Absorption and Diffusion of Imported Technology in the Machinery Industry in Korea

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I. INTRODUCTION

A case study on the absorption and diffusion of imported technology in Korea focusing on the machinery sector is presented here. Chosen because of its important role in enhancing industrial independence through increased domestic production of capital goods, the machinery sector in Korea has exhibited a considerably rapid rate of absorption of foreign techniques at their operation stage. Nevertheless, as for designing capabilities, they have still long way to go. The industry has, less surprisingly, achieved only a modest rate of diffusion of its specialized knowledge even to its inputs suppliers. As will be seen, the chief reasons for the relatively rapid absorption arise within Korea itself, out of the inclination of the people, their educational system, and their

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form of government; wheras the chief reasons for the diffusion, even though slow, originate from the character of the machinery sector or the need for cooperation and coordination between big corporations and smaller machine shops.

In outline, the approach has been to study one company in depth and as many others as time and resources permitted superficially. The first description will briefly deal with the sources of information. After this, there will be a short section on the historiccal developments of company chosen. This same company will provide the data for the next three sections describing the technology that was imported, its absorption, and the improvements that were subsequently made upon it. Following this lengthy sections will be a shorter one describing the diffusion of the imported technology, and than another shorter one analysing the impact of the degree of sophisticatedness of a technology upon the absorption and diffusion by means of comparing the rather sophisticated technology with a simpler example which really existed in Korea in the same analysis period. Finally, there will be a conclusion in which the results are gathered together and their implications for public policy derived.

II. SOURCES OF INFORMATION

Our approach has been to study one company in depth and as many others as time and resources permitted superficially. The company chosen for detailed study was Daewoo Heavy Industries Ltd., a privately-owned company in which 45% of the shares are owned by the Daewoo Industrial company, 7.6% by the Korea Development Bank, and remaining shares by a numerous body of Korean citizens. Daewoo Heavy Industries Ltd. (DHI) produces a large range of machinery items. Diesel engines, rolling stocks, fork lift trucks, excavators, machine tools, and a large variety of industrial machinery items are put out by DHI.

The information from DHI was supplemented by data gathered from other firms, both Korean and international; and from the general knowledge of the author. The sources of most of the information on DHI was the company's employees and their documentations; whenever other sources were drawn upon they will be cited: the source of information on the other companies will also be cited where it seems necessary.

III. HISTORICAL DEVELOPMENT OF DAEWOO HEAVY INDUSTRIES LTD.

The firm concerned in this study was founded in 1937 during the Japanese occupation as the Chosun Machine Works. During that era it produced industrial machines, mining equipment, and occasionally, weapons such as artillery and small sized submarines.

After Japan's retreat in 1945, the firm was nationalized by the government and, as a government workshop, resumed production of industrial machines. However, in 1963, to meet the demands for machines following the commencement of the nation's economic development plans, the government established the company as a corporation under the name of Hankook Machine Industrial Co., Ltd. and then in 1968, transferred its shares and management to private hands.

Since then, the company has extended business areas and diversified its main products step by step. In 1973 the company merged with the Bugok Rolling Stocks Plant and added to its products railroad cars and coaches. In 1975, the company established the Diesel Engine Plant and began to produce M.A.N. engines in technical collaboration with the Maschinefabrik Augusburg-Nuernberg Aktiengesellschaft and financial assistance from the German Government.

In 1976 the company also merged with the Daewoo Machinery Company. Through successive mergers and investments, the compamy has enlarged to include four main plants:

the Industrial Machine Plant

the Diesel Engine Plant
the Rolling Stocks Plant
and the Precision Machine Plant.

In managerial developments, the year 1975 was an epoch for the company. Despite its leading role in Korean industry the company had been in chronic deficit until 1975, mainly due to the lack of domestic demand and to unstable management. However, in 1976, the Daewoo Industrial Company, Ltd. together with its affiliates, took over 44.8% of the total shares of the company and participated in management. The Daewoo Industrial Company is one of the largest trading companies in the world with annual international sales of about U.S $ 1 billion currently, and is rated as the most promising one for its excellent managerial ability.

In managerial and financial collaboration with the Daewoo members and their worldwide branches for sales promotion and financial facilities, the company, renamed as Daewoo Heavy Industries Ltd. in October, 1976, planned a large investment in the Industrial Machine Plant and launched an ambitious project in heavy industries, including engineering services and plant sales on a turn-key basis.

IV. GOVERNMENTAL POLICY DIRECTIONS

The Korean economy had achieved a remarkable growth averaging an annual rate of 9.1 percent during the First and Second Five-Year Economic Development Plans (1962~1971). Despite the rapid growth and structural improvements achieved over the relatively short span of time, the Korean economy was suffering from problems inherited and brewed in the process of fast development. Disparities among industries and regions, insufficient domestic savings and heavy dependency of development financing on foreign savings, chronic inflation, less-advanced industrial structure, and backward technologies in wide segments of the industry these were the problems that had to be rectified.

Some of the most important policy measures adopted to remedy the situation were:

(1) the promotion of the Saemaeul (New Community) Movement to promote rural development through the spirit of diligence, self-help, and cooperation among farmers and fishermen,

(2) the Presidential Decree of August 3rd. 1972, to improve the financial structure of business enterprises by shifting business debt away from curb market with more favorable bank lending terms, and

(3) the Presidential Declaration of Heavy and Chemical Industrialization Policy in January 12, 1973.

The third policy measure, above all, carries most significant bearing on the technological enhancement of Korean machine industry.

Considering that less-advanced industrial structure and resulting heavy imports of capital goods as well as industrial raw materials have not only caused serious balance of payment problems but also made the economy more dependent on foreign savings, the basic policy direction was to focus on the enhancement of industrial independence through increased domestic production of industrial raw materials and capital goods. With a view to enhancing self-sufficiency in industrial raw materials, the steel industry, petrochemical industry, and non-ferrous matal industry have been selected for intensive development under the heavy and chemical industry development plan. On the other hand, the government also selected machine industry, ship-building industry, and electronics industry as major leading types of industry to be emphasized under its heavy and chemical industry development plan.

V. MAJOR POLICY MEASURES

(1) Guidelines of Foreign Capital Inducement

In Korea, major sources of equipment funds of business enterprises are self-finance and external finance. However, during 1960's with capital accumulation and the scale of industries at a relatively low level, the ability on the part of business enterprises to raise needed funds through self-finance was rather insignificant. Hence, as a matter of fact, business enterprises could not but finance most of their equipment funds from foreign loans rather than public issues of stock and debentures.

Under these circumstances, Korean Government, being aware of the far-reaching impact of foreign investments on national economy, established the following guidelines for foreign capital inducement.

First, in order to assure sound financial structuers, entrepreneurs undertaking heavy and chemical projects (including machinery projects) were requested to secure their own capital for more than 30 percent of the total investment. This was to be facilitated by improvement of development financing system, fostering the capital market and stronger savings promotion campaigns. Foreign capital was to be limited, in principle, to no more than 60 percent of the total investment. Foreign loans and investments were going to be utilized when required for acquisition of capital goods and advanced technology which were not locally available.

Second, although priority was to be given to loans on favorable terms, direct foreign investments were also to be authorized. Such investments were to be encouraged especially when they would help secure dependable sources of raw materials, expand markets of products, or induce advanced technology. In this case, however, the foreign share was expected, in principle, not to exceed 50 percent.

Third, only up-to-date technology and brandnew technology was to be approved for inducement.

Fourth, projects funded by foreign loans should be internationally competitive in scale and prices of their products must be in the neighbourhood of international price level.

Fifth, end-users of projects foreign loans would be selected in a competitive manner.

(2) Financial Support

As demands for equipment funds were expected to grow faster than ever to meet the construction plans of heavy and chemical industries, the National Investment Fund was established in this context.

The purpose and character of the National Investment Fund could be summarized as follows: First, the Fund was to provide capital needed beyond the equity and foreign loan investment to construct the planned heavy and chemical industries so that there might be no financial problems during the construction period. A part of the permanent working capital requirements were also to be financed by the Fund.

Second, since long term funds at low interest are necessary for the construction of heavy and chemical industries, the plan was for the Fund to supply low interest loans by means of establishing a combined sources of fund from private savings induced at market interest rates and capital subscribed by the government at no interest rate.

Third, the maturity period of loans from the Fund was supposed to be longer than 5 years with flexibility depending each circumstance.

(3) Tax Incentives

In order to effectively support the development of the heavy and chemical industries, tax privileges under Foreign Capital Inducement Act and other various tax laws were prepared and presented by the government.

Income and corporation taxes on foreign invested enterprises were exempted or reduced in proportion to the percentage of stocks or shares which foreign investors participated in the enterprise. In the event of a capital increase, both income and corporation taxes were also exempted or reduced in proportion to the foreign-owned increase in capital. Foreign invested enterprises were exempted from these taxes for five years from the initial reckoning date prescribed in the Income Tax Law and the Corporation Tax Law respectively and for the ensuing three years tax reductions of 50 percent were to be allowed.

Table 1. Taxes Subject to Reductions and Exemptions

Tax	Taxation Basis	Tax Rates	Tax Reduction or Exemption
Income Tax on Unincorporated Enterprises	Amount of income or earnings	8%~70%	Exemption for 5 years, 50% reduction for following 3 years, on foreign owned ratio.
Corporation Tax	1) Income in each business year 2) Income in liquidation	1) Open Corporation 20%~27% 2) Closed Corporation 20%~40%	Exemption for 5 years, 50% reduction for following 3 years, on foreign owned ratio.
Wages and Salary Income Tax	Foreign employees working in foreign invested enterprise, or under technology inducement contract	8%~70%	Exemption for 5 years.
Dividend Income Tax	Amount of Dividends Received	25%	Exemption for 5 years, 50% reduction for following 3 years.
Tax on Technology Income	Income from supplying technology (royalty)	25%	Exemption for 5 years, 50% reduction for following 3 years.
Interest Income	Gross receipt or derived from interest on loans or deposits	25%	Exemption for approved foreign loans.
Commodity Tax	1) Shipment price 2) Declared import price	2%~200% 73 commodity items	Exemption for approved capital goods
Customs Duty	Ad valorem basis (C.I.F. price)	5%~150%	Exemption for approved capital goods
Property Tax	Assessed value of land, vessels, mining district, etc.	1) Land: 0.3%~5% 2) House & Vessels: 0.3%~5% 3) Mine lot: ₩30per/ha	Exemption for 5 years, 50% reduction for following 3 years, on foreign owned ratio.
Property Acquisition Tax	Acquisition price	1) 1% 2) 2% in Seoul & Busan	Exemption for 5 years, 50% reduction for following 3 years, on foreign owned ratio.

Foreign invested enterprises were also exempted from acquisition taxes from the date of registration, and from property taxes from the initial reckoning date prescribed in the respective tax laws. Even before the registration of a foreign invested enterprise, it might be exempted from acquisition and property taxes on the property acquired for the original business purpose of the enterprise. Besides, other various taxes were subject to reductions or exemptions as shown in the following table.

(4) **Facilities Support**

1) Construction of Industrial Base

Industrial sites were selected and constructed under the governmental initiative. In order to support construction of the selected industrial sites, the Industrial Site Development Promotion Law was enacted in 1973, while the Korea Water Resource Development Corporation which was established in 1967 was reformed to the Industrial Site.

The Gumi Electrinics Industry Complex, Changwon Machine Industry Base, Yeocheon Chemical Industry Base, and many others were constructed by Industrial Sites Development Corporation and/or Water Resource Development Corporation both of which are governmental organizations established for effective construction of industrial sites.

Table 2. Construction of Infrastructure*

Industrial Base	Harbor	Water	Road
Pohang	14 Berths for 2,000~80,000 DWT Vessels	220,000 MT/D	38.9km
Koje	Breakwater 1,385m	16,000 MT/D	46.3km
Changwon	8 Berths for 20,000 DWT Vessels	200,000 MT/D	76.8km
Gumi	—	50,000 MT/D	11km
Yeochon	12 Berths for 3,000~50,000 DWT Vessels	250,000 MT/D Pipeline 60km	63km
Onsan	Breakwater 3,500m	240,000 MT/D	32km

* Source: Ministry of Construction

2) Construction of Infrastructure

One of the most important supporting measures provided by the government to promote the heavy and chemical industries was the construction of infrastructure such as harbor facilities, water supply systems, roads, and so on. Construction of these facilities was planned so as to meet the requiremments for major projects located in the industrial bases. Infrastructure constructions for major industrial bases are shown in the previous table.

VI. IMPORTATION OF DIESEL ENGINE TECHNOLOGY BY DHI

Being encouraged by governmental guidance and supporting measures as described in previous chapters, the Daewoo Heavy Industries (then called Hankook Machine Industrial Company, Ltd.) tried to make investigations starting mid 1969 into the German diesel engine manufacturing industry with the aim of manufacturing water-cooled diesel engines in the power range from 50 to 200 HP under license. The investigations carried out in this matter until July 1970 and the negotiations entered into showed that engine types produced by M.A.N. and Daimler Benz AG coincide most of all with the conceptions of the company.

On the 31 August 1970, as the result of further negotiations, a license agreement was concluded between the companies

Maschinenfabrik Augusburg-Nuernberg AG (M.A.N.)
Augusburg, Federal Republic of Germany
as the licensor

and Hankook Machine Industrial Co., Ltd. (Hanki)
Inchon, Korea
as the licensee.

The subject matter of the agreement concerns the diesel engines built by M.A.N.

—type D 0844 M, power 50 to 90 HP, DIN
—type D 0846 HM, power 130 to 160 HP, DIN

plus all modifications and improvements to the engines (effected by M.A.N.) effected during the period covered by the agreement.

The agreement was concluded between M.A.N. and Hanki as a result of the speedier negotiations and the more favorable financial conditions which became apparent during the preliminary negotiations.

Scope of the license:

The license authorizes Hanki

—to manufacture the said engines

—to draw relevant engine parts from third parties

— to market the engines in Asia, with the exception of India and Turkey

—to manufacture and market single parts as spare parts for the said engines.

The services of the licensor cover accurately specified information and documentation relating to the objects of the agreement. In addition, a skeleton agreement was drawn up relating to the residence of specialists employed by the licensee in the country of the licensor and vice-versa.

The licensor also assures the licensee the use of his own industrial rights and declares his willingness to make available foreign rights used by himself to the licensee under the most favourable conditions which can be obtained.

Royalties:

The fees agreed upon in the contract are subdivided into

—a single basic fee of DM 500,000.

—a current piece royalty, calculated by multiplying the following fee rates and the home production share of Hanki.

The basic fee of DM 500,000.—is to be payed in three installments:

—first installment within 2 months of authorization by the Korean government, at the latest 3 months after the granting of a credit by the Kreditanstalt für Wiederaufbau, Frankfurt/Main for the acquisition of equipment to manufacture the objects of the agreement DM 200,000.—

—second installment within two years of signing the license agreement DM 200,000.—

—third installment within three years of signing the license agreement DM 100,000.—

The fees for the current piece royalties are as follows:

—for the first 15,000 liter, cylinder capacity, in one year of contract
DM 22.50 per liter

—for the next 150,000 liter, cylinder capacity, in the same year of contract
DM 18.75 per liter

—the third 15,000 liter, cylinder capacity, in the same year of contract
DM 15. per liter

—for the fourth 15,000 liter, cylinder capacity, in the same year of contract
DM 11.25 per liter

—for all further engines in the same year of contract
DM 7.50 per liter.

These fees are increased if the engines are exported from the manufacturing area which covers Asia with the exception of India and Turkey.

A license fee of 5% of the respective M.A.N. CKD list price has been agreed upon for the spare parts manufactured by Hanki.

In the event that M.A.N. supplies Hanki with more than 50% (in terms of value) of the parts for the engines to be manufactured under license and providing that at least 1,500 pieces are supplied per annum, Hanki need then pay only 50% of the minimum royalties.

Duration of the license agreement

The agreement is due to run for five years after the commencement of production. It may be renewed for a further five years. In this eventuality the royalties for the period of renewal are to be negotiated anew. After ten years of prodnction no royalties are levied.

Contract concerning the employment at M.A.N. of Korean skilled workers

On 28 October, 1970, a skeleton contract was concluded between Hanki and M.A.N. providing for the employment of a total of 500 Korean skilled workers by M.A.N. at the engine and truck manufacturing plant.

According to the terms of this contract the first Koreans, numbering 20 at the beginning, should be starting work at M.A.N. on January 1, 1971. This number should be increased by approximately 70 men during the early part of the year. Further increases in the number of Korean workers depends on the amount of experience gained in the first six months.

Functions plan

The functions plan shows in schematic form the ideal production cyle, taking into account the optimum coordination of preproduction, production and storage ranges plus the associated subsidiary functions. The functions plan (technologically conditioned material flow) was worked out during the first planning section, and, on the occasion of the talks in Inchon accepted by the company.

The functions plan is shown in fig. 1. A rough division of the production ranges is shown along the top edge of the functions plan. This division shows the main ranges, these being receiving store, installations for preliminary operations, intermediate store, (machines) production, assembly lines, finishing shop, completed products.

The material flow is indicated by arrows. The factory ranges through which materials pass are named in correct sequence from left to right in the headings along the first line of the fuctions plan.

Material flow

The schematic illustration of the material flow supplies information on the volume of material transported between the individual processing or manufacturing zones.

From the store for bought parts and standard parts the material travels directly to the corresponding preliminary or final assembly point. The raw materials required for casting are taken from the raw materials store to the foundry, via the foundry cleaning room to the casting store.

At this point the material flow diverges: the individual ranges of the mech-

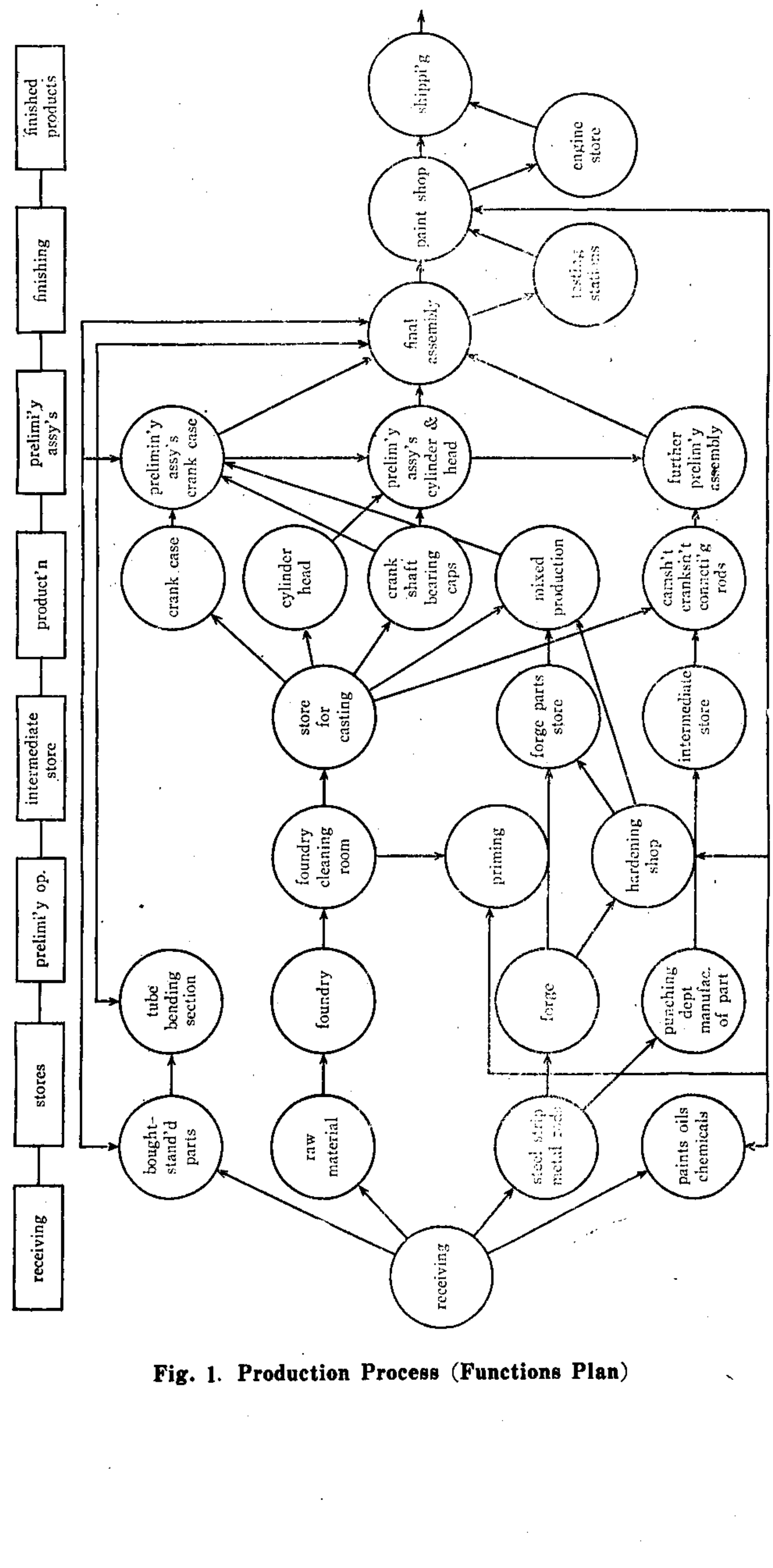


Fig. 1. Production Process (Functions Plan)

anical plant are supplied with the complete castings. These ranges are:

—crank case manufacture

—cylinder head manufacture

—crank shaft bearing cap manufacture

—a prescribed part of the 'mixed' production unit

Subsequently these branches of the material flow lead to the preliminary or final assembly. Starting at the sheet steel, strip material and rod material store, those materials which must be forged pass through the forge and hardening shop, are primed and finished up in the 'forged' parts store. They are processed further during the mechanical production procedure; here special reference must be made to these parts, flywheel, crank shaft, cam shaft, rocker arm and connecting rods. Further small parts are dealt with in the 'mixed' manufacturing section.

After the mechanical processing of these parts has been completed they pass the preliminary assembly to the final assemby. In the following line of material flow chart the use of paint, oils and chemicals in the production procedure is indicated. These materials are used in various production ranges.

Forge

The forge was built in the second expansion stage (1976). The most important forge-produced parts of a water-cooled diesel engine are;

—crank shaft

—counter weights

—rocker gear

—rocker gear bracket

—gears

—gear rings

—connecting rod

—cam shaft

—valves

In order to produce forge blanks for the parts listed the following operations are necessary:

In the hammer mill:

cutting, hand forging, pressing, upsetting.

The following machines are used:

cold circular saw, high speed swaging hammers, upsetting machines.

Operations in the drop forge:

initial heating of the rough forgings, initial upsetting of the rough forgings drop forging

For these operations the following machines are normally required:

preheating equipment (gas heated or induction heated)

friction screw presses

die-stamping presses

Operations in the straightening section:

upsetting

pressing

calibrating

grainding and polishing

surface treatment

aligning

For these operations the following machines are used:

friction screw press

eccentric press

sizing press

grinding and polishing machines

cleaning drums and sad blasting equipment

aligning machines or workbenches with devices for aligning by hand

Operations in the reannealing plant:

reanealing

treating of surfaces

The following equipment is used:

isothermal annealing plant

blasting equipment

bonding equipment

Most of the forge-produced parts used in the diesel engine are drop-forged. For this reason the first planning considerations only envisaged the construction of a drop forge with annealing plant.

After working the material in the forge the rough forgings are taken directly to the store for unworked parts situated before the mechnical production sector.

Mechanical production

In the mechanical production section the workpieces are manufactured on highly-automated individual machines such as rotating tables or other cyclic machines which are linked together. The following workpieces are dealt with in the mechanical production section:

—crank case

—cylinder head

—crank shaft bearing caps

—crank shaft

—cam shaft

—connecting rod

—rocker gear bracket

—rocker gear

—flywheel

Crank shaft line: Equipments were provided in the crank shaft line for the following operations:

—cutting to length

—centering

—turning

—circular threads

—drilling

—induction hardening

—balancing

—washing

Cam shaft production: Equipments are provided in the cam shaft line to carry out the following operations:

—centering and aligning

—turning

—drilling

—cam shaping

—induction hardening and unstressing

—grinding with circular grinding machine

—grinding with cam grinding machine

—checking and testing

—washing

Manufacture of counter weights for the crank shaft: Equipments were provided to carry out the following operations;

—milling

—drilling

—trimming

—weighing

Manufacture of connecting rods:

The following equipment were provided for the manufacture of the connecting rods;

—rotating table machines for milling and grinding the lateral surfaces and for machining two other supporting poinds of the connecting rod.

Manufacture of flywheel and gear ring:

In the case of the manufacture of the flywheel and the gear ring equipment is required for the following operations;

—turning

—tracer turning

—drilling

—milling or shaping of the teeth of the gear ring

VII. ABSORPTION OF THE TECHNOLOGY WITHIN THE COMPANY

The initiation of production took place in May 1975, even though the production depth then was rather shallow. However, in the second stage of expansion about DM 30 millions were spent for crank shaft, cam shaft, and connecting rod production lines the completion of which took place in March 1976.

Even though the nominal production volume of the engine plant was designed at 24,000 pieces per year, actual figures for production since its operation in 1975 are as follows:

Table 3. Production and sales Figures (unit; pieces)

	1975	1976	1977	1978
production	1,120	2,578	9,385	15,206
sales	285	3,119	9,313	15,041

In 1975 there were three major automobile manufacturers in Korea. However, they were very much reluctant to use the diesel engines Hanki produced. There were several reasons for their reluctance. First, they had no confidence in the quality of domestic engines. They were already having problems with the quality of many other automobile parts which were supplied them domestically.

Second, there was either insufficient or even negative price incentives to use domestic engines. This phenomenon, which was easily observable not only in automobile engines but also in most of other machineries or their parts productions areas, ensued from following reasons.

—Because of restricted market size, what is called the economy of scale in production was far from being achieved.

—Most of know-how parts and raw materials were imported from abroad at expensive cost. This was because the order quantity was not large enough (also due to smaller market size) to be negotiable for cheaper price, while most buyers were in positions of captivity nature.

—Most of machineries and facilities were bought on foreign or domestic loans, and hence, prices of their products bore the burden of interest portion.

—Costs incurred from inexperiences and lack of management know how were transferred to the price of their products.

For these reasons, domestic machinery products could not be cheaper than imported ones.

Third, there were technical problems that should be overcome for the engines to be mounted on automobiles. Engines are not final products by themselves. An engine is a subsystem of a bigger system. Hence, there always exists a certain degree of interrelationship between the subsystem and its total system. Therefore, for an engine to be mounted on a vehicle some technical problems to integrate the two into a functioning total system should be solved unless the two were designed initially as a system. However, since Korean automobile manufacturers were already producing trucks and buses with imported foreign engines by 1975, it was technically not immediately possible for the Hanki engines to be mounted on the vehicles which were being produced then. Considering that the licensing agreement did not contain any clause or mention anything about this adaptation problem, it was apparently a planning mistake for the Hanki to have overlooked this kind of important technical areas.

In short, due to confidence gaps, negative price incentives and technical difficulties, the engines Hanki produced in 1975 could not find their way in the market, and the company began to face insurmountable financial troubles and eventually fell into the state of what was called 'financial control' by the Korea Development Bank who was the company's major creditor.

Seeing situations evolving this way, the Korean Government began to seek for a private company which might be competent enough to overcome the managerial and technical predicament.

It was against these backgrounds that Daewoo Industrial Company was chosen and persuaded by the Korean Government to take over the Hanki in February 1976.

Having bought controlling portion of Hanki's equity, Daewoo Industrial Company changed Hanki's name into Daewoo Heavy Industries Company and began to delve into the problem areas in which the company was situated.

The first of the major steps Daewoo took was to ask the Korean Government to impose a ban against the importation of diesel engines from foreign countries.

On the request from Daewoo, Korean Government accepted the proposal as plausible on the condition that the price of diesel engines which Daewoo produced would come under the the control of the Government.

On the other hand, Daewoo launched a project to work out the mounting problem. First, Daewoo's project team worked in close contact with the KIST (Korea Institute of Science and Technology), a research institute established by the Korean Government to help business industries solve technical problems. Further, as for crucially important technical areas which called for deeper know-how, Daewoo asked M.A.N. for assistance. In the beginning, M.A.N. was reluctant to give extra assistance which was not included in the licensing agreement. However, at Daewoo's repeated sincere request and after having learned about the serious market barrier due to this mounting problem, M.A.N. began to help Daewoo by giving technical informations thereon.

Thus, after a year's hard work and endeavor, Daewoo resolved most of the problem areas to mount their engines on buses, trucks, and other heavy-duty vehicles which were being manufactured in Korea.

On the other hand, our analysis has found that the employment contract which was concluded back in 1970 between Hanki and M.A.N. providing for the employment of a total of 500 Korean skilled workers by M.A.N. at the engine and truck manufacturing plant in Germany played an important role in the absorption of the operating stage of the imported manufacturing technology for diesel engines.

According to the contract 350 technical manpowers from Hanki were sent to Germany as shown in the following table.

Table 4. Techincal Manpowers Empolyed in Germany

Group by time of departure	Number departed (persons)	Period stayed in Germany	Number returned home
Jan. 1971	20	2 years	16
Jul. 1971	70	2 years	51
Feb. 1972	100	2 years*	73
Jul. 1972	160	2 years	108
Total	350		248

* Some of them extended their stay up to 3 years.

On expiration of their employment contract, they returned to Korea to resume their work at Hanki.* With their experiences and practical training obtained in Germany, they played a decisive role during the operating stage of the newly imported production facilities. The analysis has concluded that this kind of employment contract is different in nature from a training program in that:

a. the size of people involved was on a larger scale than usual for a training program,

b. the period during which they stayed with the supplier firm of technology was much longer than that of a training program, here in Hanki Case more than two years,

c. and while they were with the technology-supplying firm, they got paid and treated as employees for the contracted term, etc.

This kind of employment contract program will be only possible when the technology-supplier can afford to and is willing to accept such a large number of people as their employees for a certain period of time, usually for a couple of years at least. In the Case of Hanki and M.A.N. this was possible since towards 1972 there was a shortage of skilled manpowers in Germany.

* Some of them never returned to Korea as may be noticed from the Table. Some immigrated to Germany by marriage, etc., and some went to other countries such as the United States of America, etc.

In addition to the employment contract for the skilled manpower, Hanki availed themselves of engineers training program as prescribed in the licensing agreement. More than 30 engineers were sent to M.A.N. in Germany to obtain technical training relevant to the manufacturing of diesel engines in their capacity as engineers.*

Thus, owing to those skilled manpowers and engineers employed and/or trained by M.A.N. in Germany, by the end of, say, the first year of operation of the newly erected plant in Inchon, by which time only one expatriate engineer remained, the Korean engineers and manufacturing manpowers could be said to have absorbed those portions of the imported technology relating to the start-up, operation and maintenance of the diesel engine manufacturing processes, and to have made some small progress in absorbing the knowledge required for the prior stages of equipment design and procurement and plant construction.** Basic process design had not been encountered; nor, of course, had research and development. Finally, the ability to carry out improvements was being acquired.

The evidence for the rapid absorption of the operation stage of the imported technology is very strong. It comes (i) from the production records of the Inchon Plant or the steady approach of the rate of output to the design capacity of the plant, and (ii) from the ever-decreasing rate of defective items per 100 as shown in Table 5

In the course of the case analysis a conclusion should be drawn that the absorption, diffusion, and accumulation of imported technology. Without the continuity of demand for the products, the continuity of men engaged in the technical activities for the production, or in the further technical development for the process or the products will not be possible in general. Further, when

* Some of the engineers wanted to be placed in R&D department to learn about the design technique on new model of engines. However, they were discouraged.

** The evidence for the absorption of the knowledge required for the prior stages of equipment design, procurement and plant construction was shown during the construction period of the second engine plant in Inchon with a Japanese licensing.

Table 5. Steady Approach of the Rate of Output and Decreasing Rate of Defective Units (%)

	1975	1976	1977	1978
Design* Capacity	24,000	24,000	24,000	24,000
Actual** Production	1,120	2,578	9,385	15,206
Defective Percentage	30.78	27.15	20.45	15.42

the continuity of men engaged in the technical activities is broken, the continual accumulation of the technical knowledge in the related area will seriously be hampered.

Daewoo has pronouncedly experienced this phenomenon with respect to their diesel engine project. During the earlier stage of the diesel engine production there was not enough demand in the market for the engines. Hence, personnel who were employed in the diesel engine project were transferred to other projects. The company could not afford to keep the personnel in the project where they were losing money due to lack of market demand for the product. In most developing countries even the largest companies are usually not sound enough financially to support highly-paid technical personnel in a project which is in the red.

Hence, the analysis could put it in this way that in the Daewoo-M.A.N. case the absorption of imported technologies was rather rapid at the earlier operation stage, but the absorption was unstable because of instability in positions of engineers and technical manpowers due to lack of market demand for the products of the technology.

Most people the author contacted and discussed with in regard to the analysis agreed that the rapid growth of, or rather creation of,*** market demand for the

* Design capacity was calculated by German engineers on one shift basis. However, many Korean engineers argued that it should be lower than calculated considering the quality of raw materials and parts supplied by local sources.

** Extremly low level of production during 1975 and 1976 was partially due to demand restrictions. Here the actual production figures include only non-defective units after the final inspection.

*** The creation of demand was made possible by solving the mounting problem and imposition of import ban on diesel engines as discussed afore.

diesel engines was most responsible for the success story of the imported plant.

As a matter of fact, at the outset of the project a feasibility study was commissioned by Hanki with a view to obtaining a basis for decision and planning for the project. The feasibility study was carried out by Aktiengesellschaft für Entwicklungsplanung Essen of West Germany in 1970. The feasibility study was to clarify the following points:

—sales prospects of the diesel engine plant

—suitability of the envisaged site

—technical planning up to principal lay-out plan

—profitabiltty of the plant

The study produced the following prospective sale figures for Hanki:

Table 6. Sales Figures Projected by the Feasibility Study

Year	Truck Engines	Bus Engines	Total
1970	9, 000	3, 000	12, 000
1971	10, 000	3, 600	13, 600
1972	10, 000	3, 400	14, 300
1973	11, 000	3, 700	14, 700
1974	11, 500	4, 300	15, 800
1975	13, 000	4, 900	17, 900
1976	15, 500	5, 650	21, 150
1977	18, 500	6, 375	24, 875
1978	21, 000	7, 300	28, 300
1979	22, 500	8, 300	30, 800
1980	24, 000	9, 100	33, 100
1981	25, 000	10, 250	35, 250

The siting inquiry confirmed that the envisaged site in terms of

—location with regard to markets and sources of supply

—local manpower situation

—regional and national transport networks

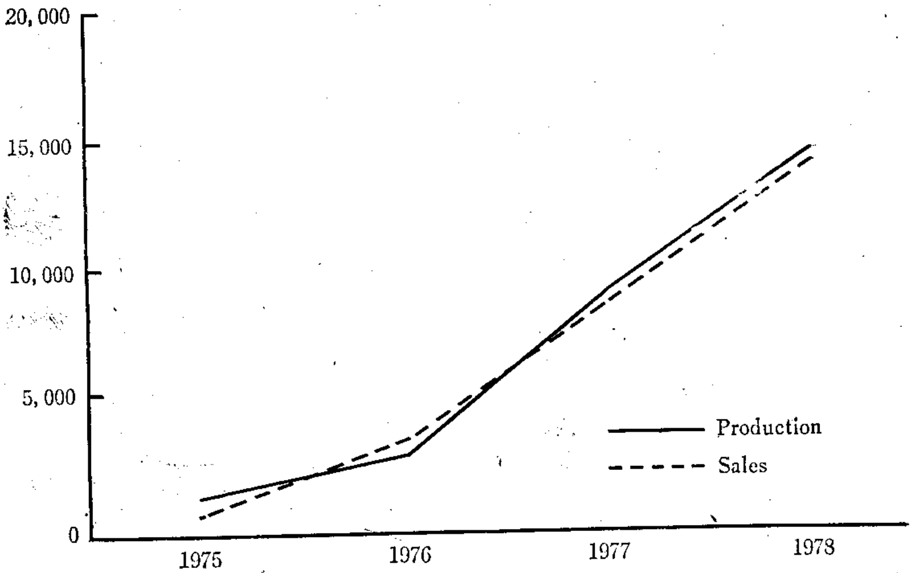
—utilities

—property conditions

meets all the requirements of the project.

On the other hand, what actually has turned out in the course of time* is shown on the following diagram.

Table 7. Actual Production and Sales



	1975	1976	1977	1978
Production (pieces)	1,120	2,578	9,385	15,206
Sales (pieces)	285	3,119	9,313	15,041

As may easily be noticed by comparing Table 7 and a considerable amount of deviation has occured between the forecast and actual sales volume of the diesel engines. In 1975 when Hanki started the production of diesel engines, the biggest commercial vehicle producers, Shinjin (Toyota/Hino) and Hyundai (Ford) obtained their engines from abroad. The reasons for those vehicle producers to import their engines from abroad were already discussed before. During the latter half of 1970s, Korean economy as a whole grew at more than 10% annually while real industrial growth averaged about 30% per annum. Hence, total transport volume rose rapidly during the same period and the nation felt sharp shortages in trucks and buses. However, due to restricted production capacities with the vehicle makers, the shortage problem remained unsolved till the time of this writing and, accordingly, the sales volume of

* Production started in 1975.

diesel engines are still far below than the forecasts by the feasibility study.

At any rate, most people the author contacted and discussed with in regard to the case analysis agreed that manufacturing knowhow and other technical knowledge were steadily absorbed and accumulated in the company since the production activities for the diesel engine were set in stable orbit due to steady increase in the market demand for the product as shown in Table 7.

VIII. THE IMPROVEMENT OF THE TECHNOLOGY WITHIN THE COMPANY

The ability to carry out improvements required, naturally a prior knowledge of the process being currently carried out, the pieces of equipment that constitute it and the mode of operation. It also requires both a fundamental knowledge of the principles of mechanical engineering and physics, and a willingness to change.

There is good evidence, from information concerning the education, experience and talents of Korean engineers,* to support the thesis that they have mastered the fundamental knowledge of their subject to a considerable extent.

Since the technology involved is considerably sophisticated, it is not to be expected that the engineers would accomplish a major technological change or a change in the 'core' technology. However, over the four year period of successful operations of the plant, there have been numerous cases of technological improvement related to peripheral equipment and complementary activities.

Since in Korea raw materials and expendable supplies are expensive especially when they are imported from abroad, many of the changes and improvement were motivated and propelled through the movements of raw material savings or loss prevention. These movements were integrated as parts of the Saemaeul Movement, which is a government-sponsored, nationwide activity encouraging the whole nation to be more productive and constructive through maintaining

* See Table 8.

new attitudes and spirits.

Table 8. Education Levels of Engineers and Skilled Workers

Classification	Primary School	Middle School	High School	Junior College	4 year College	Graduate School	Total
Engineers	—	—	93	16	162	3	274
Skilled Workers	70	264	563	10	—	—	907
Total	70	264	656	26	162	3	1181

Source: Business Statistical Review Yearkook Daewoo Heavy Industries Ltd., 1978

In the following the improvements in technology are classified by their apparent motivation; i.e., raw material savings, expendable supplies savings, and method change to reduce the defective rate. The more important improvements under each category will also be evaluated in terms of their contribution to lower costs.

1. Raw Material Development

Since long before Korean government has been encouraging manufacturing industries to make as much efforts as possible to replace imported machineries, their parts, and even raw materials with domestic products. This encouragement sometimes takes the form of conditions or requirements for a governmental approval of a business proposal.*

Against this background, a research team from the foundry department of the engine plant of Daewoo Heavy industries succeded after a couple of years of repeated experiments in producing 'ductile cast iron' of their own.

Many important parts of an engine should be manufactured of ductile cast iron, which was imported from Japan. Hence, in 1976 two foundry engineers, led by a senior engineer, were engaged in experiments with an aim to produce the ductile cast iron at their own foundary. In 1977, after two years of theoretical study and experimentation, they succeeded in producing the desired products with the following mechanical properties:

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* In case of the diesel engine project, the approval condition was to increase the percentage of domestic parts up to 30% during the second year, 40% the third year, 50% by the forth year, etc., in value.

Table 9. Mechnical Properties of the Ductile Cast Iron Produced at DHI as Import Substitute*

	T/S	EL	Hb	Hb(anneal)	Bending
1st Product	41	1.2	230	180	Passed after Heat treatm't
2nd Product	53	14.4	180	—	Passed after Heat treatm't
3rd Product	65	4.4	214	—	Passed after Heat treatm't

Prior or this successful production of the ductile cast iron, most important parts which should be manufactured of ductile cast iron were imported from foreign countries. Thus, a considerable amount of cost reduction including foreign exchange saving was achieved. For example, in case of 'end plate', each cost 7,300 won when they were imported from Japan. Since 12kg of ductile cast iron is needed per each end plate, and production cost of the former is calculated at 321 won per kg,

321 won × 12kg = 3,852 won/each.**

Hence, after the production of ductile cast iron was made possible internally, end plates, for example, began to be manufactured with almost 50% cost reduction plus foreign exchange savings corresponding to that amount.

2. Loss-Prevention Technique Developments

Korea is a country poorly endowed with natural resources. Hence, material loss prevention in manufacturing industries has always been looked at with serious appreciation. As integral part of afore-mentioned Saemaeul Movement, the company formally organized the Loss Prevention Council in 1976, and encouraged employees to propose ideas on technological improvements. They also provided full supports to implement the ideas and excellent performances were awarded.

1) Development of Idea to Save Rejected Cylinder Head

A cylinder head contains valve seats, head hole, and cold water jacket.

* Source: Research Department of DHI.

** These cost accounting data were as of 1977.
Source: Accounting Department.

Cylinder heads have to undergo a hydraulic pressure test so as cold water in the jacket cannot leak into valve seats or head bolt holes. In the test, about 2 percent of the cylinder heads were rejected. Once rejected in the test, they become of no use but as scrap iron. Under these circumstances, an idea to repair the rejected cylinder head was proposed in 1977 and after some experiments accepted to be implemented. Contents of the idea and their contribution to cost reduction are as follows.

The diameter of the head bolt hole should eventually be 16. The first step to repair the leaking hole is to drill the hole up to 17.6 and then enlarge the hole with 18 reamer. The second step is to insert a seamless pipe which is proof agaist oxigenation by water. At this second step 'locktite' metalic adhesive is applied inbetween the inner wall of the hole and the pipe. After this repair about 90 percent of them pass the hydraulic pressure test. Cost savings from this repair technique areas follows:

Raw material cost for the cylinder head;

700 won per kg

A cylinder head weighs 28 kgs.

Hence, 700 won × 28 kgs = 19,600 won each.

Labor cost; 14,000 won per piece

Then, the total cost already incurred for a rejected cylinder head is;

19,600 won + 14,000 won = 33,600 won

Cost to be incurred for a repair is;

Material cost;

seamless pipe 450 won per meter

0.2 meter needed per repair

Hence, 450 won × 0.2 = 90 won per repair

Locktite 85 won per cc

5cc needed per repair

Hence, 85 won × 5cc = 425 won per repair

Labor cost; 200 won per repair

Total repair cost: 90+425+200=715 won

Net saving by a repair: 33,600−715=32,885 won

Hence, assuming 24,000 pieces per year and 2 percent reject rate, the net saving by this repair technique amounts;

$$24,000 \times 2\% \times 32,885 \text{ won} = 15,784,800 \text{ won}$$

per year.*

2) Development of Idea to Reduce Tappet Hole Defects

A tappet hole, located in the cylinder block, is a hole through which tappet connects the push rod to the cam. However, since the early stage of operation of the new plant, this tappet hole had been a major source of defect occurrences. As may be noticed from Table 10, about 75 percent of machine shop defects originated from works on tappet holes. Hence, engineers took pains to analyse causes of the problem and to find out ways to solve it.

Table 10. Origin and Percentage of Machine Shop Defects between May 1, 1977~June 10, 1977

Origin of Defects Occurrence	Number of Defects Occurred	Percentage
Tappet hole	36	75.00
F30 Cam idle hole	2	4.10
Cylinder hole	2	4.10
F50 F60	2	4.10
F10 F20	2	4.10
F20 Bearing Cap	1	4.10
Crank shaft hole	1	2.15
Cylinder hole (ecc.)	1	2.15
Others	1	2.15
Total	48	100.00

The machine work process on the tappet hole is as follows:

After through investigations into possible problem areas, one eventually found that at the end of Drill 28 process, even a slightest tilt on the edge of the hole could cause next process to produce an eccentric instead of perfect circular

* When converted into U.S. dollars, the amount is roughly equivalent to US $31,570.

Table 11.

→ Cast hole of 23 → Drill 28 → Endmill 31. 6 → Reamer 32

hole. This eccentric or tilted shape of a tappet hole could apparently cause problems. Thus to avoid the occurrences of the tilted or eccentric shape of tappet holes, one experimented with the process by substituting an endmill for the 28 drill. This attempt, fortuately, proved to be so effective as to reduce the defect rate by 2. 5 percent. No further improvement on the tappet hole defects beyond this one has been made possible so far. However, with this much of improvement, the following cost saving was brought about:

material cost;	157, 050	won per piece
labor cost;	51, 600	won per piece
other costs;	18, 960	won per piece
Total	227, 610	won per piece

Hence, assuming 24, 000 pieces of annual production and 2. 5 percent reduction in defect rate, total annual cost saving is:

227, 610won × 24, 000 × 2. 5% = 68, 283, 000 won*

3. Ideas to Save Tip Consumptions

Boring tips and turning bites are not produced in Korea. They are imported from West Germany. Thus, from spirits of saving foreign exchanges, ideas were proposed to save the consumption of tips, bites, and other machining expendables. For example, investigations over machining processes of cylinder block lines revealed that new tips were used both for rough and fine machining processes of crank shaft holes, cam shaft holes, and cylinder holes. The proposed idea was to use, for the purpose of rough machining, the tips which

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* U.S. dollar equivalent is about $31, 569.

were used during the fine machining processes. This was not so easy as it sounded. To implement the proposed idea, a newly programmed routine for the process was to be invented so as not to interfere with other processes and line balancing, since the original design of the processes was done by assuming the use of new tips for the both machinings.

This kind of tool saving ideas were also applied to other areas of the machine shop, and according to the report of Accounting Department, as much as 13 million won's worth of foreign currencies* are, as of the time of this writing, saved each year.

4. Method Improvement on Manufacturing Fly Wheel Housing

The foundry department was manufacturing fly wheel housing. However, due to inward flanges of the housing, one could not avoid the use of cores when casting them. Hence, they began to wonder whether the design of the fly wheel housing could be changed so that the flange might be bent outwards. After some investigations, it was found that the function of engines would not be hampered even though the flange of the fly wheel housing would be bent outwards.

Thus, they developed a new method for manufacturing fly wheel housings which circumvented the use of cores in casting. This improved method could shorten the production time by 48 minutes, and save material cost of 889 won per piece. This much saving in production time and material costs effectuated total annual cost saving of as much as 49 million won.*

IX. ADAPTATION OF THE IMPORTED TECHNOLOGY TO KOREAN SITUATION

Adaptation is an 'intermediate' technology in the special sense that it is intermediate between copying or repeating the existing technologies (whether

* U.S. dollar equivalent is about $26,000.
* In terms of U.S. dollars, the amount is equivalent to about $49,000.

transferred from industrial countries or already available in the country), and using a different autonomously developed technology.* It is a mixture of existing technology and new or existing scientific knowledge applied to the modificatiom of available technology in the light of local circumstances.

The ability to carry out adaptation in this true sense requires, naturally, a fundamental knowledge of the process being currently carried out and the principles on which the mode of operation is theoretically based.

Since the technology involved is fairly complicated, it is not to be expected that the engineers would accomplish a major adaptation. Hence, even in the presence of strong incentives for adaptation, no significant adaptations have been achieved in the core-technology area. However, in peripheral or easy-to-learn technology areas, some kind of minor adaptation has been achieved. Interestingly, incentives for the adaptation in this less-involved area were related to the cost-down movement afore mentioned.

One of the work stations in the crank shaft line was engaged in machining on oil pump driving gear shaft, pilot bearing hole, and flange slot. However, this station became a bottle neck in the maching shop since the operation in this station required change of tools and intermittencies more than any other stations.

Hence, a study to solve this bottle neck problem on the station was performed. In the course of the study, investigations on the differences between Korean vehicles and those of western countries revealed that transmission center shafts are shorter with Korean vehicles than in western ones. This finding led to the fact that there was no need for machining on the pilot bearing hole at the rear of the crank shaft. (According to the original M.A.N. design, one needed machining on this hole.) Hence, they redesigned the machining process and changed the shape of bites to be utilized in the station. From this change in the process the formerly-existed bottle-neck problem

* Here, the definition of 'adaptation' was drawn from that of Professor Hans Singer.

was removed and tact time reduction was achieved as follows:

Tact time before the change:

Process #170;	12 min.
Process #175;	8 min.
Jig change & wait;	12 min.
Subtotal	32 min.

Tact time after the change:

Process #170;	none
Process #185;	8 min.
Jig change & wait	none
Flange slot;	5 min.
Subtotal	13 min.

32 min. −13 min. =19 min. saved

X. THE DIFFUSION OF THE IMPORTED TECHNOLOGY WITHIN THE KOREAN ECONOMY

Having described the absorption of the imported technology within the Daewoo Heavy Industries Ltd., it remains to describe its diffusion outside the importing firm. This means describing first diffusion of the technology to firms competing with DHI, second to other firms which supply inputs to DHI, and third to the rest of the Korean economy.

Diffusion of the first sort —to other competing firms— has taken place through the engineers who were tempted to move to other competing firms with the prospect of promotions and higher salaries. DHI imported the first diesel engine plant in Korea. Hence, in the beginning there was no competitor as far as diesel engine manufacturing was concerned. However, Hyundai Motor Company in Ulsan Korea began to prepare to enter the field only a couple of years after DHI started its operation. Engineers are vulnerable to inducements from the competing firm when they have accumulated about three years service;

by then they are eager for advancement, and by then they have acquired enough know how to make them valuable acquisitions.

Table 12. Competition in Auto Engine Manufacturing*

Company	Type of Engines	Capacity	Technical Coolaborator
Hyundai	1,238cc gasoline 1,593cc gasoline	56,000	Japan Mitsubishi Ford
Kia	985cc gasoline	36,000	Toyo
	1,985cc gasoline	12,000	
Saehan	1,498cc gasoline 1,700cc gasoline 1,897cc gasoline	50,000	Isuzu GM Opel
Hyundai	55HP diesel 82HP diesel 120HP diesel 150HP diesel	12,000	Perkins
Daewoo	90HP diesel 145HP diesel 168HP diesel 192HP diesel 215HP diesel 256HP diesel	24,000	M.A.N.
	85HP diesel 100HP diesel 145HP diesel	under construction	Isuzu
	81HP diesel 115HP diesel	under construction	Toyo

* Source: Ministry of Commerce and Industry as of the end of 1978

One evidence of the diffusion of the technology through these moving engineers is the fact that when they move from a company to another the movement is usually not by individual but by a group —a group in which they worked together as a team in the previous company. Hence, this kind of manpower movements, which were prevalent during the boom years of 1975 through 1978, have been actually detrimental to the sound accumulation of technological capabilities within a firm. During the period there were even incidents or disputes between the firms involved over what was called 'techncial manpower robbery' sometimes accompanied with blue prints buglary.

Table 13. Turnover of Employees from DHI

Year	Skilled Workers	Junior Engineers	Senior Engineers	Turnover Rate*
1976	399	34	2	36%
1977	430	38	4	34%
1978	425	23	4	25%

As may be noticed from Table 13, the turnover of technical manpowers from DHI has been very high.

Diffusion of the second sort —to other firms supplying machinery parts to DHI— has been slowly taking place. Interestingly, however, this kind of diffusion might be described, as 'a quasi-forced diffusion' This special feature of the diffusion to inputs supplying firms in Korean machinery sector comes from the nature of machine manufacfuring. Hence, to discuss the diffusion of this sort, one had better start by looking into the nature of machine manufacturing.

A machine is an assemblage of parts or components functioning together systematically to perform a specified job.

To analyse further, (i) a machine is composed of a large number of parts or components. A sewing machine, for example, comprises about 200 to 500 parts according to the degree of its sophistication. Coming from this characteristics, as far as machine manufacturing is concerned, it is neither technically nor economically feasible to manufacture all the needed parts within the firm which produce the machine. In other words, the number of parts needed for a machine, even though it is a simpler one, is in general too great for one firm to product all of the size of the firm. It may be for this reson that even in industrially advanced countries like Japan, West Germany, etc., the structure of the machine industry is based on coordination and cooperation among multitudes of firms.*

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* Turn-over rate was defined as $\frac{\text{Number left the company} \times 100}{\text{Total (average) employees}}$

* As of 1971, in Japan 66.1% of the total 166,127 machine shops were small sized firms with employees of less than 9. In West Germany also, the corresponding precentage was 44.5 for the same year.

Next, in a machine components or parts function together systematically to perform a specified job. Hence, the quality level of a machine depends very heavily on that of each functioning part. Sometimes, it might be said that the quality level of a machine is determined by the part with the lowest quality level.

In these circumstances, the theory of economics—division of labor or economics of specialization—could come into play, that is, smaller machine shops had better specialize on parts production and supply the parts to their contractors on a stable and long term basis, while large firms like DHI should specialize in major assembly works, research, development, or design.

DHI, fortunately, recognized the need for this coordination and cooperation among machine manufacturing firms. In 1975, the company, in line with government directives, established a program for the localization of materials, equipment and parts. This program has achieved some success in localizing a few materials and a large number of parts. These accomplishments have made significant contributions in cost and savings in foreign currency.

Table 14. Localized Items by DHI in 1978 by Rendering Technical Assistance to Their Subcontractors

Localised Items	Development Status
Cod. Rod Material	completed
Push Rod	completed
Tappet	completed
Cylinder Head Bolt	completed
Oil Pump	manufactured a sample
Gasket (exc. Head Gasket)	completed
Water Pump	completed
Oil Cooler	manufacturing a sample in consideration
Rocker Arm Assembly	completed

However, in spite of the strong governmental directives towards the localization, foreign dependency of raw materals, parts and equipments is still heavy, as far as engine manufacturing is concerned, as Table 15 indicates.

This heavy dependency of know-how parts and equipments on advanced

Table 15. Foreign and Local Purchase of Materials, Parts, and Equipments during 1978 for Diesel Engine Manufacture in DHI (mil. $)

Classification	Foreign	Local
Materials & Parts	59.7	22.5
Equipments	12.3	6.4

foreign countries is what they still lament for. In other words, when they want to modify or improve a certain model, such as power-up, power-down, reduction of weight, etc., they need another technical assistance from a foreign licensor. This is how they had Isuzu and Toyo as their new technical collaborators when DHI were building their second desel engine plant in late 1977* for the production of smaller size diesel engines, as may be noticed in Table 12.

In sum, it could be said that engineers at DHI have absorbed those portions of the imported technology relating to the start-up, operation and maintenance of the diesel engine manufacturing processes, and at the same time, have made some progress in absorbing the knowledge required for the equipment selection, their lay-out, and plant construction. However, basic design and R & D areas are still far from having been absorbed or diffused as far as diesel engine technology is concerned.

Hence, the author was tempted to do another case study in an area with much simpler technology in order to see whether the 'lament' for basic design and R&D technology lingers on even in the 'simpler' technology area, too.

Another Case for Comparison with Disel Engine Case Name and Location

Name of the firm: Yuhan-Kimberly Corporation

Location: 302-75 Dongbu-Ichon-Dong Yongsan-Ku, Seoul, Korea

Our preceding diesel engine manufacturing case was the one in which highly involved technologies were prevalent. Now another case with rather simpler was studied here for the sake of comparison between 'complex' and 'simpler' tech-

* The second plant cannot yet be analysed because it has not started operation by the time of this writing.

nologies. This second case study was done on the Yuhan-Kimberly Co., Ltd., a cosmetic or sanitary tissue manufacturing firm in technical collaboration with the Kimberly-Clark Corporation of the U.S.A.

Development:

Since 1968 the Kimberly-Clark Corporation of The United States of America had been grouping for investment opportunities in Korea. They were interested in setting up a foothold in Korea.

Yuhan Corporation of Korea, a pharmaceutical company of high repute for their public interest orientation with solid marketing channels, was recommended via the U.S. Embassy in Korea to the Kimberly-Clark.

At that time the Yuhan, as a pharmaceutical firm, was interested in considering the production of sanitary (feminine) napkins.

As negotiations between the two parties proceeded, Yuhan learned that they had to import what they called 'warding', the semifinished absorbent tissue material which should be put in for the final output of feminine sanitary pads. However, the transport problem of the warding material, being so huge in volume, was posed as a serious difficulty to overcome.

Eventually Yuhan concluded and began to insist that they would like to set up warding production facilities in Korea. However, Kimberly-Clark maintained that the market size was too small in Korea to justify the capital expenditure to invest in warding production plant.

While the negotiation was lingering at a stalemate in this way, Kimberly-Clark team began to learn about 'the Korean style of getting things done'—for example, they noticed that most of street buses in Seoul were built via unorthodox manufacturing processes by many small diverse companies with low capital and ill-equiped facilities.

They learned that the ingenuity, sincerity, and diligence of Korean people could somehow get things done which to the eyes of western people might appear infeasible.

This growing confidence in 'people' led the Kimberly-Clark team to understand Yuhan's assertion and finally they agreed to establish a joint-venture company (Kimberly-Clark 60%, Yuhan 40%) with warding manufacturing plant for which Kimberly-Clark was supposed to supply needed technical know-how.

At that time, in early 1970, the status of tissue manufacturing industries in Korea was still in a primitive stage. Bathroom tissue rolls were produced using machineries and facilities designed and manufactured in Korea based on time-old traditional method. Yuhan managed to secure several engineers who were able to design and construct the old style paper manufacturing machineries. Those engineers were sent to the Kimberly-Clark in the U.S.A. on a mission of learning about thie 'modern' technology for cosmetic tissue manufacturing. They made tours on several paper mills and collected information about designing, assembly, and critical parts for the construction of tissue manufacturing machinery. Above all they learned that the basic principles of 'modern' techniques are not too far from those of traditional ones as far as paper tissue manufacturing is concerned.

After returning home they started to construct the machinery to produce absorbent paper tissue on the basis of blue prints, information, and other technical assistance supplied by the Kimberly-Clark. They tried to design the system as simple as possible. Some parts were produced in their own machine shop, while many others were made through subcontracts by local machine shops. Some of very critical parts were sent to the U.S.A. for tests. Those parts which were beyond the capability of domestic production were imported.

In December 1970 the machinery system for the production of absorbent paper tissue was set up and operation started. The system was much simpler than those in advanced countries. As for quality, the production speed was slower than the 'advanced' sophisticated machines. However, the quality of the product was about the same.

Considering the small size of capital expenditure in constructing the machinery, the result came as a surprise to the Kimberly-Clark side.

Yuhan-Kimberly's next project was to set up felt producing machinery. So far most of felt products were imported from abroad. Hence, domestic production of felt was in a serious need. Kimberly-Clark agreed to supply needed technical assistance including drawings, blue prints, and informations about parts and assembly of the system.

Owing to experiences and learnings attained during the first mission, the felt producing machinery system was set up without much difficulty in February 1972.

On the other hand, due to fast growing national income and rising standard of living in Korea, the demand market for cosmetic tissue, sanitary feminine pads, felt products was ever growing at about 50 to 60 percent annually.

To keep up with market growth, Yuhan-Kimberly decided to expand their production facilities. About three fold expansion project was approved by the government in January 1972 and the project was completed by July 1974. The company's growth data are shown below:

Table 16.

	1971	1974	1977	1978
Export*($ 1, 000)	235	650	2, 300	1, 700
Assets(million won)	397	1, 880	3, 196	5, 753
Employees	206	417	430	536

* Domestic sales data were classified.

Growth of Yuhan-Kimberly:

Starting 1975 as a turning point, Kimberly-Clark Co., now having complete confidence in Yuhan-Kimberly's machine manufacturing capability, contemplated strategically fostering Yuhan-Kimberly as a machninery supply base for their international market of paper manufacturing machineries. Korean people's capability in designing, drawing, manual skill in machining, in addition to their sincere attitude toward learning, and above all cheap labor cost were presumably major factors which led them to this decision.

The first development in this direction took place in the form of machinery parts export to Iran in 1975. In the same year engineers and operators of tissue manufacturing machinery were sent to the same country as a technical assistance program to the nation. In 1976 Yuhan-Kimberly exported machineries (of cosmetic tissue and felt manufacturing) with some major parts to Philippines and Thailand.

In 1977 Yuhan-Kimberly exported a whole system of paper manufacturing plant to Columbia and sent five engineers for their operation.

Recently Yuhan-Kimberly functions, as it were, like an R&D laboratory for Kimberly-Clark. With technical assistance and guide from the American counterpart, they succeeded in producing crescent former a higher stage technology in paper industry.

In the previous section, a rather brief sketch about the success story of Yuhan-Kimberly as a machinery manufacturer was given. Now, we would like to compare the two cases and draw some conclusions from the comparison.

XI. IMPACT OF THE DEGREE OF SOPHISTICATION ON ABSORPTION, ADAPTATION, AND DIFFUSION OF THE TECHNOLOGY

Very often when one thinks of technology, only of western, large scale, centralized, capital and energy intensive technology. However, it is only possible for such a technology to exist in a society where a whole host of special conditions are satisfied.

Indeed, it is often argued that western technology is inappropriate to underdeveloped countries and that western aid should not concentrate on helping underdeveloped countries to acquire the kind of technology developed countries rely on. The following reasons are used to support this claim.*

1. Western technology is capital intensive. That is, it uses lots of expensive machinery and little labor.

* E. Braun & C. Collingridge; Technology and Survival, 1977, pp. 61–62.

2. Western technology depends on a supply of highly skilled labor of all kinds, from skilled manual workers to managers. This cannot be provided by most underdeveloped countries. For this reason imported plant is either run inefficiently or else its running depends upon a team of foreign experts.

3. Western technology is extremely expensive and its import by an under-developed country means a significant drain on its foreign reserves.

For these and other reasons,* Schumacher has suggested that a far more appropriate kind of technology for underdeveloped countries is what he calls 'intermediate technology.' Intermediate technology is defined in terms of cost of equipment per worker.

Interestingly, executives and top managers of Daewoo Heavy Industries agreed that DHI's diesel engine technology deserved all the criticisms from the standpoint of the above stated arguments, that is, arguments of capital intensiveness, demand for high skilled labor, and foreign reserve drainage.

As for the first point, argument of capital intensiveness, DHI has been trying to resolve the problem by running the plant on a three shift basis instead of one shift as designed originally. Since in Korea interest rate is about three times higher than in western countries, they say, plants erected on borrowed capital should be exploited about three times higher than in western countries. This has been their philosophy and they really try to do so.*

As for the second argument, western technology's demand for high skilled labor, this problem has ailed the company since its initiation of operation of the plant, even though the afore-discussed manpower employment contract with the technology supplier alleviated the problem considerably.

Concerning the third point, there is no question about the validity of the argument on foreign currency drainage.

Thus, our case analysis on diesel engine technology has affirmed the validity of arguments against the inappropriateness of highly advanced western techno-

* Other arguments were dropped by the author because of their irrelevance in Korea.
* However, due to insufficient demand stituations three shift operation is seldome followed.

logies in underveloped countries. However, as we already saw in the Yuhan-Kimberly case, with a less-advanced or less sophisticated technology, the problem was far less severe. Furthermore, what the comparison between the complicated diesel engine technology and rather simple tissue-manufacturing one suggests is that when a developing nation is in a serious need for learning, absorption, and diffusion of imported technologies, she had better start off with simpler technologies. Needless to say, simpler technologies are to be absorbed and understood with much ease than sophisticated ones, since principles exploited by the former are in general simpler and easier than the latter. When they are less sophisticated and easy to learn, they might be easily indigenised, duplicated and further adapted to local conditions. This reasoning was verified by the Yuhan-Kimberly case. Executives and top managers of the Yuhan-Kimberly Corporation emphasized that their phenomenal success in their technological development in machine manufacturing was primarily attributed to the fact that they adhered to simpler technologies in the beginning.

However, in case of products like automobile engines, precision, standardisation, and consistency in manufacturing process are primary determinants for the final quality of products. Hence, when developing countries hope their products to be competitive in international markets, the requirements of quality of their products call for importation techniques which are designed to be sophisticated with specialised automation control mechanism.

However, the highly sophisticated technologies are much harder for the recipient of the technology to learn than simpler ones. Hence, the importation of sophisticated technologies in order to be competitive in international markets is likely to hamper the process of learning, absorbing, and adapting the imported technologies.

Hence, our case analysis with one firm who imported highly sophisticated technologies and a second firm with simpler technologies could lead us to the following hypothesis:

When a direction in being competitive in international markets with the final products is to be followed, the other direction in raising technological capabilities by learning, absorbing, adapting, and diffusing the imported technoloy might be sacrificed eventually, and vice versa.

To the extent that this reasoning applies, developing nations will face something like a dilemma: To be competitive in international markets in the short run or to become competent technologically in the long run? This will pose a policy issue for a developing nation.

XII. SUMMARY AND CONCLUSIONS

The purposes of this last section are to summarize the findings of the enquiry and to suggest some reasons for them: these two matters will be considered together in what follows. The findings themselves could be stated, in a simplified manner, as (1) the role of the Korean government has been crucial in determining the rates of absorption and diffusion of the imported technology; (2) the rate of absorption has been steadily increasing as long as the market for the products of the technology was secure; (3) the rate of diffusion, especially to inputs supplying firms, has been slowly taking place in recognition of the fact that the eventual determination of the quality level of their products depends heavily on that of the inputs supplied by those smaller firms; and (4) the impact of the degree of sophistication of the technology on its absorption, adaptation, and diffusion was vividly observable.

1. The Role of the Korean Goverment

During the First and Second Five-Year Economic Development Plans (1962~1971), with the capital accumulation and the scale of industries at a relatively low level, business enterprises in Korea could not but finance most of their equipment funds from foreign loans rather than public issues of stock and debentures. Under these circumstances, Korean government, being aware of the far-reaching impact of foreign investments on national economy, established guidelines for foreign capital inducement.

First, in order to assure sound financial structures, enterpreneurs undertaking heavy and chemical projects* were requested to secure their own capital for more than 30 percent of the total investment. Foreign capital was to be limited, in principle, to no more than 60 percent of the total investment. Foreign loans and investments were going to be utilized when required for acquisition of capital goods and advanced technology which were not locally available.

Second, although priority was given to loans on favorable terms, direct foreign investments were also to be authorized. Such investments were to be encouraged especially when they would help secure dependable sources of raw materials, expand markets of products, or induce advanced technology.

Third, in order to effectively support the development of the heavy and chemical industries, tax privileges under Foreign Capital Inducement Act and other various tax laws were prepared and presented by the government. Income and corporation taxes on foreign invested enterprises were exempted or reduced in proportion to the percentage of stocks or shares which foreign investors participated in the enterprise. Other various taxes were subject to reductions or exemptions.

Fourth, industrial sites were selected and constructed under the governmental initiative. In order to support construction of the selected industrial sites, the Industrial Site Development Promotion Law was enacted in 1973, while the Korean Water Resource Development Corporation which was established in 1967 was reformed to the industrial site.

Considering that less-advanced industrial structure and resulting heavy imports of capital goods as well as industral raw materials have not only caused serious balance of payment problems but also made the economy more dependent on foreign savings, the basic governmental policy direction was to focus on the enhancement of industrial independence through increased domestic production of industrial raw mateials and capital goods. With a view to enhancing

* Machinery industry was included in the category of 'heavy and chemical industry'.

self sufficiency in industrial raw mateials, the steel industry, petrochemical industry, and non-ferrous metal industry have been selected for intensive development. On the other hand, in order to promote self-sufficiency through localization of capital goods, equipments, and parts, government also selected machine industry and electronics industry as major leading types of industry for emphasized support.

2. The Absorption of the Imported Technology

In the course of the case analysis, a conclusion was drawn that the absorption of imported technology would be highly dependent upon the continuity of demand for the products of the technology. During the earlier stage of the diesel engine production, there was not enough demand in the market for the engines. Hence, personnels who were employed in the diesel engine project were transferred to other projects. The company could not afford to keep the personnel in the project where they were losing money due to lack of market demand for the products. Thus, when the continuity of men engaged in the technical activities is broken, the continual accumulation of the technical knowledge in the related area will be seriously hampered.

Since the technology involved in the production of diesel engines is considerably sophisticated, it is not to be expected that Korean engineers would accomplish a major technical change in short period of time. However, over the four year period of successful operation of the plant, these have been numerous cases of technological improvements which were motivated through the movements of raw material savings and loss prevention. These movements were integrated as parts of the Saemaeul Movement, which was a government sponsored nationwide activity encouraging the whole nation to be more productive and constructive through maintaining new attitudes and spirits.

They succeeded in producing ductile cast iron of their own, invented new methods by which they could save raw materials, expendable supplies etc. and reduce the defective rates. These technological improvements were conducive to lowering costs.

3. The Diffusion of the Technology

Diffusion of the imported technology to other competing firms has taken place through the eingineers who were tempted to move to other competing firms with the prospect of promotions and higher salaries. Further, when they move from a company to another, the movement is usually not by individual but by a group--a group in which they worked together as a team in the previous company. This kind of manpower movements, which were prevalent especially during the boom years of 1975 through 1978, were sometimes detrimental to the sound accumulation of technological capabilities within the firm which lost precious technical manpowers.

Diffusion of the technology to inputs suppliers has been slowly taking place. This kind of diffnsion to inputs suppliers in the machinery sector came, interestingly, from a need which is intrinsic to the sector. Since a machine is an assemblage of a large number of parts or components functioning together systematically to perform a specified duty, the quality level of a machine is likely to be determined by that of the parts with the lowest quality level.

A machine manufacturer should, therefore, recognize the need for cooperation and coordination among firms engaged in machinery manufacturing. DHI, fortunately, was aware of this need and established, in line with government directives, a program for the localization of materials. equipments, and parts by assisting smaller parts manufacturers with technical knowhow and, sometimes, financial support. The successful accomplishment of the program has made significant contributions in cost and savings in foreign currency.

4. As For The Sophisticated Technology

In sum, it could be said that engineers at DHI have absorbed those portions of the imported technology relating to the start-up, operation and maintenance of the diesel engine manufacturing processes. However. basic design and R&D areas. especially when the technology involved is highly sophisticated, are still far from having been absorbed or diffused.

Hence, another case analysis in an area with much simpler technology was also performed in the study in order to see the impact of the degree of sophistication of the technology on its absorption and diffusion.

As a result, what the comparison between the complicated technology and a rather simpler one suggests is that when a developing nation is in a need to learn, absorb, and diffuse the imported technology, she had better start with a simpler technology. Simpler technologies are to be absorbed and understood with much easier than sophisticated ones, since principles exploited by the former are in general simpler and easier than the latter. However, when developing countries hope their products to be competitive in international markets, the requirements of quality of their products call for the importation of foreign techniques which are usually sophisticated. Thus, a developing nation faces a conflicting situation between a long-term optimization of technology developments and a short-term optimization of international trade.