4 Technology Transfer for Development of New Diesel Engine

4 Technology Transfer for Development of New Diesel Engine

4.1 Improvement of Production Design of Present Product

The design of the engine body is old. At the time of the first field study we tore down the CUMMINS ENGINE (KT1150, 19L, 6-158 X 158), CUMMINS being a competitor of the Company, and compared the two engines as to productivity, cost and reliability (Fig. 4-1-1). As a result we were able to extract the thirteen proposals for improvement indicated below (Fig. 4-1-2).
Later we carried out a study in Japan and then accomplished technology transfer to Mr. A. Adamczyk and Mr. J. Yaworcki, section chief, of the C/P development department on the basis of specific examples.
At the time of the second field study we undertook a design review, the progress made regarding the improvements, which are in the course of being implemented, being given below (Table 4-1-1).

(1) Engine models covered: SW680, SWT11, MD111E
(2) Aims of the improvements: improvement of productivity design and reliability
● : already implemented ○ : now testing or testing scheduled
◇ : to be implemented starting with EURO-3 M/C

No.	Improvement item	Implementation status	State of progress
1	Cylinder head fastening Stud bolts --> Bolts	◇	Since the improvement is far-reaching, it will be implemented starting with EURO-3 M/C
2	Shrink fitting of ring gear	○	Testing now under way with 10 prototypes
3	Easier insertion of cylinder liner	○	Testing of newly devised cylinder liner insertion guide
4	Elimination of wire check bolt	●	
5	Elimination of connecting rod nut split pin	○	Now testing prototype for which split pin has been eliminated
6	Elimination of machining of front plate	◇	Under presentconditions procurement of materials is difficult
7	Elimination of crankshaft rear knock pin	◇	Since the improvement is far-reaching, it will be implemented starting with EURO-3 M/C
8	Changing to camshaft No. 1 spiral(?) bush	◇	Same as preceding item
9	Folding washer --> washer-based bolt	○◇	Partial implementation
10	Crankshaft seal oil leakage	○	To be implemented after making arrangements with parts manufacturer
12	Improvement of auxiliary starting device, Combustion type heater --> Electric heater	○	Same as preceding item
13	Miniaturization of starter	●	Starting from MD111E

Table 4-1-1 State of Progress Concerning Improvements

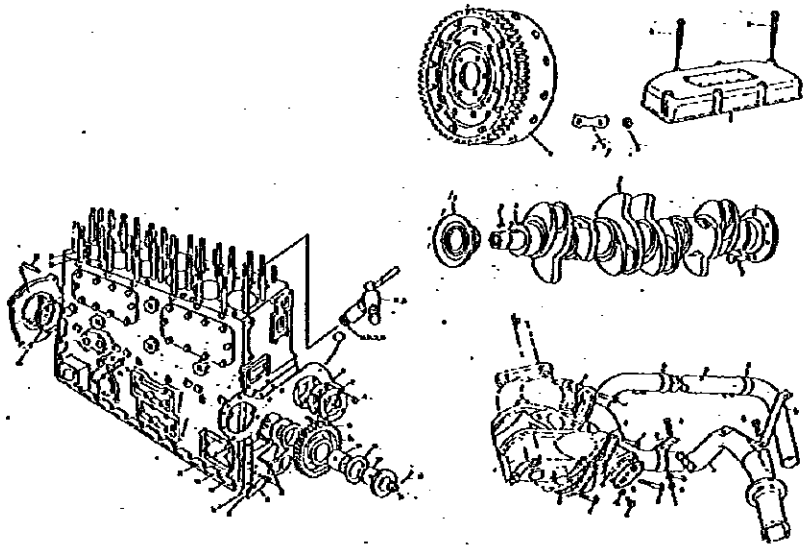
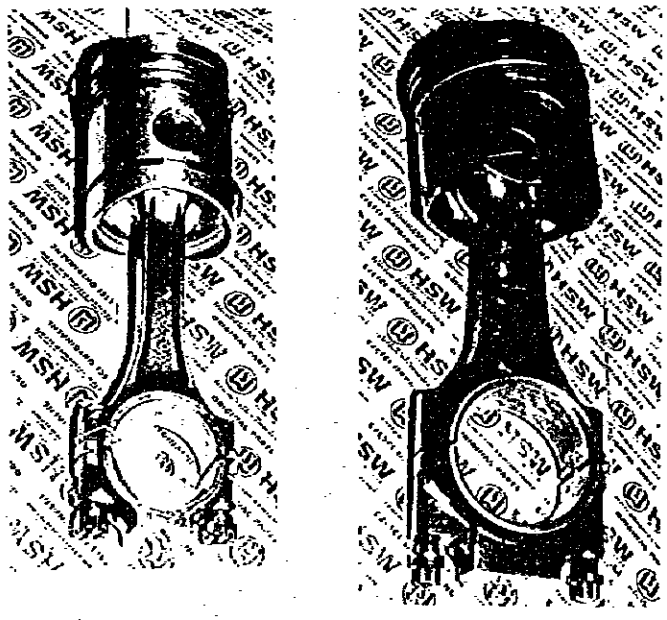


Fig. 4-1-1 Parts of the Company's SW680
Source : Mielec Engines Co.



Comparison of the Company's SW680 and CUMMINS' KT1150	
The Company SW680 (11L) • Use of connecting rod nut split pin • Long length of connecting rod in bolt (no split pin) comparison with piston diameter • With skirt ring • Long piston	CUMMIS KT1150 (19L) • Use of connecting rod • Short length of connecting rod in comparison with piston diameter • Without skirt ring • Short piston

Fig. 4-1-2 Comparison of the Company's SW680 and CUMMINS' KT1150

4.2 Concept of Development of EURO-3 Engine

4.2.1 Aim of development: Clearance of EURO-3 European exhaust gas controls and achievement of quality the same or better than that of competitor engines as regards fuel consumption, weight, size, reliability, durability and productivity.

4.2.2 Concerning EURO-3 European Exhaust Gas Controls

The goal is that of meeting the EURO-3 standards, which, for the reasons indicated below, requires major change in engine design different from that for EURO-2.
The figure below shows the standard values and the proposed measures for meeting them. Reduction of black smoke and particulates, which has always been stricter than in the case of the Japanese standards, will become still stricter, and reduction of NOx, which in the past has not been as strict in Europe as in Japan, will also become stricter. The measure to be adopted, which works in the direction of holding down combustion temperature, is in a trade-off relationship with measures against particulates (see Fig. 4-2-1). Since that would result in lower output and fuel consumption, cylinder head design will have to be changed for improvement of the air intake system, including increase of engine displacement.

(1) Change to 4 valves and cross-flow cylinder heads
(2) Improvement of output at maximum or present engine displacement

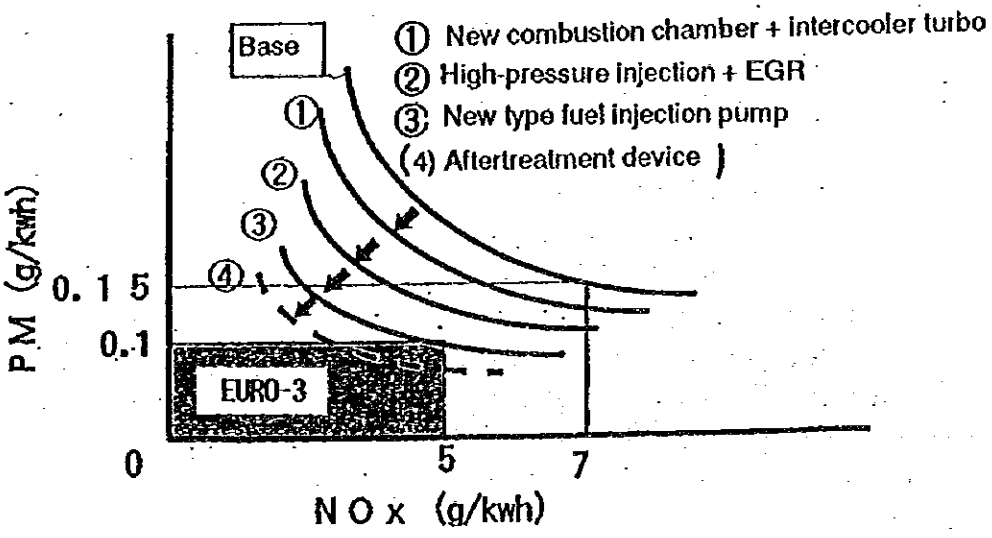


Fig. 4-2-1 EURO-3 Controls and Proposed Measures for Meeting Them

Japan is ahead in NOx reduction technology, and study team was invited to accomplish technology transfer by the University of Krakow and the University of Rzeszow and at a diesel seminar held at the Company.
The EURO-3 European exhaust gas controls become effective in the Autumn of 1999.

4.2.3 Trends Concerning Competitor Engines

It is assumed that progress is being made by competitors in Europe in development of engines for EURO-3 exhaust gas controls. Let us take a look at how the different manufacturers presently stand as regards exhaust gas controls, change to 4 valves, which is advantageous in terms of high output and low fuel consumption, cross flow and the 2-value type, which is disadvantageous.

(1) 4-valve type: Mercedes Benz, Scania, Iveco
(2) 2-valve type: The Company, DAF, Volvo, Liaz

It is assumed that the companies presently with the 2-valve type, i.e. DAF, Volvo and Liaz will also be changing to the 4-valve type for EURO-3.
It might be added that there is information that Volvo and Scania are already at the EURO-2.5 level regarding exhaust gas standards.

4.2.4 Study Concerning Development of EURO-3 Engine

The development study consisted mainly of technical study with Mr. J. Yaworcki, section chief of the C/P development department, concerning the development scheduleand the development expenses, and development was discussed on November 25 with professors M. Zablocki and Z. Szlachta of Krakow University, the Company development departments heads A. Lesinski and Syes and study team chief Watanabe and Mr. Higuchi.
The technical talks treated separately the themes "EURO-3 exhaust gas controls and engine performance with respect to fuel consumption" and "improvement of the engine body".

(1) Response to EURO-3 Exhaust Gas Controls
   a) Injection time delay
      Delay of fuel injection time is the most effective means of reducing NOx. But that results in lower thermal efficiency and lower performance in terms of fuel consumption, etc. It also leads to increase in PM, HC and CO and deterioration of low-temperature starting, which becomes about BTDC -8o, which is about the same as for the MD111E engine.
      (see Fig. 4-2-2).

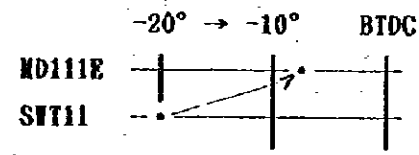


Fig. 4-2-2 Injection Time Delay

b) Feed air cooling (supercharging with intercooler)
In the turbo-supercharging engine the compressed air that has passed through the supercharger is at a high temperature of over 100°C, and if it is used in combustion without first being cooled, the combustion temperature will rise. The most effective means of reducing NOx is lowering combustion temperature by cooling such high-temperature supply air. That is also effective in terms of reducing black smoke and fuel consumption. That is why the new engine should have supply air cooling like that of the MD111E.

c) High-Pressure Injection
High fuel pressure makes the injected fuel more refined, thus promoting mixture with air, which has a considerable effect in terms of reduction of PM.

MD111E: injection pressure = 1200 kg/cm²
EURO-3: injection pressure = about 1600 kg/cm²

d) Pilot injection
A means of reducing premixing combustion, which has a big influence on discharge of NOx, is pilot injection. It consists in injection of a small quantity of fuel before the main fuel injection, temporarily interrupting the fuel and then carrying out real fuel injection after that small quantity of fuel has reached the ignition state (see Fig. 4-2-3). Reduction of fuel injection quantity in the period of ignition delay reduces premixing combustion and is effective in reducing NOx and noise.

However, delicate injection quantity control is necessary for pilot injection of a small quantity of fuel, and in the actual multicylinder engine with a broad rotation range that is difficult to realize. It is therefore necessary to coordinate with the fuel injection pump manufacturer concerning an electronic common rail fuel injection system.

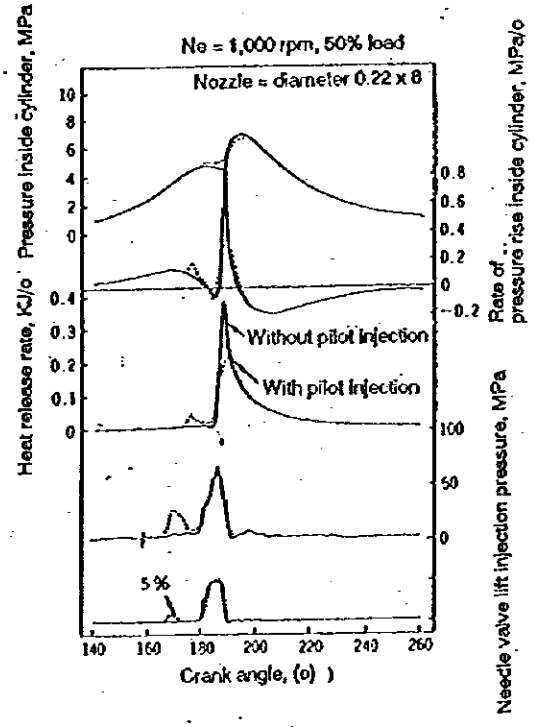


Fig. 4-2-3 Pilot Injection Combustion Analysis

Source : Automotive Diesel engine

e) Swirl ratio and the combustion chamber

Depending on the injection pressure, the swirl ratio as per Fig. 7-5-D on combustion chamber type changes. If an injection pressure of 1600 kg/cm² is selected for the EURO-3 engine, the combustion chamber will be of the low-swirl, shallow-bowl type (see Fig. 4-2-4).

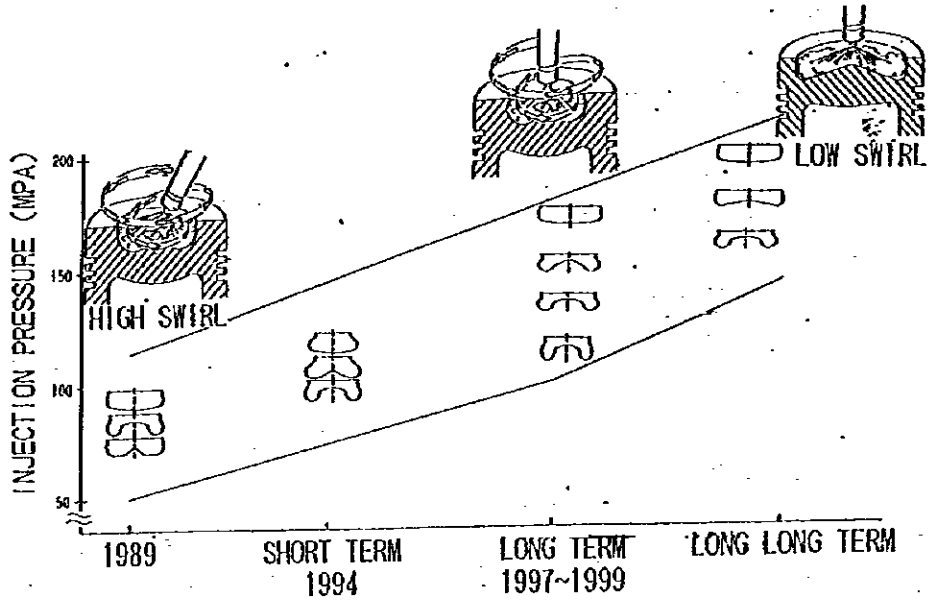


Fig. 4-2-4 How Injection Pressure Relates to Swirl Ratio and the (Type of) Combustion Chamber

f) Exhaust Gas Recirculation

Since EGR recirculates a part of the exhaust gas back to the air intake, the concentration in the mixed air of CO_2, which has a large specific heat, increases, and it is possible to reduce NOx because of the consequent lower temperature at the time of combustion. However, since the concentration of emitted smoke and HC increases in the high-load zone where there is not sufficient air because of reduction in the concentration of O_2, electronic control or other means of precision control of the amount of EGR according to load and rotation speed is necessary in order for EGR to be adopted. Since EGR means reintake into the engine of black smoke and sulfur oxides in the exhaust gas, that has a big impact on piston and cylinder abrasion resistance performance and engine oil life, and hence the need to improve the engine body.

g) Reduction of Oil Consumption

PM consists of black smoke and SOF (Soluble Organic Fraction), and when black smoke is reduced by improvement of the diesel engine, it will no longer be possible to disregard the part of SOF in exhaust gas due to oil consumption and not combustion. Further reduction will also be necessary taking composition into account (see Table 4-2-1).

	MD111E	SWT11/SW680
Oil consumption rate, g/kWh	0.3	0.8 ~ 1.2

Table 4-2-1 Oil Consumption Rates of the Company Engines

h) Turbo-supercharger with waste gate (WG)
One of the improvements of the turbo-supercharger is the turbo-supercharger with a waste gate (WG). It bypasses the exhaust, thereby reducing the exhaust turbine's work load, in order to prevent excessive supply air pressure or exhaust pressure. By putting the normal efficient operating point of the supercharger in the low-to-medium speed range, it is possible to mitigate insufficient torque of turbo-supercharging in the low-speed range, thereby improving performance in the high-use-frequency medium-speed range.

i) Turbo-supercharger with variable geometry (VG)
For improvement of characteristics in the engine low- speed range there is a type whereby the turbine input surface area of the supercharger is made variable. A variable vane is installed in the nozzle part of the exhaust turbine in order to make the nozzle surface area variable. By reducing the nozzle surface area when the quantity of gas is insufficient for operation of the supercharger, such as in the engine low-speed range, exhaust gas speed is increased, the energy recovered by the exhaust turbine is increased, and the supply air pressure is raised. That makes for improvement with respect to low-speed torque, low- speed black smoke and acceleration performance.

(2) Improvement of Engine Body
As indicated in Table 4-2-2 and Fig. 4-2-5, alternatives A, B and C were considered concerning improvement of the engine body. As a result, it was decided to adopt alternative C in order to make the engine at least equivalent to those of the competitor companies. The features and problems of those different alternatives are as follows:

	Features	Problems	Evaluation
Alternative A	1. 2-valve one-side flow as in the case of the present MD111E 2. No change in cylinder block dimensions 3. No change in the basic piston and connecting rod dimensions	Not possible to meet the EURO-3 control standards	X
* Alternative B	1. Cylinder head of 4-valve type, with cross flow 2. 1 head/1 cylinder ★ 3. Shorter cylinder block C dimension 4. Piston with high top ring	1. Engine inferior to competitor engines in terms of size and weight.	△
☆ Alterna tive C	1. 4-valve, cross-flow cylinder head 2. Not 1 head/1 cylinder 3. Shorter cylinder block D and C dimensions 4. Change of cylinder liner from dry to wet type 5. Shorter piston G dimension and connecting rod H dimension	1. Quality equivalent to that of competitor engines can be obtained in terms of fuel consumption, size and weight	○

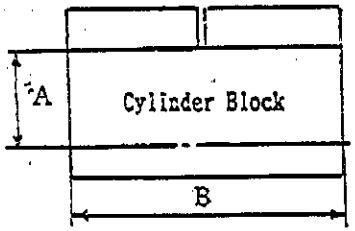
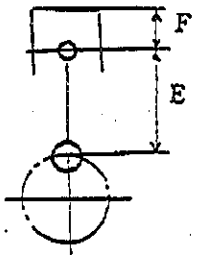
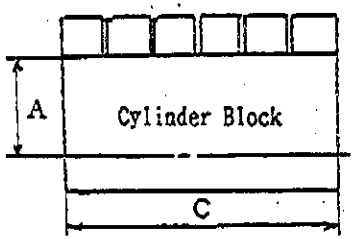
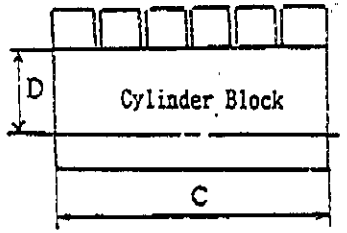
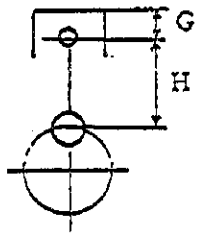
Table 4-2-2 Engine Body Improvement Alternatives

★ Features of 1 head/1 cylinder:

1) Low equipment cost (dies and machining equipment)
2) Castings easily made
3) Easy cutting of water channels
4) Low repair expense (parts, repair work)
5) Possibility of interchangeability of parts of future V-type engine
6) Disadvantage: larger number of parts

* Alternative B: Minor model change ☆ Alternative C: Full model change

Fig. 4.2.5 Engine Body Improvement Alternatives

Alternative A ✕	Alternative B, minor model change △	Alternative C, full model change ○
1. 2-valve type 2. Dimensions A, B, C, E and F the same as in the case of the present engine    Problems 1. Not much possibility of meeting the EURO-3 controls without engine body improvement	1. 4-valve, cross-flow type 2. 1 head/1 cylinder 3. Shorter C dimension 4. Change to high top ring piston   ← Features of 1 head/1 cylinder: . Low equipment costs (dies, machining equipment) . Castings easily made . Easy cutting of water channels . Low repair cost (parts, repair work) Problems 1. Inferior to competitor engines in terms of engine size and weight	1. ← 2. ← 3. ←  4. Shorter D dimension 5. Change of cylinder liner from dry to wet type  D = A - 51mm G = F - 19mm H = E - 32mm 

4.2.5 Consideration of Development Schedule and Rough

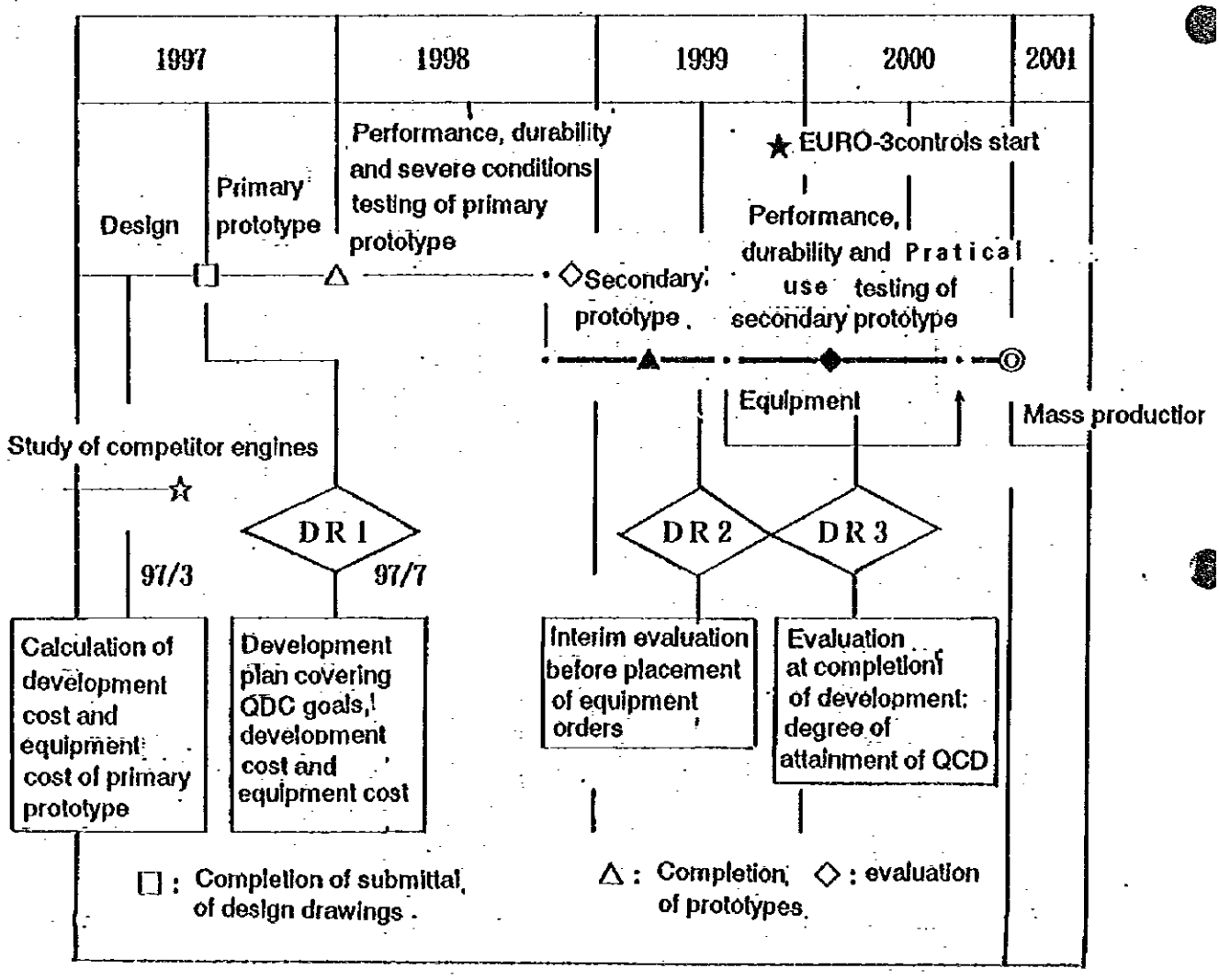
Development Cost and Equipment Cost

The development schedule and rough development cost and equipment cost were studied on the basis of the specifications for (1) meeting EURO-3 exhaust gas controls and (2) improvement of the engine body.

(1) Development Schedule

It was decided to have the development schedule include a secondary prototype since the selected alternative involves full model change of the engine body and development of sophisticated technological devices for meeting EURO-3 (see Table 4-2-3).

Table 4-2-3 Development Schedule



a) Aims of primary prototype

- Performance tests: selection of component parts for meeting EURO-3 (new injection system, turbocharger, etc.)
- Durability tests: determination of reliability and identification of problems
- Severe conditions testing: identification of problems of operation of engine under severe conditions, such as overrun and overheating (technology transfer concerning severe conditions testing has been accomplished at the time of the second field study)

b) Aims of secondary prototype: dealing with problems identified in testing of the primary prototype with a view to confirmation of possibility of practical use . Performance tests: checking of performance in testing of the engine on different vehicles type with a view to practical introduction of engine for meeting EURO-3
- Durability testing: confirmation of durability of prototype developed for the purpose of coping with the problems of the primary prototype . Practical use testing: installation of engine on different type of vehicles of clients and evaluation of actual performance

c) For reference
The new MD111E (for EURO-2) was developed with 10 prototypes representing only minor change for improvement of the cylinder heads of the engine body.

(2) Consideration of Rough Development Cost and Equipment Cost
In the conceptual stage without design planning drawings development cost and equipment cost have been roughly calculated on the following basis (see Table 4-2-4).

a) Noninclusion of increase in cost due to inflation in Poland.
b) Noninclusion of support from the KBN (State Scientific Research Commission).
c) More precise calculation of development cost and equipment cost in the next steps:
March 1997: At time of completion of design planning drawings
July 1997: At time of preparation of design plan (completion of design parts drawings)

Table 4-2-4 Rough Calculation of Development Cost and Equipment Cost

Unit: 10,000 zloty

Cost item \ Year		1997	1998	1999	2000	Total	Remarks
Dev. cost	Development equipment cost	150				150	PM measuring devices, *3
	Cost of prototypes	400	100	190		590	See *2
	Cost of testing				10	110	Cost of test parts, fuel, etc.
	Subtotal	550	100	190	10	850	
Equip-ment cost	Cost of dies	100		400		500	100: wooden dies 400: metal dies
	Machining equipment			1000	500	1500	See *1
	Subtotal	100		1400	500	2000	
Totals		650	100	1590	510	2850	

Table 4-2-4 Rough Calculation of Development Cost and Equipment Cost

Development person	15	20	30	20	

*1 Machining Equipment Unit: 10,000 zloty

Cylinder Block	1050 (= 175 x 6 machines)	Machining Center
Cylinder Head	350 (= 117 x 3 machines)	2 shifts, 3000 pieces/year
Connecting Rod	100 (= 100 x 1 machine)	Including tools and jigs
Total	1500	

As far as the investments to be made for working facilities are concerned, the amount required for new facilities has been calculated as shown above, based on the principle that existing facilities must be used to the maximum extent. For the concept applicable to facility investment, refer to the following Section 4-2-6 Concept of facility investment.

*2 Cost of prototypes 700 (= 46.7 x 15 prototypes)
Number of prototypes 15
Cost per prototype: 46.7 (= about 3.9 x Factor of 12)
Mass production price
Based on experience

*3 Development equipment cost 150 PM measuring devices, dilution tunnel

The Company does not have much of its own in the way of research facilities. Most of

those used are outside the company, as indicated in detail in 5.3.2, "Research Facilities." At the time of development of the EURO-2 engine they used the PM measuring facilities of Krakow University. However, for development of the EURO-3 engine, which will required still more advanced technological development, the Company will have to install its own PM measuring devices as an essential research facility.

(3) Outline of PM Measuring Device

A dilution tunnel is used for measurement of PM (particulate matter). After continuous adequate mixing of exhaust gas and diluted air in the tunnel, some of the mixture is scavenged in a suction filter at constant flow using a PM sampling device, and PM mass flow rate is obtained from the difference in weight before and after testing (see Fig. 4-2-8).

The dilution tunnel for all of the engine exhaust gas is a large facility that is hard to accommodate in the engine testing room. That being the case, there is a "branch-flow dilution tunnel," i.e. a smaller tunnel for dilution of a shunted part of the exhaust gas. The engine's exhaust gas is divided into separate flows by a divider consisting of a cluster of fine tubes all of the same form. One of the fine tubes, "the exhaust gas introduction tube," lead into the dilution tunnel, where the diluted gas is drawn at constant flow by a CVS device. Furthermore, improvement of distribution ratio precision is accomplished by installation, at the outlet of the exhaust gas introduction tube, of a structure that sprays appropriate quantities of clean high-pressure air by automatic control (see Fig. 4-2-6 and Fig. 4-2-7).

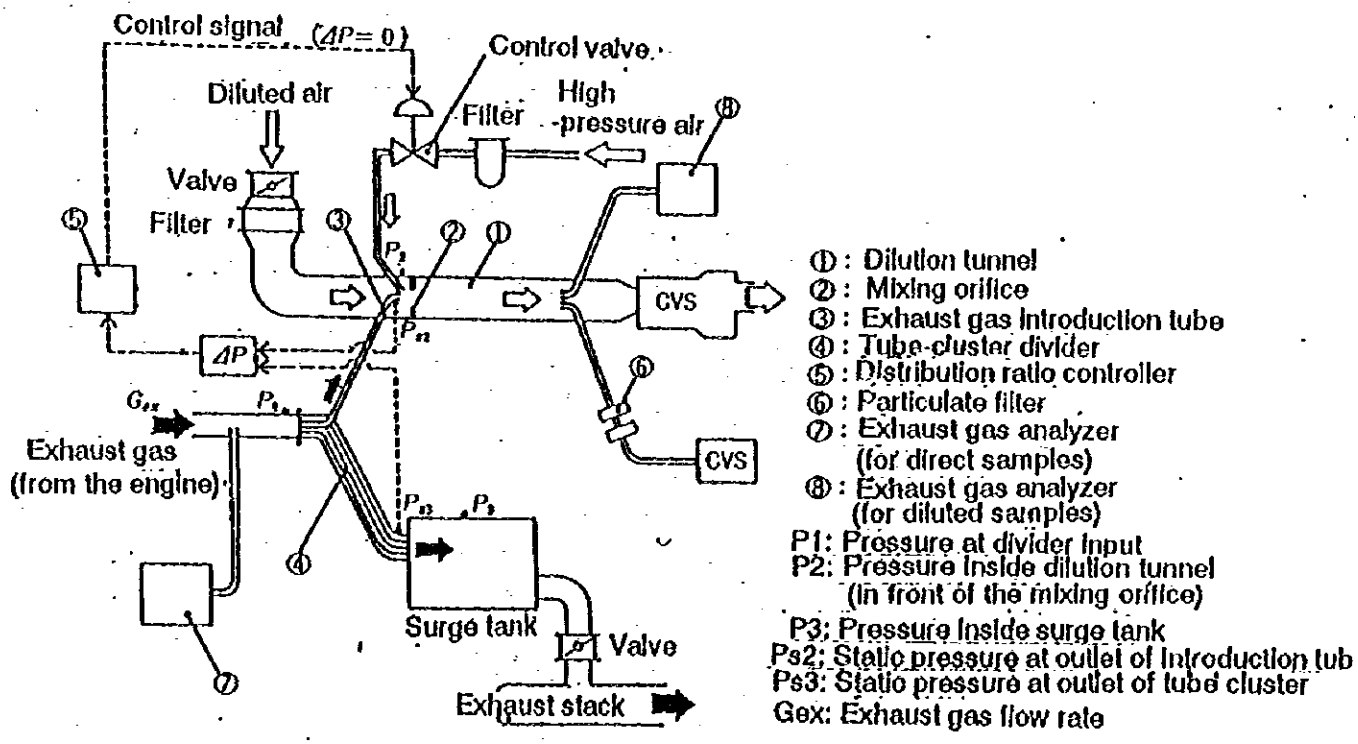


Fig. 4-2-6 PM Measuring Device (Dilution tunnel type)

Source: Automotive Diesel Engine

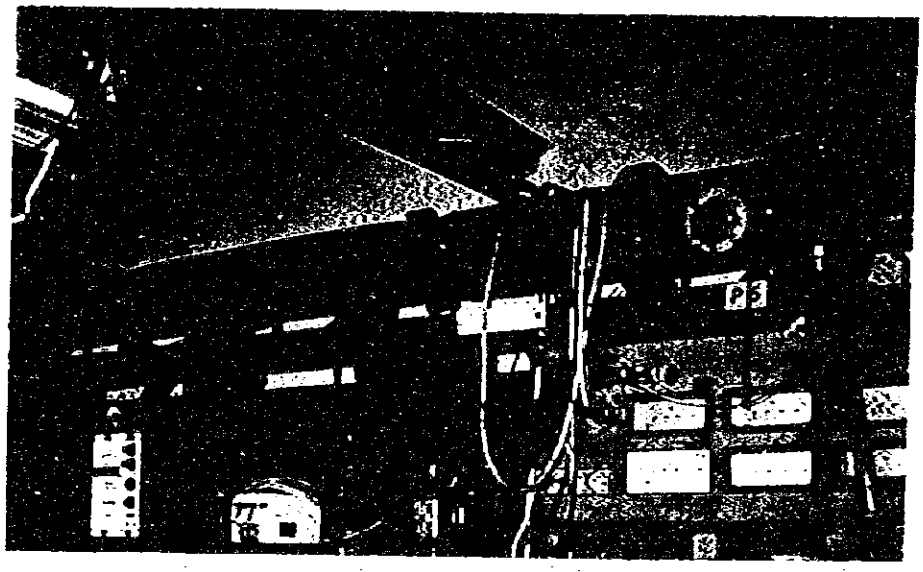


Fig. 4-2-7 PM Measuring Device (Krakow University), Dilution Tunnel Type

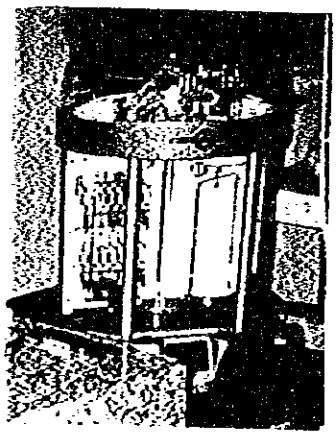


Fig. 4-2-8 PM Weighing Device

4.2.6 Consideration of Plant and Equipment Investment

Although at the present stage not very great improvement has yet been made in terms of production technology in efforts for production plant process improvement, two production engineers were included in the improvement teams this time, and one of them was promoted to production department chief at the time of the second part of the survey, which can be interpreted as an expression of the company's great resolve concerning its restructuring.

(1) Machining Plant

Improvement activities were undertaken with the cylinder block line as a model line, the main points being equipment maintenance and reduction of in-process inventory by keeping only 10 units on each of the three sublines at a time instead of the former 20 units.

As mentioned in section 12.4.2, the present machinery consists of about 380 main equipment items. Most of it is of old types, but considering past production volume, it can still be effectively used if better maintenance is implemented although efficiency is an entirely different matter.

Looking at Isuzu Motors' Fujisawa plant, for instance, one sees that even now the transfer line installed twenty-five years ago is effectively serving its purpose, which shows that if machining of the same type of engines is continued without major changes, such lines are capable of service for very long periods.

Since the long line at Mielec Engine that once produced 12,000 units a year is too large for the production volume of 3,000 units/year determined by the restructuring plans, a good possibility is that of considering how to make better use of it in terms of mixed production of new and old engines until such time as the new setup takes shape.

The draft equipment plan that we have presented calls for such a mixed production line consisting mainly of NC and MC machining equipment, and it is necessary to consider what combination of replacement of obsolete equipment, conversion to more internal production by changing divisions between internal and external product and other measures will be the best solution given the present equipment limitations, taking investment efficiency into account as well.

The company's production engineers say that they have no time to think about the future because they are now putting their entire effort into equipment improvements for commencement of production of a EURO-2 engine, but considering the fact that development of the EURO-3 engine will be starting this spring, equipment planning for it will also have to be started before too long, or it will be too late. Considering that, it would appear to be necessary to reinforce the company's production engineering staff.

(2) Engine Assembly Plant

Up to now the long 60-meter assembly line was moving at a speed of only 7 cm/minutes, but implementation of reduction of in-process volume in the improvement team activities this time has raised that speed to 14 cm/minute. Although that doubled line capacity,

production volume remains unchanged (8 engines/day with every other set jig).
Even with production volume of 3,000 engines/year and 50% reduction of total line length, production is more than possible. It would therefore appear to be advisable to raise space efficiency and undertake effective rationalization activities.

(3) The standard time table issued by the production technology department in the past is still being used by them without any updating. The production department, however, is not using it at all because to do so would only result in poor quality and claims since the figures set in it in the old days were considered and used as absolute production volume norms. Although the financial affairs department is using that table as cost accounting standards, there would appear to be considerable divergence between cost calculated on that basis and actual cost.
Since, as improvement work progresses, standard times will become important information serving as standards, ongoing follow-up regarding them is necessary to avoid problems. We made a considerable effort to explain that to them and were very emphatic in requesting that they act in that direction.

(4) Description of Equipment Investment
- Machining
As already mentioned, the lines presently are overequipped. However, complete revamping of them would not be the best policy. We consider, rather, that line efficiency should be enhanced by introduction of MC and NC machines concentrating on particular parts of the lines.
Since the workers on the lines now are all-around workers who can be employed in a flexible manner, it should be possible to work out a system whereby minimum investment yields maximum results.
For the cylinder block machining line, it should suffice to reinforce it with a couple of new MC machines.
As indicated in the example of Annex No. 15, an investment of about 250 million yen in the hexagonal cutting process and pentagonal boring process should be sufficient.
Other parts that undergo machining can be left as they are now, but since the equipment invested in will differ according to whether or not extension of internal production as opposed to outside production is promoted, the company's top management and its production technology department will have to consider that.
Inflation is also a relevant factor, but an investment of less than 500 million yen, including investment for model changes, should suffice.

- Assembly Department
Although the present assembly line is way too long considering its present production volume, there should not be any problem in leaving it as it is in terms of equipment in order to avoid inordinate increase in investment.
Nevertheless, a lot can be done in terms of space efficiency and elimination of unnecessary

quantity of labor without much investment, including reduction of the line to under half its present length, reducing the space it takes up by adopting a merry-go-round layout and securing places for setting parts to be added on the line side for feed thereof. Such possibilities should therefore be considered. The necessary investment for that would probably not exceed 30 million yen.

4.3 Development Technological Capacity

The technological capacity of the development department can be assessed as per the chart given below. On the whole it is characterized by a small number of "elite" personnel with long years of experience and who know their work inside out and by high number of cases of development output per person.
On the other hand, modernization of design in terms of EDP, CAD, experiment equipment, etc. and improvement on the control side in terms ISO design control and patent control are needed.

(1) Percentage of Personnel
The development department's staff strength is 72 persons, or approximately 10% of the company's total number of employees, which is lower than what it is in Japan in the same business (10-20%).

(2) Years of Experience
The average number of years of experience is twenty years in both the design section and the prototype and testing section, and the staffs of both consist of outstanding people who are well versed in their work.

(3) Testing Equipment
Test cell (8 chambers), hydraulic dynamometer, exhaust gas measuring device, combustion analysis device, vibration testing machine, six injection pump test stands

- ◆ Use of facilities outside the company
  - ◇ Krakow Institute of Technology: swirl measuring device, piston temperature measuring device, PM measuring device (of diverging-flow dilution tunnel type)
  - ◇ Aeronautical Research Institute: low-temperature testing chamber, noise testing chamber
  - ◇ The company Group WSK Facility: material analysis, chemical analysis

What is needed is modernization of testing equipment and other facilities.

(4) ISO 9001 Design Control
Among the company-wide activities for acquisition of ISO 9001 certification, documentation and design review regarding "design control," for which the development department is responsible are behind schedule. It appears that there is now a rough draft for documentation, but progress is not being made as planned.
The development department tends to place emphasis only on getting results, making light of development planning and the development process.

(5) Standardization

The company's design work is based on Polish Standards (PN) and ISO standards. However, they have not yet prepared internal standards such as design standards and compilations of actual examples of failures which can serve as accumulative design know-how and techniques.

Testing standards (standards setting testing conditions) have been set and are being used. Such testing standards require mention of the products to which they apply.

(6) EDP, CAD, CAM

EDP is making information retrieval easier and improving work efficiency on the basis of data base input of specifications.

Two CAD machines were introduced in 1995 and are being used for drawings approved by clients and new product development drawings. But they are not being used for such finite-element method (FEM) and other analytical techniques.

Furthermore, CAD and CAM are not connected.

(7) Important Research Themes

There is no particular implementation of such important research themes as predevelopment new technological development.

(8) Patent Control

There is presently no control of patent applications and patent infringements. Up to 1979 such control was carried out, but it has not been implemented since the rationalization measures at that time.

(9) Work Improvement

In the way of routine work improvement, editing design has been introduced and CAD input of parts group system drawings has been carried out for standardization of parts and improvement of design work. Improvement of design work has also been accomplished by applying editing design to assembly drawings as well.

A great deal of other improvement of design work is also in evidence, including that concerning method of control of entry and exit of kept specifications.

(10) Number of Cases of Development Output

The total number of cases of development output is thirty-four, which shows how high the production per employee of the development department is. The breakdown of that total number of cases of development output is as follows:

Ambulances	Generators	ECO engine	Gas engine	Engines for mounting on order basis	Engines for mounting on sales basis	Total
1	3	1	1	25	3	34

(11) Development Time

The development time is short considering the cases of development of ambulances, an ECO engine and engines for mounting on order basis.

(12) Cost Reduction Techniques

At the present time emphasis is placed on functional design for improvement of function. That should be changed to design for easy production putting emphasis on productivity. In other words, it is necessary to study value engineering and teardown techniques and change to design for raising productivity.

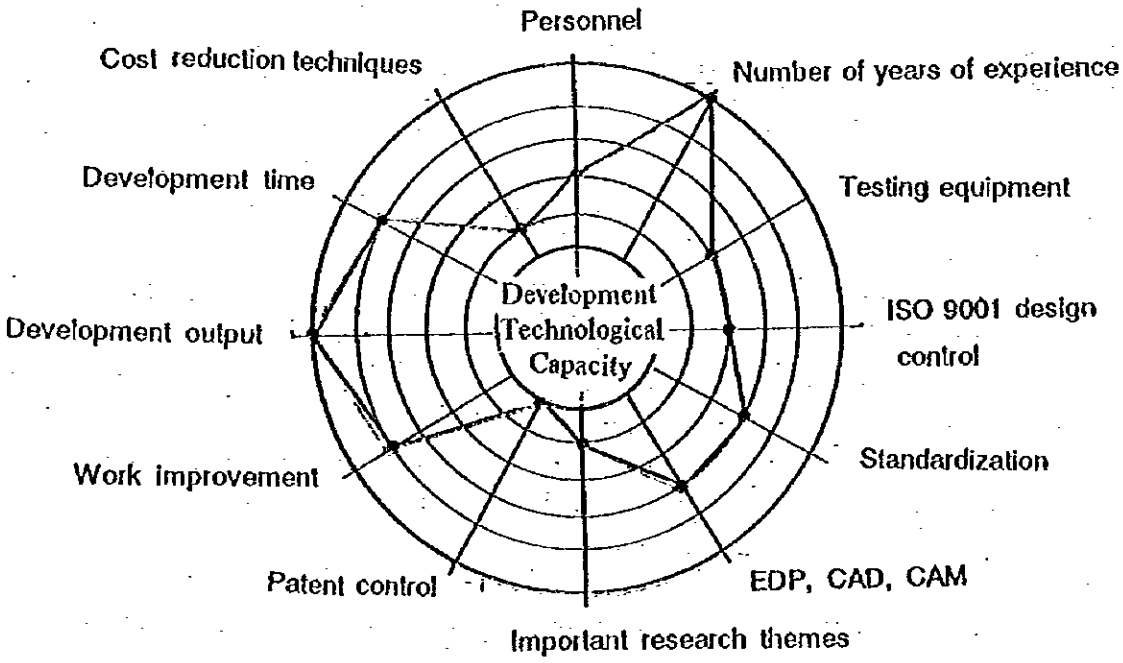


Fig. 4-3-1 Development Technological Capacity

4.4 Improvement of Development Work

4.4.1 Problems of Development Work

As mentioned in 5.2.1, the Company's research and development system does not have the functions development control and technology control. Hence the following problems concerning it:

(1) Problems Concerning Development Control
In the company's efforts toward acquisition of ISO 9001 certification the situation regarding percentage of completion of establishment of the necessary documents for each department and section is poor, it being 0% for four sections, and so far there has been no preparation, approval and design review of development plans concerning design control as required by ISO 9001. Problems concerning development are being addressed individually, but there is no company-wide development system.

(2) Problems Concerning Technology Control
Acquisition of patents and investigation of possible patent infringements are presently not being done. They were implemented before the Company split up but not since then. Furthermore, development budget, personnel, information, drawings and technical standards control is poor.

4.4.2 Improvement of Development Work

The company has a small number of "elite" development control and technology control functions under the direct control of department chiefs.

(1) Role
a) Establishment of documents required by ISO 9001 and promotion of development plans and design review
b) Acquisition of patents and investigation of possible patent infringements
c) Development budget and development personnel, information, drawings and technical standards
d) It has been suggested that, besides the department or section head, about three capable individuals be hired after retirement age for such work.

(2) When to Be Implemented
Starting with commencement of important development work on the EURO-3 engine in 1997.

4.4.3 Research and Development System

The new research and development system will be as indicated below (in Fig. 4-3-1).

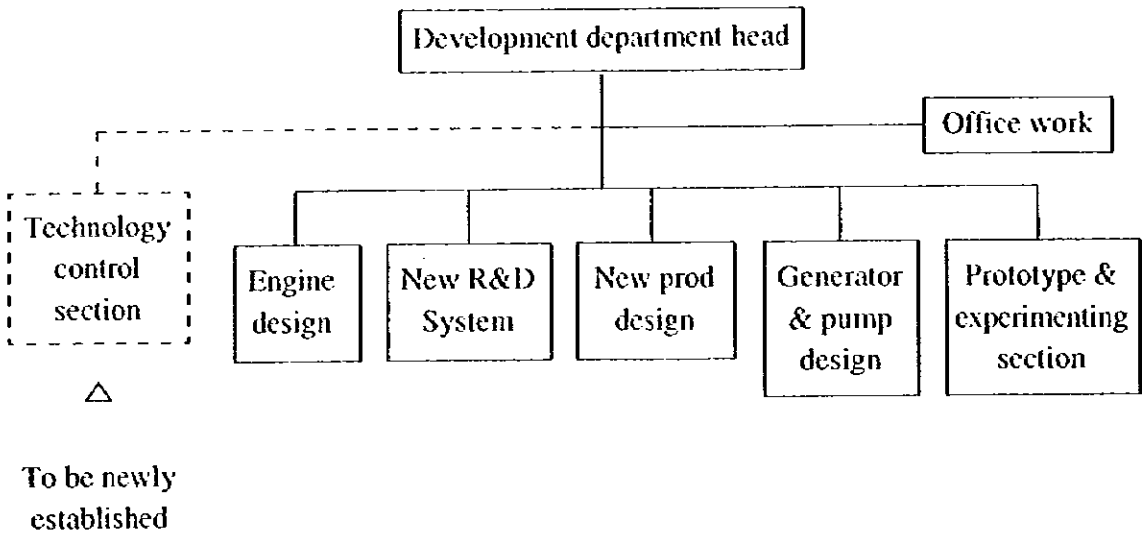


Fig. 4-4-1 Research and Development System

5 Restructuring Plans for Mielec Engines Company

5 Restructuring Plans for Mielec Engines Company

5.1 Review of Current Restructuring Plans

The restructuring of Mielec Engines Co. has been in development independently since April 1993, when the Company separated from its parent Company, WSK PZL-Mielec. Specifically, the Company began operation with 713 employees from the previous 1,091 persons employed right before the separation.

Two departments, finance and accounting and one other for marketing and product development, were newly established after the separation. Regarding new product development, a small sized generator was marketed in 1995 followed by an ambulance in 1996 in addition to the conventional OEM products such as diesel engines. Entry into the end-user market is a new experience for the Company, although these products were developed by applying technologies the Company already owned.

A series of the restructuring efforts by Mielec Engines Co. has not been guided by a mid-and long-term plan, but carried out on year-to-year decision of the company's management. Difficulties in adjusting to the changing environment always provide an excuse why Mielec Engines Co. has not developed mid- and long-term corporate business plans. From a viewpoint that mid- and long-term planning is vital in order to cope with environmental change by taking a risk. The Company faces the urgent issue of development of Euro-3 engines (new product), which requires a considerable amount of investment by the year 2000. The research and development for the engines may also take several years. The Company, therefore, recognized to the importance of mid-term planning, elaborating strategies in financing, production and marketing.

For the purpose of developing and implementing a new restructuring plan of Mielec Engines Co., the study team recommended the development of a restructuring committee in cooperation with the study team. The Company established a restructuring committee. The committee consists of the president of the Company, directors and representatives from production and production technologies, product planning and marketing, and finance.

The following plans and recommendations are based on the discussions made jointly with the committee and the study team.

5.2 New Restructuring Proposal

5.2.1 Development of Restructuring Plans

Fig. 5-2-1 gives a conceptual flow of restructuring planning, and Fig. 5-2-2 explains the development procedures, which follow.

(1) Define the market positioning of products and illustrate on a portfolio diagram for the year 1996.
(2) Produce alternative portfolios from mid-term perspectives and/or the bare minimum for the Company to survive in the market.
(3) Conduct simulations according to the goals and prerequisites. (Simulation is defined as a tool which evaluates the applicability of each scenario.)
(4) Identify and analyze Key Success Factors (KSF) by type of products.
(5) Evaluate the competitiveness of the products focusing on the KSF. Also identify the capabilities for achieving goals and the shortcomings of the Company.
(6) Discuss the results of simulations and evaluation of competitiveness with top management of the Company. Then determine specific goals and strategies.
(7) Develop a mid-term corporate business plan and prepare implementation programs.

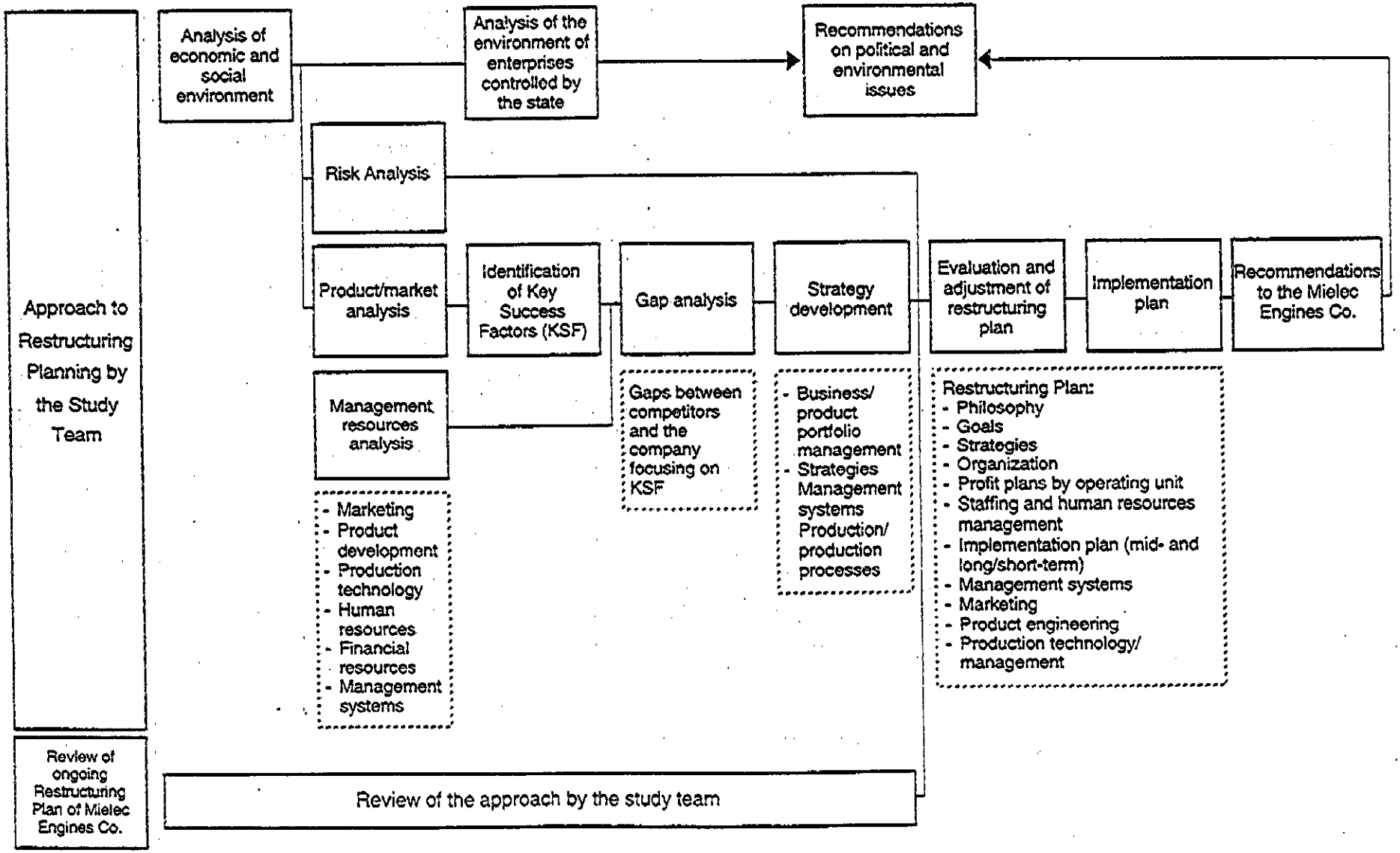


Fig. 5-2-1 Conceptual Diagram of the Restructuring Plan of the Enterprises Controlled by the State

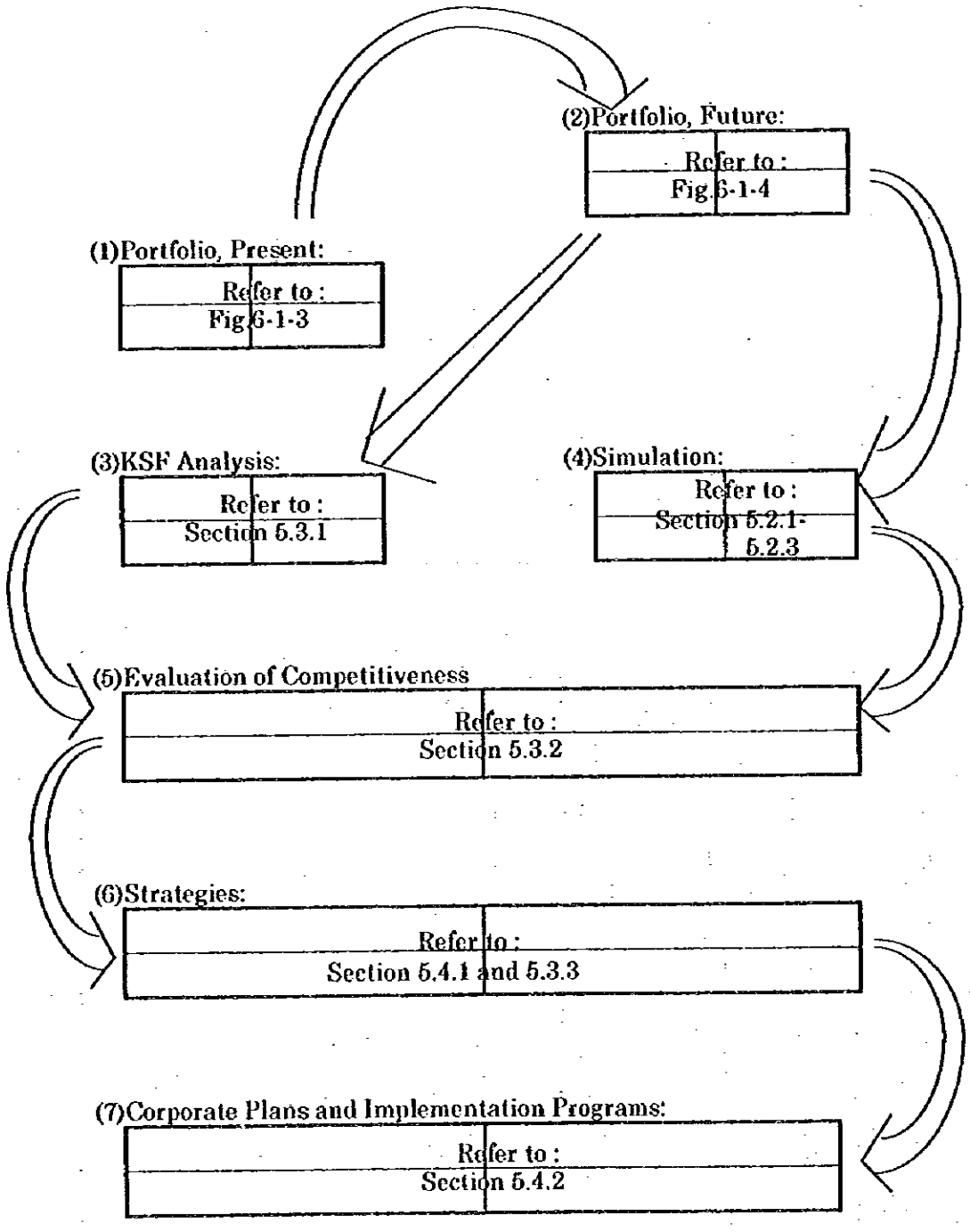


Fig. 5-2-2 Development of Restructuring Strategy

5.2.2 Scenarios of Restructuring and Prerequisites

5.2.2.1 Assumptions and Prerequisites

(1) Background of Scenarios

The target year is 2001. Strengthening of regulations on air contamination, particularly for Nox, and shifts to high powered engines will be demanded by the target year. Major competitors are expected to market new engines which meet Euro-3 standards.

Diesel engines will be the core of business for Mielec Engines Co. Harsh competition foreseen in the central and eastern Europe, and government policies for liberalizing the economy may lead to withdrawal from the engine business, if the Company fails in product development and marketing strategies including export development.

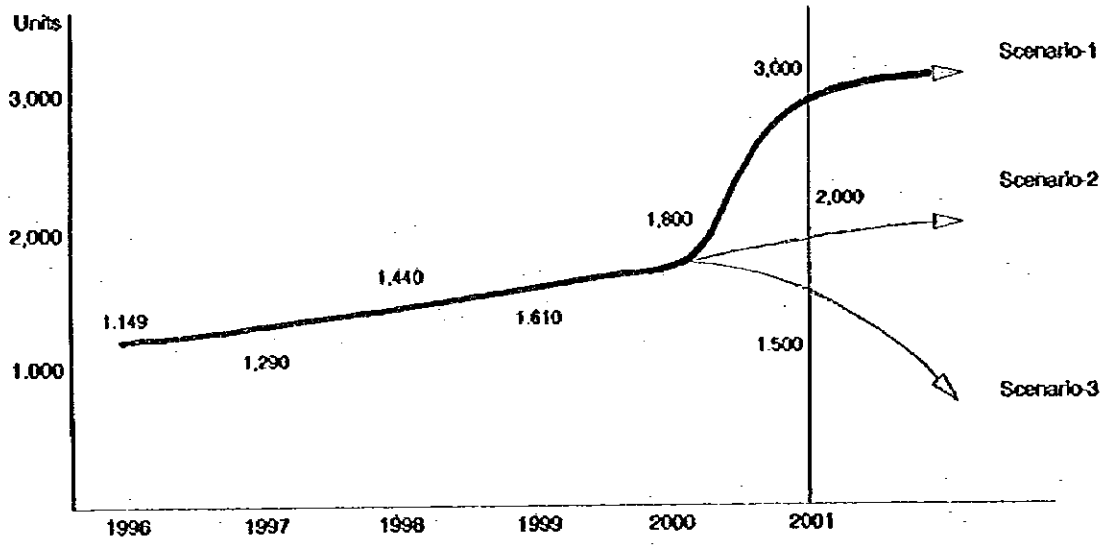
(2) Assumptions

Three scenarios are described on the basis of engine units. Estimating the current level of engine sales of 1,149 units a year, the sales is assumed to be 1,800 units in 2000 for every scenario, and, in 2001, 3,000 units for Scenario-1, 2,000 units for Scenario-2 and 1,500 units for Scenario-3 (See Fig. 5-2-3). However, The growth in sales value will go down according to the increase of exports and the decline of unit prices for exports.

In estimating the future growth of automotive industries in Central and Eastern European countries, the engine sales of Mielec Engines Co. is expected to be 3,000 units by the year 2001. Scenario-1 assumes that the Company will remain in the market as a major supplier, exporting substantially to these countries. Scenario-2 with 2,000 units of engine sales assumes that the Company provides engines mostly for domestic markets. Scenario-3 reflects remaining at the current level with a minimal sales growth in engines.

Sales of Euro-2 engines is foreseen to increase steadily during the period 1997-2000. A sudden sales increase of new engines (Euro-3) in 2001 may not happen if the Company loses market share and/or does not make any serious efforts on the development of export businesses.

Total sales of the Company will be doubled in Scenario-1 (the most challenging). Sales of other products and services is assumed to be the same level for every scenario in terms of value.



Sales forecast: (* PLN, ** PLN 1000)

Scenario-1

Year	1996	1997	1998	1999	2000	2001
Units (1)	1,149	1,290	1,440	1,610	1,800	3,000
Unit price* (2)	22,035	21,400	20,800	20,200	19,600	19,000
Sales** (1*2)	25,318	27,606	29,952	32,522	35,280	57,000

Fig. 5-2-3 Simulation: Scenario 1-3

(3) Prerequisites

For successful development of Euro-3 engines, total investments are expected to require PLN 28.5 million, including PLN 8.5 million for R&D and PLN 20.0 million for production facilities during the projected period. Details of investment was discussed in the section, 4.2.

Other prerequisites are as follows:

- Material cost will be cut 5% a year by conducting cost reduction activities.
- Fifty percent of productivity increase, 2.5% a year in this instance, will be rewarded to employees for cooperation of productivity improvement.
- Cost reduction effects according to the experience curve are not incorporated. Relative costs to sales differs by product, however, the cost ratio on average is assumed not to change during the subject period.
- Number of employees will remain by increasing the efficiency of operations and the maximum utilization of current facilities for production.

(4) Remarks

- All expected values for the projected years are presented with a fixed price, the 1996 price, hereafter. Inflation is not counted in forecasting.
- Base year is placed in 1996. Basis of computation is on the financial results from 1995, specifically, the cost structure of 1995 is used for computation on the estimated sales in 1996.

5.2.2.2 Scenarios in 2001

Fig.5-2-2 gives the scenarios in the target year 2001.

- Scenario-1: Development of Euro-3 engines and successful in strengthening competitiveness with increased market share. Produce 3,000 engines in the target year.
- Scenario-2: Development of Euro-3 engines, but not strengthening competitiveness. Produces 2,000 units in target year 2001.
- Scenario-3 Fails in product development and marketing. Withdrawal from the engine market will be scheduled. 1,500 units are produced in the target year.

Products and services other than engines are assumed to be as follows for each scenario: (in PLN 1000)

- Generators	9,000
- Ambulances	8,000
- Others (parts production and repair services)	23,400

5.2.2.3 Prospective Types of Engines in 2001

Discussions in previous sections assume the production of current engines, Euro-1, i.e. the other types or new engines such as Euro-2 and Euro-3 are computed on the unit converted to Euro-1 engines. This section will confirm a prospective product mix of the Mielec's engines which would be most likely in the year 2001 and also confirm the assumptions for further discussions.

The types of engines the Company would provide in 2001 would be determined by the following alternative environment in the market, specifically,

(1) Euro-3 engines dominate.
(2) No more production of Euro-1 engines.
(3) Euro-2 engines still active.
(4) All 3 engines remain.

Discussions with management concluded that, theoretically, Euro-3 dominates, however, because of the deferred enactment of exhaustion regulations and continuing demand for existing engines, Euro-2 engines will still be on the market. Meanwhile, Euro-1 engines will be virtually gone by 2001.

Assuming the company's sales of engines hits the same level as Scenario-1, 57 million PLN, the product mix of engines in the year 2001 would most likely be a combination of two engines, Euro-3 engines and Euro-2 engines.

Further discussion in this report will follow the conversion basis on Euro-1 engines. It should be confirmed that engine sales would be lower in terms of units in the year 2001. Levels of sales and the cost structure of products in total are assumed to be the same as the statistics shown in the previous discussions, even if the product mix and number of units to be sold are changed.

5.2.3 Simulation and A Proposal of New Restructuring Plan

5.2.3.1 Application of Simulation and Results

Simulation used here focuses primarily on whether the necessary cash flow for investment on R&D and production facilities could be financed in the Company. The outcome is shown in Fig. 5-2-4.

Scenario-1, a plan for doubling sales, may generate cash flow particularly after new engines are introduced. Scenario-2, regardless the cash flow by 2000, may raise a question whether it could maintain its position in the market without any offensive counter-activities. Regarding Scenario-3, it may not justify investments on production facilities of engines, and will reduce the effectiveness on generators which use the company's own engines. The survival of the Company will be the question.

5.2.3.2 A Proposal to Mielec Engines Company

(1) Proposals

Scenario-1 is recommended for the Mielec Engines Company to pursue in the target year 2001, achieving a doubling of sales at an engine production level of 3,000 units. The Company will be a major player in the engine business in the Central and Eastern European markets. Active also in generator sets and ambulances.

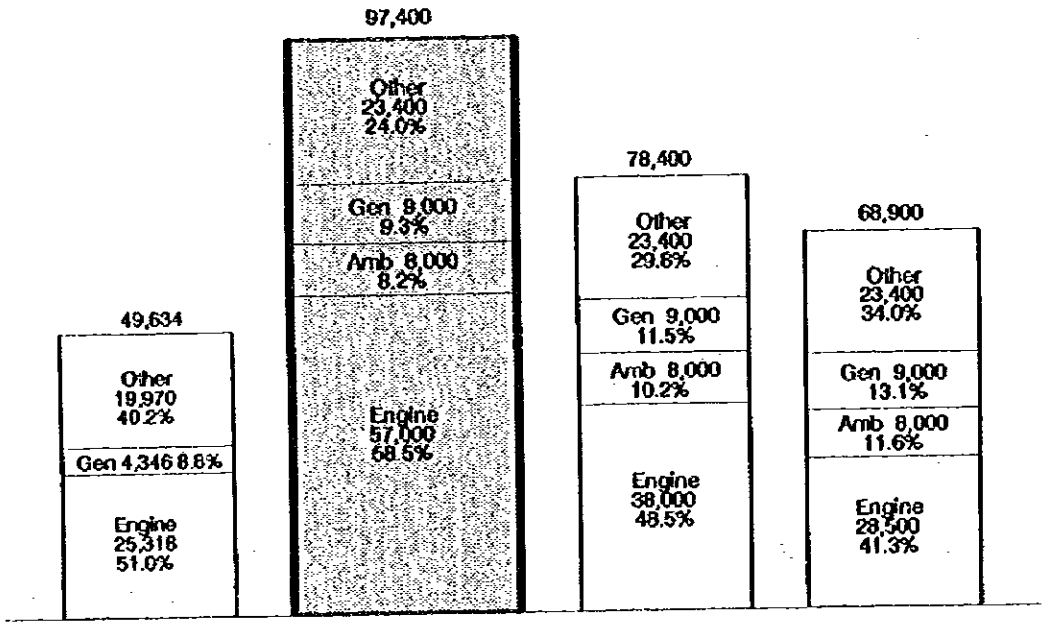
Competitiveness evaluation of the Company has concluded, as discussed in the section 5.3, that the Company is able to accomplish the goals of Scenario-1. However, several assumptions with regard to funding to accomplish the required investment must be satisfied for the Company to achieve the goal. The assumptions include:

- Investments on R&D and production facilities for Euro-3 engines will be made for the period 1997 through 2000. Funds from outside sources should definitely be obtained in 1997 and particularly in the year 1999.
- The Company enters Euro-Park and will gain the benefits. Impacts on cash flow would be enormous.
- Dividend and profit bonuses for employees will be a minimum level of 450,000 PLN, at greatest, a year in totals until 2001.

Table 5-2-1 indicates the funding from outside sources, strategic investors and/or banks, is required. Tables 5-2-2 through 5-2-4 explain the computation basis of cash flow and a series of investments. A forecast of balance sheet and an overall cash flow, including operating capital for each of the projected years until 2001, are presented in Tables 5-2-5 and 5-2-6.

PLN 1000

1996 (Est.)	Scenario-1	Scenario-2	Scenario-3



Sales Breakdown:

Scenario-1

Year	1996	1997	1998	1999	2000	2001
Generators, ambulances, others	24,316	26,915	29,791	32,975	36,499	40,400
Engines	25,318	27,300	29,300	31,400	33,600	57,000
Totals	49,634	54,215	59,091	64,375	70,099	97,400

Fig. 5-2-4 Simulation: Scenario in 2001

PLN 1000

	Capital Investment		Cash Flow		Gaps
	Annual (1)	Cumulative	Annual (2)	Cumulative	Annual (2-1)
1997	1,500	1,500	366	366	-1,134
1998		1,500	3,188	3,554	3,188
1999	14,000	15,500	3,998	7,552	-10,002
2000	5,000	20,500	9,585	17,137	4,585
2001		20,500	19,753	36,890	19,753
Totals	20,500		36,890		16,390

* Assumes Scenario-1.

Table 5-2-1 Gaps between Investment and Cash Flow*

Table 5-2-2 Computation of Cash Flow*

PLN 1000

	1996	1997	1998	1999	2000	2001
Sales (1)	49,634	54,215	59,091	64,375	70,099	97,400
Materials (2)	25,032	26,307	27,659	29,034	30,547	42,053
Labor cost (3)	10,979	11,254	11,539	11,825	12,121	12,417
Depreciation (4)	628	683	735	1,725	3,090	3,405
Interest (5)	199	300	200	1,000	1,600	700
R&D cost (6)		4,000	1,000	1,900	100	
Others (7)	11,510	12,548	13,679	14,912	16,256	22,587
Total costs (8) (1...7)	48,348	55,092	54,812	60,396	63,714	81,162
Non-operating profit (9)	260	560	560	560	560	560
Profit (10) (1-8+9)	1,546	-317	4,839	4,539	6,945	16,798
Net profit (11) (10*60%)	815	-317	2,903	2,723	6,945	16,798
Dividend and profit bonuses for employees (12)	300	0	450	450	450	450
Cash Flow (11+4-12)	1,143	366	3,188	3,998	9,585	19,753

Remarks:

* Assumes Scenario-1.

(2) Refer to Table 5-2-2-A.

(9) Land tax (rent) exemption. Assumes entering Euro-Park.

(11) Profit in 1996 is the actual figure. Assumes no corporate income tax for the year 2000 and 2001.

(12) The amount in 1996 was for the dividend of 1995. An absolute minimum level is assumed to be paid out.

Table 5-2-2 Computation of Cash Flow*

PLN 1000

	1996	1997	1998	1999	2000	2001	2001
Mairials totals (a+b)	25.032	26.307	27.659	29.034	30.547	42.053	33.023
	c	c*d	c*e	c*f	c*g	c*h	c*i
Engines (a)	13.417	14.088	14.813	15.538	16.342	27.116	18.086
Mat. increase (1)	1.000	1.073	1.152	1.236	1.327	2.251	1.501
5% cut of mat. (2)	1.000	0.950	0.903	0.857	0.815	0.774	0.774
Mat. increase. 3% (3)	1.000	1.030	1.061	1.093	1.126	1.160	1.160
(1) * (2) * (3)	1.000	1.050	1.104	1.158	1.218	2.021	1.348
		d	e	f	g	h	i
	j	j*k	j*l	j*m	j*n	j*o	j*p
Other (b)	11.615	12.219	12.846	13.497	14.205	14.937	14.937
Growth (4)	1.000	1.107	1.225	1.357	1.501	1.661	1.161
5% mat. cut (5)	1.000	0.950	0.903	0.857	0.815	0.774	0.774
(4) * (5)	1.000	1.052	1.106	1.162	1.223	1.286	1.286
		k	l	m	n	o	p

Remarks:
(1) (4) In proportion to sales increase, 7.3% a year, by 2000.
(3) Cost increase according to the unit cost decline of engines.

Table 5-2-2-A Materials Cost Forecasting

PLN 1000

	1997	1998	1999	2000	2001	Totals
R&D:						
Equipment (1)	1.500					1.500
Costs (2) *	4.000	1.000	1.900	100		7.000
Production facilities:						
Molds						
(3) wood/(4) metal	1.000		4.000			5.000
Equipment (5)			10.000	5.000		15.000
Capital investment (1). (4). (5)	1.500		14.000	5.000		20.500
Costs (2). (3)	5.000	1.000	1.900	100		8.000
Totals (1)... (5)	6.500	1.000	15.900	5.100		28.500

* Does not include personnel costs for research and development.

Table 5-2-3 Investment on R&D and Production Facilities

PLN 1000

	Capital Investment	Depreciation* 1997	1998	1999	2000	2001
Test equipment	1,500	113	225	225	225	225
Molds	4,000			300	600	600
Production facilities	10,000			750	1,500	1,500
Production facilities	5,000				375	750
Totals (1)	20,500	113	225	1,275	2,700	3,075
Existing facilities (2)		570	510	450	390	330
Grand total (1+2)	20,500	683	735	1,725	3,090	3,405

* 15% of straight-line depreciation is assumed on average.

Table 5-2-4 Depreciation

PLN 1000

	1996	1997	1998	1999	2000	2001
Assets:						
Fixed assets	8,178	8,995	8,260	20,535	22,445	25,938
Current assets	15,321	16,735	18,240	19,871	21,638	30,065
Totals	23,499	25,730	26,500	40,406	44,083	56,003
Liabilities and stockholders equity:						
Stockholders equity	18,042	17,725	20,178	22,451	28,946	45,294
Liabilities other than loans	5,457	5,961	6,322	7,078	7,707	10,709
Loans	0	2,044	0	10,877	7,430	0
Totals	23,499	25,730	26,500	40,406	44,083	56,003

Table 5-2-5 Balance Sheet - Forecast

PLN 1000

	1997	1998	1999	2000	2001
Sources:					
Net profit	-317	2,903	2,723	6,945	16,798
Depreciation	683	735	1,725	3,090	3,405
Loans	2,044		10,877		
Totals	2,410	3,638	15,325	10,035	20,203
Applications:					
Investment	1,500		14,000	5,000	
Change of working capital	910	969	875	1,138	5,425
Loans, repayment		2,044		3,447	7,430
Devidend, bonuses		450	450	450	450
Totals	2,410	3,463	15,325	10,035	13,305
Cash surplus	0	175	0	0	6,898

Table 5-2-6 Cash Flow Expectation

The amount of investments indicated in Table 5-2-1 is a rough estimate based on the discussions with responsible persons of the Company. The amount may be modified in the course of drawing new engine designs, which is expected to be drafted in March 1997 and at the time of its completion in July also in 1997.

(2) Evaluation of the Investment Decision

An investment for the development of Euro-3 engines has a key for Mielec Engines Co. to continue its engine manufacturing business. The importance, of course, does not justify the investment. This section an examination from the financial management viewpoint essentially based on the generation of "cash flow" will discuss whether the prospective investment would be justified or not under the condition of Scenario-1 and Scenario-2.

Cash flow to be used for investment decision is a cash inflow which would be generated purely from the subject investment. Cash flows which have already discussed in the previous sections is a composite incorporating those generated not only by the investment on production facilities but also by other efforts and outcomes such as sales increase, materials cost reduction and any other fruits from management improvements. Study team estimates the contribution of the investment against total cash flow judgementally by fifty-fifty. Cash flows for investment evaluation in this section will be defined as follows:

a. Cash flow in Scenario-1: PLN 5,000,000
Total cash flow after investment - PLN 19,753,000 ..... (a)
Total cash flow before investment - PLN 9,585,000 ..... (b)
(a)-(b) = PLN 10,168,000 ..... (c)
Contribution of the investment against total cash flow 50% ..... (d)
(c)x(d) = PLN 5,084,000 (approx. PLN 5 mil.)

b. Cash flow in Scenario-2: PLN 600,000
Total cash flow after investment - PLN 10,784,000 . ..... (e)
Total cash flow before investment - PLN 9,585,000 . ..... (f)
(e)-(f) = PLN 1,199,000 .... (g)
Contribution of the investment against total cash flow 50% .. .. (h)
(g)x(h) = PLN 600,000

Table 5-2-7 gives the results of evaluation, using four principal methods.

PLN 1000

Methods*	Results Scenario-1/Scenario-2	Judgement
a. Payback period	4.1yrs/34yrs	Attractive with faster recovery (Sc-1). Out of question, too long (Sc-2).
b. NPV (Net present value)	PLN 24,350/ PLN 4,200	Larger than investment PLN 20,500 (Sc-1). Sc-2 could not justify investment.
c. IRR (Internal rate of return)	15%/1%minus	Much higher than the rate usually expected in the market (Sc-1). Extremely low in Sc-2.
d. ROI (Return on investment)	9.8%/minus%	On an average level of return Sc-1). Out of question for Sc-2.

*Formulae:

a. Payback period = Amount of investment / Cash flow x 7yrs
(Assumes cash flow continues for 7 years.)
b. NPV = Present value of Cash flow x 7yrs (Assumes capital cost of 10%)
c. IRR : An interest rate at the level,i.e. Initial investment = Present value of cash flow, or NPV = 0
d. ROI = (Cash flow - depreciation) / Amount of investment

Table 5-2-7 Evaluation of Investment

Payback period method (a) is used commonly to estimate how many years it will take to recover on investment. NPV and IRR are a method which takes the "present value" concept into consideration for measuring the levels of cash flows in terms of value (PLN) and percentage, respectively. ROI is a common method based on the return (profit) against the investment compared with the one which can be gained in the market. It is recommended making decision on investment by employing several alternative methods.

The evaluation clearly indicates to go ahead with Scenario-1, but does not justify Scenario-2. In case of Scenario-2 or the engine production of 2,000 units may lead to a different alternative that will be indicated in the forthcoming section, Contingency Planning.

From a cost savings point of view, the investment of 28.5 million PLN is not justified. Two out of 13 workers in the subject machining process are expected to be cut. The following computation shows the evaluation between cost before and after the investment.

- Before investment:
  Costs for the machining process (800PLN x 12 months x 13 persons) — PLN 124,800 ..... (1)
- After investment:
  investment — PLN 28,500,000
  Costs for the machining process (800PLN x 12 months x 11 persons) — PLN 105,600
  Annual costs (Present value) — PLN 5,957,756..... (2)

Cost (1) is smaller than Cost (2), therefore , the investment is not justified.

Remarks;

- Economical life of equipment is assumed 7 years and 10% of capital cost.
- Equipment which has an impact on cost savings, two machining centers, 6.25 million PLN of the total 28.5 million PLN.

Cost savings generated by the investment alone do not justify the investment. The above computation shows efforts in increasing sales and modernization of management, both in production and administration, and the subsequent increase in cash flow would also be vitally important.

5.3 Competitiveness Evaluation of Mielec Engines Company

5.3.1 Corporate Goals and Key Success Factors (KSF)

Factors which are most important for a Company to survive in the market is defined as Key Success Factors (KSF). KSF will be identified and analyzed for each product group of Mielec Engines Co. in this section. Further, in the next section, the strengths and weaknesses with respect to the KSF of the Company will be evaluated.

KSF of the products and services the Company provides is identified from the viewpoint indicated in the following questions. Those questions include:

(1) what are the important factors for the products and markets,
(2) what factors are most critical in each management function including designing, production and marketing,
(3) what are the important factors according to the stage of life cycle of the product,
(4) which cost and/or value added of the product are the largest in terms of absolute value of the Company total, and
(5) what are the factors the user determines purchase decisions.

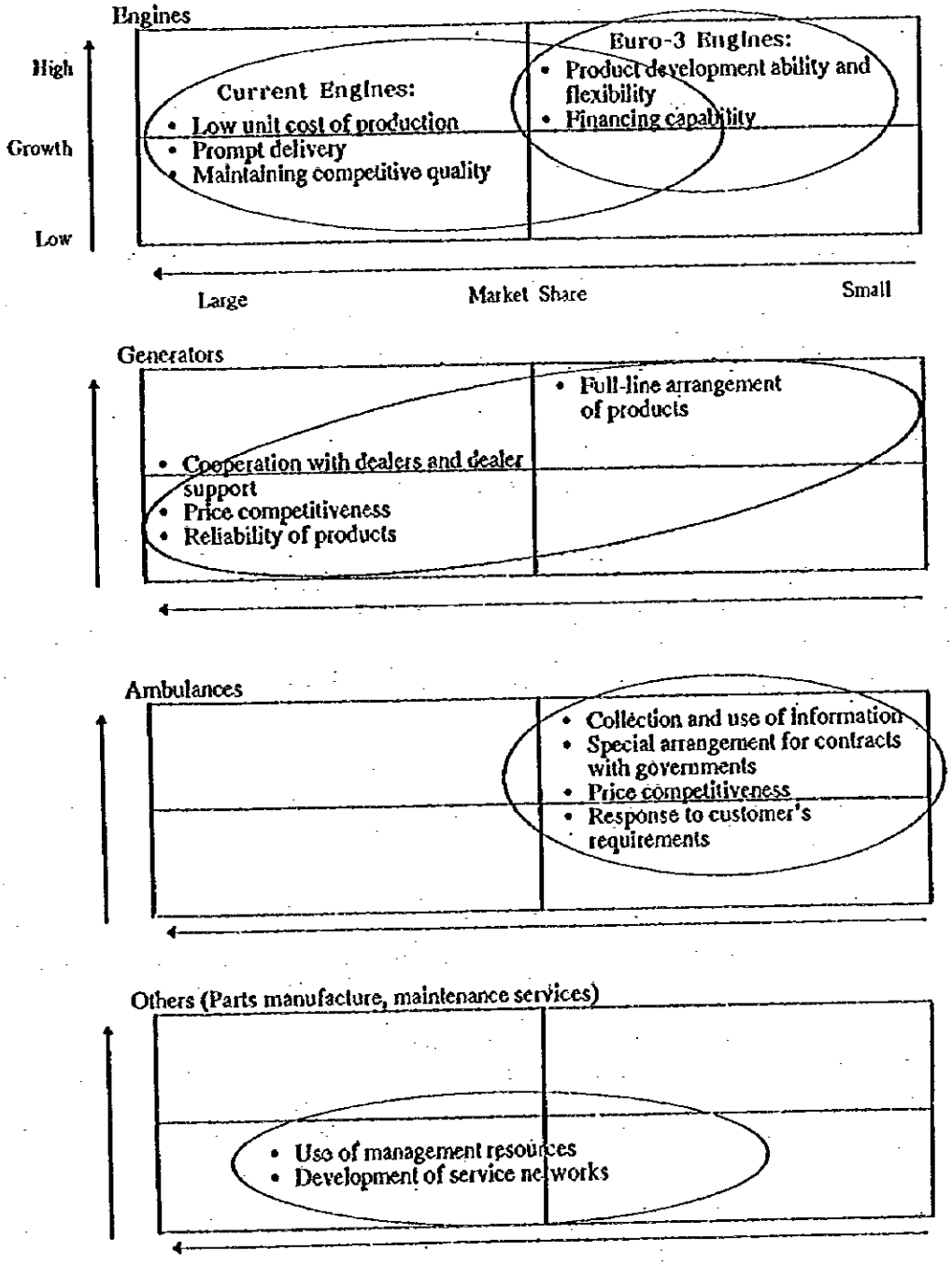
KSF are determined by a group of people experienced primarily in product development and marketing. The above questions may provide different views of a product and/or market, helping to facilitate identification. In engine businesses, "product development ability" of Euro-3 engines, for example, is most important at the initial stage of products life cycle, they should be followed by an investment on production facilities, in other word, "financing capability". At the mature stage, "low unit cost" of engines, Euro-1 engines for instance, would be most important since the technologies are already well known in the market.

A preliminary study that the team conducted in Japan before visiting Poland identified a series of KSF regarding the products of the Company based on experiences of the team in Japan and overseas. The following KSF derives from the data and information obtained in Poland in August and September and the preliminary study in Japan. Fig. 5-3-1 places the KSF at the one sphere of a quadruple square where the product meets most appropriately.

A summary will follow by product group.

(1) Engines: Dual directions are indicated. First, development and marketing of new engines (Euro-3), and, second, in the product improvements and sales promotion for the existing products and markets. Regarding the former, "product development and flexibility" and "financial capability," which are required particularly at an early stage of product growth, are the KSF. For the latter, "low unit cost for production" and "prompt delivery" are identified as KSF for sustaining the share or penetrating further into the market. "Maintaining competitive quality" may also be the KSF as a fundamental factor.

(2) Generators: KSF includes "full-line arrangement of products" and "cooperation with dealers and dealer support" (particularly for smaller type products) for establishing sales and service activities firmly in the market. "Price competitiveness" and "reliability of products" are also important both for new and current products in this competitive market.



Remark: Oval indicates the location of products and services in the market.

Fig. 5-3-1 KSF by Major Product

(3) Ambulances: "Collection and use of information" must be achieved first in order to know the users and competitors. At the entry stage when penetration into the market has not yet been satisfactorily achieved, this factor would be critical, otherwise, the business could not start up. "Price competitiveness" and "response to customer's requirements" may follow. In-house production of parts and sourcing strategies would be the issue to be discussed for strengthening price competitiveness.

(4) Others (including part processing and maintenance services): These businesses are in the mature stage. "Use of management resources" such as idle production facilities must be KSF. Management resources may also include human resources. "Service networks" will follow.

5.3.2 Strengths and Weaknesses

Strengths and weaknesses of Mielec Engines Co. are analyzed and evaluated in relation with the KSF which was discussed in the previous section. Management systems and factors not listed in the KSF previously identified are also discussed.

Fig. 5-3-2 shows the evaluation of KSF based on the judgement of the study team.

Assuming the satisfaction level is "2" in the Exhibit, the lower evaluation or marks may be encouraged to be shifting ultimately to the level "2." The key is, therefore, whether the gap between the evaluated marks and the level to be achieved could be eliminated. The product would be taken out of the market because of only a single item which could not achieve its target.

The following will summarize a conclusion regarding countermeasures for shortening the gaps of major KSF. It ends up positive.

(1) "Financing capability" will be supported by a banking group. Funding from outside sources is seen to be positive, particularly in relation to the investment for new engine development.

(2) Efforts for "low unit cost for production" regarding exporting engines will direct to dual ways, i.e. (a) cost-cut of materials including outsourcing materials, and (b) modernization of production processes incorporating inventory reduction and simplification of production designing.

(3) Regarding "generators", a new line of products will be marketed colaborating particularly with dealers to be more active in sales.

(4) "Ambulances" may require more sales to get rid of the current deficit condition. Chances are good, but the success demands enormous marketing efforts. More discussions will follow in the following section, 6-2.

Evaluation*	-2	-1	0	+1	+2	Remarks
1. Engines						
- Product development ability and flexibility				X		No cooperation activities with customers, e.g. "design-in"
- Financing capability	X					No accumulated deficit and not substantial in bank loans.
- Low unit cost of production	X			X		Maintain advantages to imports. But no price competitiveness in export markets.
- Prompt delivery					X	Advantageous to imported products.
- Maintaining competitive quality				X		Fair in quality to the current level pricing.
2. Generators						
- Full-line arrangement of products			X			Plans a new line of 50kVA.
- Cooperation of dealers and dealer support			X			Not so active yet.
- Price competitiveness				X	X	Competitive in large generators, but not in smaller units.
- Reliability of products				X	X	Same as in the above.
3. Ambulances						
- Aquisition and use of information			X			Customer development comes first.
- Special arrangements for contracting with governments			X			Competitors are providing.
- Price competitiveness	X					Operating in deficit, but no data in details.
- Response to customer's requirements				X		Systematic responses will be the issue.
4. Others (Parts manufacture and repaire services)						
- Use of management recources					X	Maintaining substantial idle facilities.
- Development of service networks			X			Basically waits orders.
Ref. Corporate management						
- Management leadership				X		Required from a mid-term view point.
- Cost management			X			Cost accounting and cost centers in particular.
- Human resources development and management			X			Demands a systematic education system.

* -2: Low, -1: Lower, 0: Average, +1: Higher, +2: High

Fig. 5-3-2 Analysis of KSF

5.3.3 Perspectives in the Future and Contingency Planning

5.3.3.1 Prospects in the Mid- and Long-term Future

The study team has recommended that Mielec Engines Co. plans the mid- and long-term. There would be no contingency plans for risks the Company may face in the future if no perspectives has the Company. Therefore, the Company would move aimlessly with no particular goals and achievements. There are successful companies that share a similar experience in Central European countries, including Poland, after they joined the market economy at the beginning of 1990s, losing the majority of their markets in the former Comecon countries. Several companies have a message which would be pertinent for the Mielec Engines to review (See section 5.5).

5.3.3.2 Contingency Planning

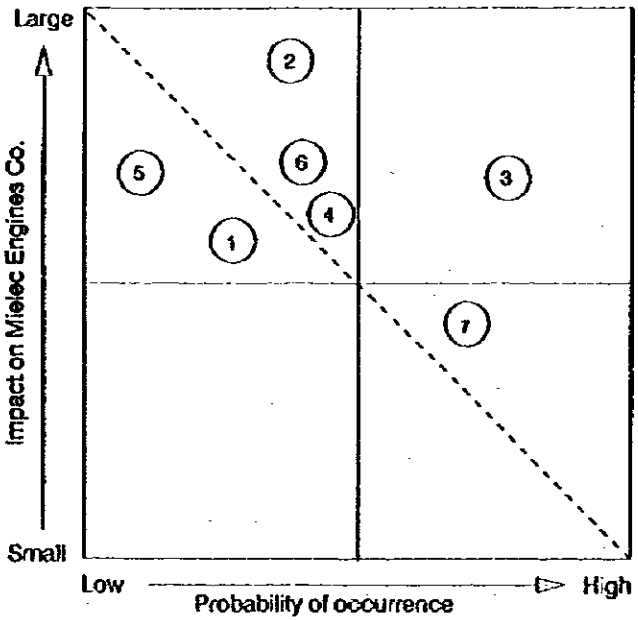
Scenario-1 has been selected for the company's strategy development, and product strategies in the mid-term have also been determined as in the following section, 6.2, assuming that every product and service group would be placed solidly in the market in the target year 2001.

Those expectation for Mielec Engines Co. may differ from the reality the Company would face in the future. Risks, if they are defined as threats or impacts which would affect the company's benefits adversely, should be examined beforehand. Fig. 5-3-3 describes potential risks, examples of trigger points and countermeasures or contingency plans the Company may react at the right time. The Company is now in a position to complete a major series of contingency plans.

Risks	Trigger points	Countermeasures
(1) Exchange rates (Higher PLN)	PLN 2.0 equals to US$ 1.00 (e.g. 30% appreciated)	• Imports of main materiels and components from Eastern Europe
(2) Engine production of a major customer (end-user)	An earliest timing, e.g. a year before production	• Focuses on exports • Promote marketing in non-engine businesses
(3) Invasion of foreign brands (local production, etc.)	At an earliest timing of obtaining information	• Full-scale cost cut • Outsourcing overseas
(4) Rise of energy cost	Cost increase by e.g. 30%	• Cost cuts
(5) Low economic growth	0% or minus	• Cancels new engine development
(6) Fails in exporting	10% of less	• Consider cancelation of new engine development • Cost reduction
(7) No increase of sales	When marketing efforts are proven ineffective.	• Doubling assignments in marketing • Comprehensive training • Focusing human allocation in "other" section.

Fig. 5-3-3 Risks and Contingency Planning (Examples)

Incidentally, which risks should Mielec Engines focus on most urgently? Fig. 5-3-4 gives a guideline to scaling relative importance by taking two factors into consideration: "probability" of the occurrence of risks that may come up and "impacts" the Company would face when it happens.



Note: Numerals in circles correspond to the number of Fig.5-3-3.

Fig. 5-3-4 Risk Analysis (Conceptual)

In the four-sphere diagram, the risks, which may have a extremely huge impact with a substantial probability and those of high probability with very substantial impacts, would be those the Company should be well prepared to act on immediately when the trigger point rings the bell. A preliminary analysis on the diagram indicates that (2) "engine production of a major customer" and (3) "invasion of foreign brands" into the domestic market, respectively, would be most serious.

5.4 Development of Mid- and Long-term Business Plans

5.4.1 Development of Mid-term Plans

Fig. 5-4-1 show a process for the development of a mid-term strategy based on the goals which have already been defined in the section, 5.2.3, Scenario-1.

Corporate goals and specific issues to be achieved in the mid-term are integrated in the master plan. The plan will be developed further by a division such as production and production engineering, product development, marketing, and supporting functions including human resources management and development, financing and information management. The plan will also require the listing of issues to be achieved with priorities and specific goals in individual operating divisions.

It should be mentioned that the master plan and subsequent programs to be implemented would be modified according to change in the management environment particularly when an unprecedented occurrance comes (as discussed in the previous section, 5.3.3, contingency planning). The plan has to be reviewed regularly every year based on the quarterly follow-up checks.

Processing and implementation planning have been demonstrated in this project. However, the project has not put forth a collaborative discussion for developing the plans. The study team expects the client Company to follow the procedure for further development.

5.4.2 Implementation Plans

Implementation planning is to develop an action plan which provides a guideline for individual employees to take action by themselves. Individual employees are expected to be motivated to act by the guideline to implement the plan.

Fig. 5-4-2 illustrates planning annual goals by functional division, defining goals for mid- and short-term at the corporate level and followed by the departmental level. The departmental goals must, of course, be specified further at the product level such as engines, generators, ambulances and others.

For example, a goal specified in the master plan, 3,000 engines in the year 2001, has allocated 2,000 units for the domestic sales division and 1,000 units for the export division. Goals for individuals may be provided by a guideline for action, for example, "Develop new dealers (3 dealers)," "Exhibit fairs overseas in Ukraine, Russia, ..." etc. The management of the Company is expected to initiate the development of a program motivating individual divisions and individuals who are responsible.

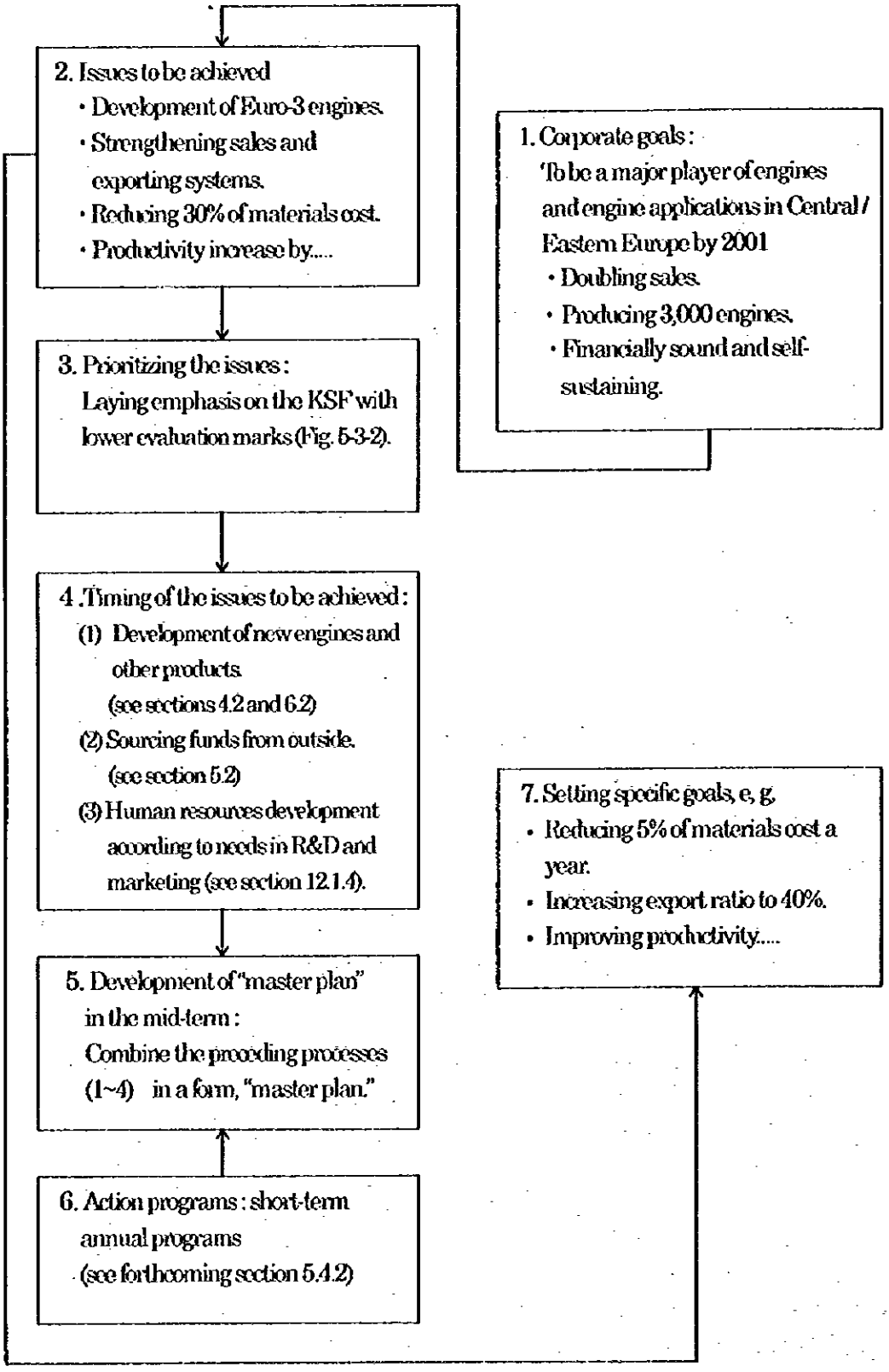


Fig. 5-4-1 Development of Mid-term Business Plans By Functional Division (An Example)

Corporate Goals

Mid - Term (in 2001)

Goals :

- Doubling sales to 97.4mil,PLN,incl. engines xx, generators xx, ambulances xx, and others.
- Producing 3,000 engines.
- Financially sound and self-sustaining.

(Refer to Fig.5-4-1)

To be achieved :

- Development of Euro-3.
- Engines with an investment of 28.5mil,PLN.
- Finance half of the investment internally by increasing cash flow.
- Streng thering sales and exporting systems.
- Reducing 30% of materials cost
- Productivity increase by ....

(Refer to Fig.5-4-1 "Master Plan")

Annually (in 1997)

- Achieve total sales 54.2 mil.PLN, incl. 27.6mil.PLN for engines(Fig.5-2-3).
- Initiate R&D for Euro-3 engines, investing 6.5mil.PLN(Table 5-2-3).
- Make the operation lean by reducing 20% of inventories,....

Remarks : Specific figures of the goals are shown as an example.
They can be changed according the development of plans.

Goals by Division

Division	Mid - Term (in 2001)	Annually (in 1997)
• Development and sales department	• Sales of 97.4 mil. PLN. • Market Euro-3 engines. • Development new customers, doubling the number of dealers. • Increase export ratio up to 40 %.	• Domestic sales of: - Engines xx units - Generators xx units -Ambulances xx units - Others xx PLN • Design new product development and implement. • Develop 5 new dealers for genorators.
• Production and procurement department	• 30 % materials cost cut by poducing defects. • 50 % reduction of inventories by reviewing production management system. • 30 % productivity increase in cooperation with employees.	• Reduce materials cost by 5 %. • Reduce 20% of inventories. • Increase productivity by xx %. • Establish a production management committee. • Maintain two "model" lines and transfer the management method to other operations.
• Finance and administration department	• Management by profit centers for product groups. • Human resources development systems for activating employees, incl. job rotation. • Raise financial capability.	• Establish cost centers. • Begin operation of cost accounting systems by product group. • Obtain ISO-9001 certification. • Finance R&D cost of 2.0 mil. PLN for engines (Fig. 5-2-6). • Review education systems . • Maintain activities of restructuring committee.

Fig. 5-4-2 Planning Annual Goals by Division
(An Example)

5.5 Restructuring Status of State-owned Enterprises in Poland and Hungary

In order to verify the validity of the restructuring plan it had proposed to Mielec Engines Co., the study team visited the related enterprises and inspected the restructuring situation at each firm. Several instances would offer a guide to Mielec Engines.

Case 1. STAR S.A. (Poland)

As this Company manufactured medium-sized trucks and was making military vehicles such as all-wheel-drive cars, its output had reached the 30,000 level, but it sharply fell after the reform and amounted only to the 1,600 level in 1993. This situation resembles that of Mielec Engines closely, Star S.A. however succeeded in doubling its output in 1996 to 3,200 cars. According to the Industrial Development Public Corp. that concerned itself with the restructuring process of this Company, this is a model Company in Poland that succeeded in restructuring with self-helping efforts.

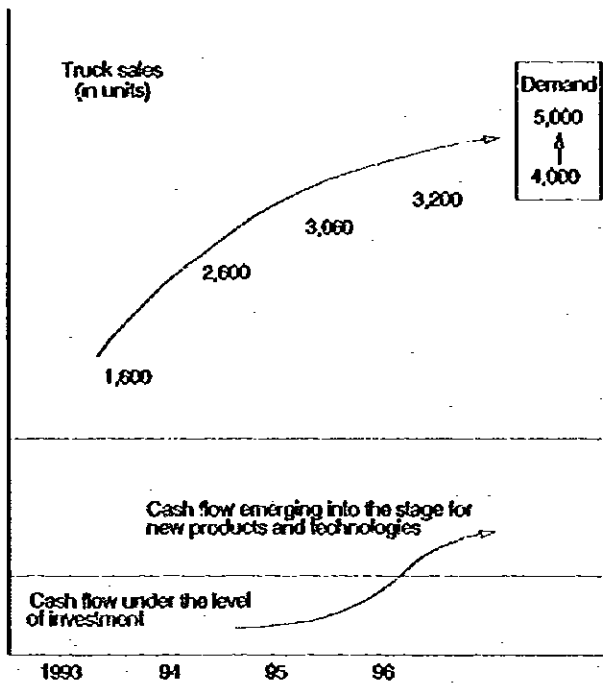


Fig.5-5-1 Trends of Sales and Cash Flow
(STAR S.A.)

The figure demonstrates that the Company stands ready to go ahead on investments on new products and technologies. It should be noted that the Company knows the market in which they

are competing as well as market demand in the mid-term, This was achieved by outside consultants.

The Company is also aggressively proceeding with "comprehensive packages" for cost reduction. In procurement and logistics areas, for example, they are evaluating alternative suppliers, initiating procurement jointly with other companies in the same group, targeting the cost reduction of procurement from other countries by 3% a year (achieved 2% in 1996) and outsourcing things such as transportation services down to 60% from the previous 90%. Management considers the Company to be attractive enough for potential investors from outside, domestic and foreign.

Case 2. Andoria (Poland)

Andoria received in 1995 a technology transfer on diesel engines from the British Leyland as Mielec Engines Co. did. Andoria introduced a medium-sized model 400 of 8-liter as against the large-sized model SW 680 of 11-liter which Mielec Engines introduced, but the paths which the two companies followed afterward contrasted with each other.

What is worthy of note is that while Mielec Engines continued with the introduced engine till recently, Andoria developed 4-cylinder and 1-cylinder engines on the basis of the original 6-cylinder engine.

The 2.4-liter diesel engine in particular on its own 4 years ago offered a decisive factor in expanding the enterprise. This is a world-level engine which has adopted a Richard-type sub-combustion chamber under the guidance of Kracow Engineering University and includes an overhead cam and rubber timing belt. Considering its design that dates back to 20 years ago, we can see how this enterprise possesses a progress oriented structure.

Comparison with Mielec Engines is given in the following Table 5-5-1.

	Andoria	Mielec Engines
Basic line of engines	4	1
Appl. target of ISO 9001	1997-1	1997-6
Insourcing possib. of large castings	○ (% defec.; 1%)	x(% defec.; 20-30%)
Export ratio	23%	2%
Vehicle assembly	Van type, car body imported, own engine mounted	Ambulance assembled. most parts imported

Table 5-5-1 Andoria and Mielec Engines: Comparisons

At Andoria, the experience of having been in the most difficult time at the beginning of 1990 and developed the new engine saved the Company. They have newly employed about 700 workers this year as in last year.

Case 3. Jelscz (Poland)

The Company is largest bus and truck maker in Poland. As in other makers, its product demand fell to a few tenths by the reform.

A series of restructuring programs is as follows:

- Reduction of operating costs
- Modernization of products
- Elevation of quality
- Setting up of a marketing department for the sales expansion
- Effective management of funds
- Reform of the organization, not directly related with its main buisiness, e.g. filtration plant, transport, catering, boilers and hotel management
- Regulation of the land and building, 23% reduction of the total site and 14% reduction of building. Leased land was used for 43,000m² of the site.
- Reduction of employment by 54% to 3,192 persons, currently employing 3,200 persons
- Contact with customers and organizing a marketing function for meeting their needs
- Continuous improvement of products.

Case 4. IMAG Ltd. (Hungary)

The Company is an affiliated auto-parts maker with the internationally well-known Hungarian bus manufacturing Company, Ikarus Ltd., having 1,300 employees and is manufacturing passenger car seats (60%), seat belts (25~30%), and door and plastic parts. What is destined for the Hungarian local plant of Suzuki Motor Corp. of Japan accounts for the majority amounting to 60%.

Although the parent Company Ikarus fell into a structural depression after the collapse of Soviet Union and its recovery is still doubted, the Company is doing very well and this will offer a useful information for the restructuring of state-owned Polish enterprises.

The success in its operations is based on the fact that the company follows a clearly defined philosophy and specific goals for the year 2000 and 2005 (See Fig. 5-5-2). The Company foresees to be the Number 1 supplier of seats in Central Europe in the mid-term, attaining the level of Germany by good in terms of productivity, and keeping an annual growth of 5% for the period 2001-2005. The company will maintain the present level of employees.

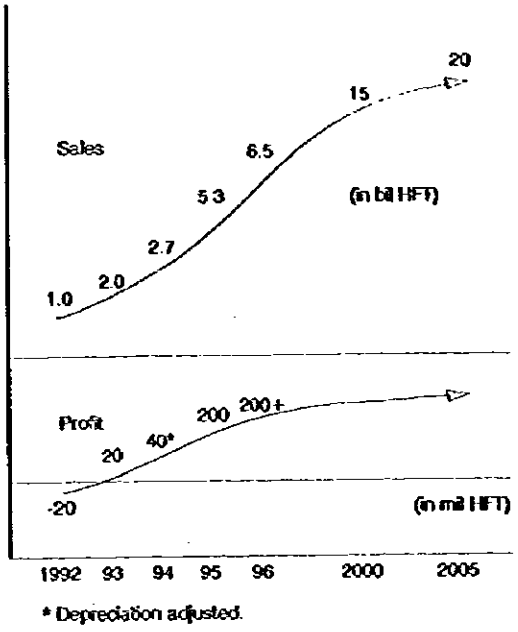


Fig. 5-5-2 Trends of Sales and Profit
(IMAG Ltd.)

Regarding corporate management, the Company created 7 profit centers in each operating unit to assure profits by eliminating unnecessary work processes and inventories. The Company was certified with ISO-9001 in June 1995.