aluminum, Optical functional film, etc. In addition to providing a stable supply of high-quality products, it supports the company in opening up new business opportunities in such fields as petrochemicals and specialty chemicals.

3.1.2 Change in business portfolio of Sumitomo Chemical Ehime Factory

Sumitomo Chemical Ehime Factory's core business is basic chemicals productions. For example, Sulfuric acid, Nitric acid/ Aniline, Acrylonitrile, Caustic soda, Methacrylic resins, Alumina, High purity alumina, Alumina fibre, High purity aluminum, Optical functional film, etc. They are continuously changing their business

Table.1 Numbers of labore and fixed assets of Sumitomo ehime works

	labor	lot area	machine	fixed assets	area/labors	machine /labor	assets /labor
1970	6,438	2,546	35,194	48,492	0.40	5.47	7.5
1971	6,206	2,804	34,706	50,339	0.45	5.59	8.1
1972	5,847	2,804	34,968	50,234	0.48	5.98	8.6
1973	5,693	2,820	31,199	47,169	0.50	5.48	8.3
1974	5,870	3,316	32,494	49,402	0.56	5.54	8.4
1975	5,546	3,446	32,709	51,276	0.62	5.90	9.2
1976	4,662	3,493	30,657	49,219	0.75	6.58	10.6
1977	3,778	3,540	28,604	47,162	0.94	7.57	12.5
1978	3,244	3,234	27,756	45,325	1.00	8.56	14.0
1979	2,953	3,890	27,267	47,682	1.32	9.23	16.1
1980	2,798	3,854	28,154	49,684	1.38	10.06	17.8
1981	2,454	3,798	28,354	50,597	1.55	11.55	20.6
1982	2,109	3,742	28,554	51,509	1.77	13.54	24.4
1983	1,595	3,703	24,994	47,939	2.32	15.67	30.1
1984	1,570	4,025	25,522	56,558	2.56	16.26	36.0
1985	2,064	4,005	39,009	73,345	1.94	18.90	35.5
1986	1,998	3,928	37,253	70,928	1.97	18.65	35.5
1987	1,982	3,668	33,377	64,159	1.85	16.84	32.4
1988	1,947	3,679	32,989	64,648	1.89	16.94	33.2
1989	1,970	4,516	32,937	76,507	2.29	16.72	38.8
1990	1,923	4,541	33,547	80,581	2.36	17.45	41.9
1991	1,935	4,321	34,696	81,475	2.23	17.93	42.1
1992	1,948	4,369	37,853	86,970	2.24	19.43	44.6
1993	1,908	4,369	35,328	84,807	2.29	18.52	44.4
1994	1,638	4,367	35,832	85,845	2.67	21.88	52.4
1995	1,583	4,367	36,855	87,003	2.76	23.28	55.0
1996	1,520	4,925	32,922	82,753	3.24	21.66	54.4
1997	1,480	4,925	29,565	78,216	3.33	19.98	52.8
1998	1,460	4,923	30,825	78,580	3.37	21.11	53.8
1999	1,435	4,923	28,982	76,194	3.43	20.20	53.1
2000	1,415	5,068	27,018	79,962	3.58	19.09	56.5

portfolio by promoting diversification into new business. Figure 1 shows, how Sumitomo Chemical Ehime Factory has changed its business portfolio. Starting off with the production of fertilizers, the plant expanded its operations into related basic industrial chemicals and in 1958 entered the petrochemical field by commissioning the first low density polyethylene plant in Japan.

The facility was expanded with a focus on petrochemicals until 1983, when a decision was made to reorganize the Company's petrochemical operations by integrating them into the Chiba Factory near Tokyo and closing down relatively small-scale facilities such as the ethylene units.

Figure1 Changes in the business portfolio of Sumitomo Chemical Ehime Factory (Ehime Works)

1) Inorganic Chemicals business
   Withdrawal from Sodium triphosphate business (1976.8)
   Withdrawal from Phosphoric acid business (1978.6)
   Withdrawal from Carbon tetrachloride business (1981)
   Withdrawal from Ammonia business (1985.11)
2) Petro chemistry business
   Withdrawal from Ethylene business (1979)
   Withdrawal from Polyethylene business (1979)
   Withdrawal from Polyvinyl chloride (1981)
   Withdrawal from BTX-benzene toluene xylene (1983)
3) Aluminum refining business
   The aluminum operation is transferred to the newly formed Sumitomo Aluminium Smelting Co., Ltd. (1976)

3.1.3 Change in number of employees and organization

The number of employees in Sumitomo Chemical Ehime Factory (Ehime Works) in 1970 was 6,438 people.

They resolutely carried out reengineering; therefore the number of employees has decreased for 1,609 in 2008. After 1970, they changed the organizational structure six times at Ehime Factory. Currently, they have one office, 3 factories (Niihama, Owe, Kikumoto), and 13sub-divisions.

3.2 Toray Industries

The Ehime factory is the core factory of Toray. We researched and interviewed the managers of the Toray Ehime factory, which is in Ehime Prefecture Masaki-cho.

3.2.1 Change in business portfolio of Toray Ehime Factory

Table2 Numbers of labor and fixed assets of Toray Ehime factory

	labors	work area	machine propaty	fixed assets	area/labor	machine/labor	assets/labor
1970	2,370	515	5,757	8,156	0.22	2.43	3.4
1971	2,430	555	10,734	14,221	0.23	4.42	5.9
1972	2,416	558	10,638	14,061	0.23	4.40	5.8
1973	2,299	565	8,773	12,082	0.25	3.82	5.3
1974	2,307	565	8,562	11,854	0.24	3.71	5.1
1975	2,323	566	8,417	11,808	0.24	3.62	5.1
1976	1,981	566	7,712	11,011	0.29	3.89	5.6
1977	1,876	566	6,698	9,903	0.30	3.57	5.3
1978	1,505	561	6,124	9,210	0.37	4.07	6.1
1979	1,200	561	5,521	8,458	0.47	4.60	7.0
1980	1,131	560	5,989	8,972	0.50	5.30	7.9
1981	1,057	560	6,698	9,557	0.53	6.34	9.0
1982	1,086	845	8,133	15,057	0.78	7.49	13.9
1983	1,066	896	17,242	28,227	0.84	16.17	26.5
1984	923	893	16,958	27,011	0.97	18.37	29.3
1985	895	885	16,878	27,213	0.99	18.86	30.4
1986	864	877	19,713	30,523	1.02	22.82	35.3
1987	830	877	21,376	32,575	1.06	25.75	39.2
1988	758	877	17,813	28,743	1.16	23.50	37.9
1989	698	877	15,954	26,654	1.26	22.86	38.2
1990	698	877	13,789	24,187	1.26	19.76	34.7
1991	892	877	17,258	29,366	0.98	19.35	32.9
1992	942	876	18,541	31,114	0.93	19.68	33.0
1993	958	876	17,235	30,039	0.91	17.99	31.4
1994	948	875	16,945	29,706	0.92	17.87	31.3
1995	902	875	15,883	28,691	0.97	17.61	31.8
1996	852	875	13,327	28,034	1.03	15.64	32.9
1997	842	842	12,663	27,049	1.00	15.04	32.1
1998	863	873	19,652	38,959	1.01	22.77	45.1
1999	869	869	21,015	39,838	1.00	24.18	45.8
2000	840	866	18,529	38,256	1.03	22.06	45.5

Toray Ehime Factory's core business is fiber and textiles. Its corporate strategy is to place emphasis on core business, fibers and textiles. They are continuously changing their business portfolio by promoting diversification into new business. As Figure 2 shows, how Toray Ehime Factory has changed its business portfolio. In 1975, Toray completely withdrew from rayon business after 50 years of involvement. They began to promote new businesses. Toray Ehime Factory began to produce engineering plastics (PBT) in 1976, carbon fiber (Torayca) in 1973, and membranes (Toraypure and

Romembra) in 1985.

Figure 2 Changes in the business portfolio of Toray Ehime Factory

1) Fiber business
   Withdrawal from rayon business (1975)
2) Resin business
   Beginning to Engineering Plastics PBT (1976)
3) Carbon Fiber Business "Torayca"
   Beginning to Carbon Fiber "Torayca" (1973)
   Beginning to Prepreg Processing Equipment (1990)
4) Membranes business
   Beginning to Membranes "Toraypure" and "Romembra" (1985)
5) Interferon business "Feron"
   Beginning to Interferon "Feron"(1993)

3.2.2 Change in the number of labors

In 1970, Toray Ehime Factory employed 2,370 women laborers that were Junior high school graduates. Since the oil crisis, Toray has produced fiber raw material and plastics. The products of Toray Ehime factory changed gradually to synthetic fiber raw material and functional materials.

In the factory, capital investment in information technology and restructuring has continued. It has changed into a chemical factory where a lot of employees are men.

The capital equipment ratio per person increased rapidly. At the Ehime factory, the technological R&D section and the headquarters R&D section were separated. Moreover, the transfer of laborers was promoted. The number of laborers in 1990 was 700 people or less. Because the number of employees decreased, organization was simplified.

4. Teijin limited

The Teijin Matsuyama works is the core factory of Teijin. We researched and interviewed the managers of the Teijin Matsuyama Works, which is in Ehime Prefecture Matsuyama city Kita-Yoshida.

4.2.1 Change in business portfolio of Teijin Matsuyama Works

Table−3 Teijin Matsuyama Works number of labour and fixd assets

	labors	lot area	Machine property	Fixed assets	area/labors	machine/labor	fixedassets /labors
1970	4,374	857		24,559	0.20		5.6
1971	4,863	1,637		29,909	0.34		6.2
1972	4,673	1,638	19,685	27,966	0.35	4.21	6.0
1973	4,409	1,638	17,272	25,241	0.37	3.92	5.7
1974	4,595	1,659	17,758	26,281	0.36	3.86	5.7
1975	4,648	1,630	17,754	26,900	0.35	3.82	5.8
1976	4,671	1,862	25,001	36,413	0.40	5.35	7.8
1977	4,617	1,822	23,473	34,644	0.39	5.08	7.5
1978	4,220	1,821	22,103	32,985	0.43	5.24	7.8
1979	3,510	1,821	21,210	31,938	0.52	6.04	9.1
1980	2,799	1,830	20,318	30,891	0.65	7.26	11.0
1981	2,680	1,842	19,309	29,923	0.69	7.20	11.2
1982	2,676	1,842	16,914	30,499	0.69	6.32	11.4
1983	2,710	1,814	22,303	36,128	0.67	8.23	13.3
1984	2,710	1,814	22,389	35,967	0.67	8.26	13.3
1985	2,701	1,814	18,631	31,989	0.67	6.90	11.8
1986	2,549	1,805	17,704	30,650	0.71	6.95	12.0
1987	2,099	1,804	15,938	28,432	0.86	7.59	13.5
1988	1,834	1,793	14,274	26,561	0.98	7.78	14.5
1989	1,565	1,769	13,868	25,742	1.13	8.86	16.4
1990	1,491	1,732	15,578	27,410	1.16	10.45	18.4
1991	2,044	1,708	20,385	32,889	0.84	9.97	16.1
1992	2,047	1,708	24,064	38,280	0.83	11.76	18.7
1993	2,092	1,700	24,039	39,761	0.81	11.49	19.0
1994	2,201	1,700	29,430	46,750	0.77	13.37	21.2
1995	2,161	1,688	25,562	42,296	0.78	11.83	19.6
1996	2,106	1,682	22,477	38,631	0.80	10.67	18.3
1997	1,979	1,682	19,584	34,966	0.85	9.90	17.7
1998	1,842	1,679	19,537	34,611	0.91	10.61	18.8
1999	1,755	1,679	18,575	33,042	0.96	10.58	18.8
2000	1,646	1,675	19,710	33,659	1.02	11.97	20.4

TEIJIN LIMITED:"Financial Statements", Ministry of Finance Japan, (1970−2000).

TEIJIN Matsuyama Works' core business is synthetic fibers products and plastics and films products. For example, Polyester fibers (brand name is Tetoron®), Para-aramid fibers (brand name is Technora®), Polycarbonate resin (brand name is Pnlite® / Panlite®sheet),etc. Synthetic fibers products are manufactured by Teijin fibers that are Subsidiary company of TEIJIN.

Figure3 Changes in the business portfolio of Teijin Matsuyama Works

1) Synthetic Fibers business
   Beginning to Para-aramid fibers (brand name is Technora®)
2) Plastics and films business
   Withdrawal from Film resin business (There are moved to another factory)

Plastics and filmes products are manufactured by Teijin Chemicals that is Subsidiary company of TEIJIN. They are continuously changing their business portfolio by promoting diversification into new business.

As Figure 3 shows, how TEIJIN Matsuyama works has changed its business portfolio.

4.2.2 Change in the number of laborers

In 1970, Teijin Matsuyama works employed 4,374 laborers. The number of laborers in 2000 was 1,348

people or less. Because the number of employees decreased, organization was simplified.

In 1989, Teijin Matsuyama works abolished the part systems, advanced the organization integration.

5 Conclusions

5.1 Reengineering

Three companies responded to the changes over time in economic conditions, resulting from petroleum-crisis, evolution of industrial structure and economic globalization.

Three factories promoted reengineering, that is reorganization of work process internally to move effectively create its products or services by changing workers responsibilities and tasks and altering relationships among them.

5.2.1 Change in business portfolio of Factory level

(1)Change its products and Manufacturing process

A: Sumitomo Chemical Ehime Factory

Sumitomo Chemical Ehime factory withdraw from inorganic chemicals business (Sodium triphosphate business in 1976, Phosphoric acid business in 1978, Carbon tetrachloride business in 1981, Ammonia business in 1985) and Petro chemistry business (Ethylene business in 1979, Polyethylene business in 1979, Polyvinyl chloride in 1981 BTX-benzene toluene xylene in1983).

Ehime factory products the Polymethyl Methacrylate(PMMA) resin and the functionality materials, and it became a material production factory.

B: Toray Ehime Factory

Toray Ehime Factory withdrew from rayon business in 1975, and began to Engineering Plastics PBT in 1976, Carbon Fiber Business “Torayca” in 1973, Prepreg Processing Equipment in 1990, Membranes business “Toraypure” and “Romembra” in 1985, Interferon business “Feron” in 1993.

C: Teijin Matsuyama Works

Teijin Matsuyama Works withdrew from film resin business (There are moved to another factory), and began to Para-aramid fibers (brand name is Technora®)

(2)Manufacturing process

A: Sumitomo Chemical Ehime Factory

Considered to environmental problems, Sumitomo Chemical Ehime Factory changed its manufacturing method from Mercury method to diaphragm process and ion exchange membrane process.

B: Toray Ehime Factory

Toray Ehime Factory developed prepreg processing method corresponding to the demand for carbon fiber.

C: Teijin Matsuyama Works

Teijin Matsuyama Works developed new production method of Tetoron.

5.2.2 Change in the number of laborers of Factory level

(1) An increase in employee numbers of factory or works

A: Sumitomo Chemical Ehime Factory

As a result of IT investment, the shop floor was automated. The number of employees of the manufacturing divisions of Sumitomo Chemical Ehime Factory decreased from 6,438 to 1,421 people.

B: Toray Ehime Factory

The capital equipment ratio per person increased rapidly. At the Ehime factory, the technological R&D section and the headquarters R&D section were separated. Moreover, the transfer of laborers was promoted. The number of laborers in 1990 was 700 people or less. Because the number of employees decreased, organization was simplified.

C: Teijin Matsuyama Works

In 1970, Teijin Matsuyama works employed 4,374 laborers. The number of laborers in 2000 was 1,348 people or less. Because the number of employees decreased, organization was simplified. In 1989, Teijin Matsuyama works abolished the part systems, advanced the organization integration.

In this paper, we suggest Restructuring and Reengineering for Sumitomo Chemical, Toray Industries and Teijin Co.ltd, especially enterprise level entry into new business and withdrawal from ailing business, reduction in number of employees, and reengineering at shop floor level.

Three companies changed its business portfolio because of the oil crises in 1973 and 1979. In three companies, many employees were transferred to dependent businesses and related companies from the headquarters. Each company promoted restructuring after the oil crisis. They decreased hiring of new employees, and have increased the rate of relocation. Three Factories has also changed its business portfolio. Since 1970, three factories had acted on restructuring and reengineering, each time with a drastic reduction in the labor force. The labor force of the product section is about 1/4, what it was in 1970. Gradually, the factory became uninhabited

because of automation. The factory labor force is making it to a high academic background. We can point out that higher employee education levels and production system are related.

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化学産業工場における工場改善と生産現場の変化

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要約：本稿は、企業内部の効率化を求めて実施された工場改善とこれに伴う生産現場の変化について、住友化学株式会社、東レ株式会社、帝人株式会社の愛媛工場について、有価証券報告書のデータと各種資料、ヒアリング調査から得た情報を基に、「清品・製造プロセスの改善」「組織統合」「省力化」について検証したい。
キーワード：化学産業、工場改善、リエンジニアリング、比較分析