CHAPTER V

COST OF IRRIGATION BY OIL ENGINES.

It may be pointed out, at the outset, that whereas the sample of electric motors pertained only to those villages which had developed irrigational use of electricity, the sample of oil engines covered besides above stated villages, also the villages in the category, 'not having developed the irrigational use of electricity'. Table 3.7 in Chapter III gives the details of the number of oil engines selected in sample villages. Out of 65 oil engines studied in the sample, two engines were having horse power as 7.5 and 10, while the rest 63 were having 5 horse power each. For the purpose of fitting the cost function we have considered only these 63 engines of 5 horse power each.

Components of Costs

As in the case of electric motors, the total costs of irrigation by oil engines have also been divided into two broad categories viz., fixed costs and variable costs. Depreciation charges and interest rate charges, are the two constituents of fixed costs. Operation charges (cost of fuel) and maintenance changes are the components of variables costs. The costs of irrigation by oil engines in the sample have been computed for the year, 1st June 1965 to end of May 1966 as in the case of electric motors.

Distinctive Features of Oil Engines

Though oil engine and electric motor are both mechanically operated devices, certain distinctive characteristics were observed in respect of oil engines (covered by the sample) thus necessitating modification in the method of computing costs. These distinctive features of oil engines are discussed below.

(i) For computing depreciation charges, the life of an oil engine is assumed to be ten years. The basis for this assumption, as in the case of electric motor, is the fact that the Land Development Bank recovers the loan amount for engine and motor in ten annual instalments, however, 6 out of 63 engines in the sample were found to be older than 10 years during the year 1965-66. In other words, these engines had exceeded their normal economic life. It may be recalled that in the sample of electric motors, none of the motors was found to have exceeded its economic life in the year 1965-66, as the programme of electrification was started in the Poona Division only during the year 1957-58.

(ii) In view of the necessity of shifting the engine from one well to another well, more flexible types of pipes were used to meet the requirements of different wells. These pipes were mostly rubber-based with iron-cast springs round the rubber-wall of the pipe for imparting suste~~e~~nance to it. Under the circumstances, the life of the pipe could not be taken as ten years. Most of the dealers in these pipes also stated that the pipes last for about 3 to 5 years, depending upon the quality of rubber. The rate of depreciation for the pipes is, therefore, taken to be different from that of engine and pump in the case of this mode, while in the case of electric motor, it was the same for all the three items, i.e., motor, pump and pipes.

In the following sections, the methodology for working out fixed costs for engines is described. To begin with, the limitations of data regarding fixed costs are brought out.

Fixed Cost : Limitations of Data

It may be noted that in case of engines, the break-up of investments in different items could not be provided as in the case of sample electric motors. This was due to the following two reasons : (a) While the years of purchase of sample electric motors belonged to relatively recent period (1961 onwards) those of sample engines belonged to a comparatively distant periods (earlier to even 1955-56) from the date of survey. Therefore, in case of electric motors the receipt books stating the details of cost of sample motors could be tapped from the dealers from their records but this was not possible in the case of engines as the relevant records were in most of the cases destroyed being out-dated. The details of costs, therefore, could be provided only for a broad classification, such as engine and pump, pipe, etc. depending upon the memory of cultivator. (b) Not in all cases the engines installed were purchased directly from the dealers. Many of the sample engines were bought second-hand from other cultivators. In such cases, the entire unit was purchased; and, although the purchaser had implicit valuation of each item, it was deemed unnecessary to get the minutest details of his subjective valuation of different items. The classification has been, therefore, limited to only few major items of costs.

Initial Investment in Oil Engines

In Table 5.1, the data on broad break-up of average total costs of sample engines installed in different years are presented. It may be noted that the costs stated in the table refer to initial investment costs. It should be borne in mind

Table 5.1 : Initial investment in oil engines.

(cost in Rs.)

Year of installation of oil engines	Number of engines in the sample	Average cost of oil engine & pump (Rs.)	Average cost of pipes (Rs.)	Average cost of installation charges (Rs.)	Average cost of other charges (Rs.)	Average total investment (Rs.)
1951-52 & 1952-53	3	1240.00	136.00	191.67*	15.00	1582.67
1953-54 & 1954-55	3	1805.67	201.00	260.00	-	2266.67
1957-58	5	1705.60	330.70	88.00	9.00	2133.30
1958-59	8 (7)	1721.25 (1796.67)	452.78 (484.38)	134.27 (142.36)	12.22 (14.71)	2320.52 (2438.12)
1959-60	3	2183.33	295.34	165.00	1.67	2645.34
1960-61	6	2182.17	265.33	166.17	14.17	2627.84
1961-62	4	2606.75	298.25	69.50	20.25	2994.75
1962-63	7 (6)	2258.53 (2313.28)	537.48 (582.07)	160.00 (186.67)	15.71 (18.33)	2971.72 (3100.35)
1963-64	6 (5)	2165.67 (2368.80)	358.83 (370.60)	278.33 (334.00)	10.00 (12.00)	2812.83 (3085.40)
1964-65	3	2821.67	416.67	128.33	10.00	3376.67
1965-66	14 (10)	2699.28 (2876.49)	460.57 (378.30)	186.43 (212.50)	19.28 (22.50)	3365.57 (3489.79)

Notes:

1. Data in respect of 62 oil engines could be provided, since one of the engines was hired by the respondent. The user had paid rent of Rs.300 per annum for the engine. In addition, he was required to carry out repairs.
2. Figures in brackets indicate position for oil engines newly purchased during the year.
3. * Installation cost on trolly was Rs.100/- during 1951 and 1952, whereas it was Rs.144.28 per engine in 1965.
4. Average cost refers to purchase price in the year of installation.

that unlike electric motors, in case of oil engines the initial investment costs and the costs considered for computation of interest rate charges for the use of capital during the year 1965-66 are two different entities. This is mainly because in case of some engines, part of the investment (Hose pipes, foundation etc.) got replenished earlier to 1965-66 and was, therefore, replaced. We shall of course dwell on this aspect in a later section.

It can be observed from Table 5.1 that the average total investment cost per engine have slightly more than doubled over the period in which the sample engines were distributed (1951 to 1965). However, not all the components of costs have recorded identical increase over the period. For example, average cost of pipes per engine have recorded the highest increase over the period (roughly 2.5 times) followed by engines (1.16 times the initial average cost in 1951 and 1952), trolly installation (roughly 0.5 times) and transportation cost (0.33 times). However, not much inference can be drawn from this table, since the table averages out the details of costs for engines of different makes, pipes of different types and transportation costs for different distances. For instance, the rise in the average cost of pipes per engine is not so much due to rise in the prices of pipes, but due to the combination of different sizes (in length) and different types (hose, iron-cast etc.) of pipes used by oil engines installed in different years. Similarly, the erratic behaviour of average cost of engine and pump in some years is because of averaging of costs of engines of different makes in different years.

Method for Changing Depreciation

However, Table 5.1 is provided to discuss the various methods available for computing the fixed costs for use of engine during the year and to give reasons for selection of a particular method. Unlike the installation of electric motors in the sample the installation of oil engines in the sample, covers quite a considerable time-span and hence there is considerable variation in the initial investment cost of different engines when compared to that of different electric motors. In view of such variations in the installation costs of engines, the relevance of the method adopted for computing fixed costs of electric motor in respect of engine may be doubted. We may, therefore, discuss here the alternative to the method adopted for working out fixed cost of electric motor.

The method adopted for charging depreciation of electric motor for its use during the year was a straight line method, thus accounting for one-tenth of its initial investment cost. Since there are not large variations in the investment costs of different motors, this method did not lead to large differences in the depreciation charges of different electric motors. However, as seen earlier, there are large differences in the cost of different engines and pumps since the oil engines in the sample were spread over a number of years (1951 to 1965). The application of the same method would, therefore, yield large differences in the fixed-cost component of different engines.

An alternative to this method would be to compute fixed cost component on the basis of replacement cost of engines. Such a method would of course not lead to differences in the fixed-cost of different sample engines. But the adoption of this method would distort the picture of total costs of irrigation (fixed + variable costs) in a particular year for engines covered by the sample.

It should be noted in this connection that depreciation charge is only one of the components of the total costs of irrigation, the other component being variable costs consisting of two parts, namely, operation costs and maintenance costs. Both these costs (operation and maintenance) in a particular year, as elaborated in later parts of the chapter, varied directly, to some extent, with the age of the engine in that year. In other words, older the engine in a particular year, higher would be its operation and maintenance costs in that year.

Thus it can be seen that the two major components of total costs (fixed and variable) move in opposite direction with respect to age of engine in a particular year (older the engine smaller will be the amount chargeable for depreciation and higher will be the operation and maintenance cost). Since we are computing the costs of irrigation for a particular year, and taking into consideration the above stated factors, it was thought that the application of the same method of charging depreciation (as in respect of electric motor) to oil engine would bring out the true picture of costs of irrigation by engines.

In case of electric motors, the equipment installed with all its accessories were assumed to have economic life of ten years. Secondly, all the motors were installed well within ten years of the period for which the costs of irrigation are being worked out. This being the case, the depreciation charges for the year of study were derived from the initial investment cost of sample motors. However, these conditions did not exist in case of all the sample engines.

Neither the engine, pump and pipe could be assumed to have uniform life of ten years in view of altogether different types (Hose pipe in some cases) of pipes used in this case, nor all the engines, in the sample were installed within ten years of the year for which the costs of irrigation are being computed. Although some of the engines (6 out of 65) were found to be working beyond their normal life (10 years), in none of the cases the pipes were found to be in use beyond their normal life. As stated earlier, the normal life of hose pipe is assumed to be five years and that of iron-based pipe as ten years. Since the costs are being computed for the year 1965-66, the engines with hose pipes installed earlier to 1960 had different set (new) of hose pipes during the year 1965-66 and not the original ones, and therefore, the value of the newly purchased pipes are considered for accounting depreciation charges for their use during the period of study. Similarly, for the computation of depreciation charges of galvanised pipes (iron-based pipes) of engines installed in the year 1955 or earlier, the value of new set of pipes is considered rather than the value of the original set.

Use of Pipes by Engines in the Sample

Out of 62 engines of 5 H.P., 37 reported the use of hose pipes at both the ends (i.e., suction and delivery), 15 reported the use of galvanized (iron-based) pipes at both the ends, while 10 reported the use of both the types of pipes.

During the year 1965-66, out of 37 engines using entirely hose pipes, 21 sample engines had still in use the original set of pipes (purchased along with the engines), whereas 16 engines had already replaced their original set of pipes with the newly purchased pipes. All these 16 engines were installed in the year 1960 or earlier, while all the 21 engines having still the original set of pipes in use during the year 1965-66 were installed later than 1961.

Out of 15 engines reporting entirely the use of galvanized pipes, only 3 had replaced their original sets by the year 1965-66. All these 3 engines were installed in the year 1951-52, the other 12 engines which had the original set in use during the year 1965-66 were installed either in the year 1957 or later.

Lastly, out of 10 engines using both the types of pipes, 3 engines reported the replacement of original set of hose pipes only. The original set of galvanized pipes were found in use for all the 10 sample engines during the year 1965-66. All these three engines were found to have been installed earlier to the year 1960.

It may, therefore, be observed that in respect of 40 sample engines (roughly 66 per cent of total engines) using hose pipes, the difference in the depreciation charges of pipes attached to the engines was not due to their installation over a larger span of time, since the pipes of the engine installed in the earlier period were mostly replaced by the pipes purchased at a later date. The difference in the amount of depreciation charges for hose pipes for different sample engines was essentially due to (a) different length of pipes used and (b) different quality of pipes used.

Assumptions Underlying Computation of Depreciation Charges

The assumptions made in working out the depreciation charges for the year 1965-66 on different items of investment costs are discussed below :

Engine and Pump : As in the case of electric motor and pump, the life of engine and pump is also assumed to be ten years. For working out the depreciation charges for a particular year, therefore, one-tenth of the book value is taken into account. However, there is one difference between electric motors and oil engines. Whereas all the installations of motors were first-hand, some of the installations of oil engines were second-hand. In other words, not all the sample engines were directly purchased from the dealers; some of them were purchased from other cultivators who had used these engines for some time. The owner-cultivators of such sample engines were, therefore, asked to state whether they had knowledge regarding the number of years of use of such engines by their previous owners. In all cases the present owners of second-hand engines were able to report on the age of engine as at their time of purchase. It must be noted that there was no other way to have a cross check on the information provided by the respondent.

Second-hand Engines : Although the price paid for the purchase of second-hand engine could have been taken as an indicator of the age of engine on the date of purchase, it may be noted that not in all cases the price paid for engine could be equated to original price of engine minus the depreciation charges for the number of years of use of engine by its previous owner. The price paid for the engine appeared to have been determined by the intensity of the need of either the buyer to possess it or that of the seller to dispose it of. It also must have depended on the working condition of the engine. In any case, the price paid for the engine could not be taken as an indicator of the age of engine, and hence the age reported by the respondent has been taken as correct. In such cases (cases of second-hand engines) the depreciation charges (based on straight line method) for the year 1965-66 are computed as follows. The price paid for the purchase of engine is divided by the remaining years of normal life. The remaining part of the life of an engine is arrived after deducting the age of the engine on the date of purchase from its normal life of 10 years. Under this method of calculation of depreciation charges for the year 1965-66 for the second-

-hand engines, the actual computed charges have become higher or lower in case of second-hand engines than the corresponding newly purchased engines of the years, depending upon the price paid by the cultivator to purchase the engine. Wherever the price paid for the second-hand engine was found to be more than the depreciated value of the engine as on date, the depreciation charges of the engine for the year 1965-66 have shot up when compared to the newly purchased engines of those years and vice-versa.

Out of a total sample of 63 engines, 7 were reported to have been purchased second-hand. In respect of 5 out of these 7 engines, their owner cultivators had paid price much higher than the depreciated value of the engine, resulting in higher depreciation charges for the engines than the newly purchased engines installed in those years. In case of only one second-hand engine, the cultivator had paid a price lower than the depreciated value of the engine.

Table 5.2 presents the relevant information of second-hand engines.

A few observations can be made on the basis of this table. For example, it can be seen from the table that the engines which were purchased second-hand were mostly of a particular make, namely Kirloskar, although there were other types of makes included in the sample of engines such as

Table 5.2 : Details of Second-hand engines in the sample.

Sr. No.	Village	Make of the engine	Year of purchase of engine	Age of engine on the date of purchase (in years)	Price paid for the engine by the user (Rs.)	Depreciated value of the engine on the basis of dealer's' price (Rs.)	Average price paid for the same type of new engine during the year of purchase of second-hand engine (Rs.)
1.	Walunj	Kirloskar	1965	2	2500	1920	3100
2.	"	"	1965	2	2090	2000	3150
3.	Shivari	"	1965	4	2315	1450	3100
4.	"	"	1965	3	2165	1820	3250
5.	"	"	1962	1	1930	2190	2400
6.	"	"	1963	5	1150	900	2200
7.	Phursangi	English Peter	1958	2	1850	N.A.	N.A.

(N.A. = Not available)

Cooper, Test-tool, Imani, Jawahar, Vishwas and Pacco etc. Furthermore, it can also be observed that most of these second-hand dealings of engines pertain to a relatively recent period with respect to period of survey, i.e., 1962 onwards. (As stated earlier, the total span of time covered by the sample engines is 1951 to 1965). A few other facts presented below would explain this phenomenon.

Among the engines of Indian make, Kirloskar by far is the most popular one, perhaps because of its better performance with respect to consumption of fuel and maintenance cost when compared to the engines of other makes. Although this cannot be conclusively proved from sample data, it may be observed that out of a total of 63 sample engines of 5 HP, as many as 44 (more than 66 per cent) were Kirloskar engines. Further, it may be mentioned that since November 1963 the name of Kirloskar engines was excluded from the list of Government approved engines for tacquavi loan purpose. This was done mainly because the manufacturers of Kirloskar engines declined to tone down their prices. In other words, the manufacturers of Kirloskar engines did not deem it necessary to rely on the demand coming forth from tacquavi loan applicants for clearance of its inventories. In spite of higher prices of the engines of this make, there was great demand for these engines. The cultivators owning the sample engines reported that they had to wait for quite some time to have Kirloskar engines. In this connection, it may also be noted that although the engines were manufactured at Poona, two owner-cultivators of two engines in the sample from village Shinoli had to go as far as Bombay to place their orders as the Poona-dealers in the engines refused to book the orders because of heavy rush. Under such circumstances, the cultivators chose to go in for second-hand engines rather than to wait and buy new engines of this make. It must also be mentioned here that the price of new engines (of all makes) in the year 1965 was roughly Rs.2,875,as against the average price of a second-hand engine bought in that year which came to Rs.2,250.

Incidentially, one more observation is pertinent which is relevant to the computations of interest rate costs. As stated above, from November 1963 the name of Kirloskar engines was removed from the Government approved list of engines for tacquavi loan.Consequently, the Land Development Bank did not grant tacquavi loan at the interest rate of 4.5 per cent for the purpose of installation of Kirloskar engines. The loan sanctioned by Land Development Bank for the installation of Kirloskar engine after November 1963 pertained to different loan scheme and was subjected to different rate of interest. This loan scheme was known as normal loan and rate of interest applicable was 5.5 per cent,as against 4.5 per cent for tacquavi loan. For computation of interest rate costs of Kirloskar engines purchased on finance from Land Development Bank after November 1963, 5.5% is taken as the interest charge, as this was the cost actually borne by the farmer.

<u>Pipes</u> : The cultivators owning the engines were found to have been using the pipes of both the types ofor irrigational purposes, i.e., (a) galvanized pipes (b) hose pipes. Broadly, the galvanized pipes were coupled with the engines installed permanently or quasi-permanently at one place; while the hose

pipes were coupled with engines often moved from one well to another well. The flexibility of hose pipes made their movement easier.

As in the case of electric motors, the life of galvanized pipes coupled with engines is also assumed as ten years. For charging depreciation costs of these pipes for a particular year, therefore, one-tenth of their ~~the~~ book value is computed.

However, for reasons stated earlier, the life of hose pipe cannot be assumed on par with that of galvanized pipe. Secondly, within this category of pipes, there were pipes of different qualities having different costs per foot of length. The cultivators using these pipes were, therefore, asked to state the life of the pipes used. By and large, the life of the pipe and the cost of pipes per foot were found to have positive relationship. The prices of pipes, however, were rising throughout this period. In Table 5.3 the expectation of life of pipes purchased in different years (as stated by the cultivator) and the prices of the pipes per foot paid by the cultivator are juxtaposed.

Since the maximum life of the best quality pipe was stated to be five years, although the above table gives the prices of pipes purchased from the year 1957 onwards to 1965, for the purposes of computation of depreciation charges for the year 1965-66, only such pipes are considered which were purchased in the year 1961 and onwards.

Table 5.3 : Expectation of life of the pipes according to the year of purchase and the price paid.

Price paid per foot of hose pipe (Rs.)	1957	1958	1959	1960	1961	1962	1963	1964	1965
				(Life in years)					
1-2	-	-	-	-	-	-	-	3	3
2-3	-	5	5	-	-	-	-	3	-
3-4	5	5	-	-	-	-	3	-	3
4-5	5	5	-	5	5	-	-	3	3
5-6	5	-	-	-	5	5	5	-	-
6-7	-	-	-	-	-	5	-	5	-
Above 7	-	-	-	-	-	-	-	5	5

Foundation (Pumpshed), Trollies etc. : Unlike electric motors which were installed permanently on one well, some of the sample engines were moved from one well to another. These mobile engines were mostly affixed on trollies to facilitate their movement from one well to another. Out of a total of 62 engines in the sample, 19 were installed on trollies, 33 were installed on foundation while another 10 were neither installed on trollies or on foundation but, were just fixed on a base plate (a plate at the base of engine). However, not all the engines fixed on trollies were moved from one well to another. Two out of 19 engines fixed on trollies were found to be stationary and being operated on one well only. On the other hand, 8 out of 10 engines which were installed on base plate were moved from one well to another.

All the respondents using sample engines, which were founded on ground with a pumpshed, were able to state the expenditure separately for foundation and pumpshed. Hence for the purpose of computation of depreciation charges, the expenditure on foundation and the pumpshed is considered separately. The maximum life of the foundations of the engine is considered as 10 years, which is the normal life of engine. In respect of engines fixed on base plates, however, the respondents were not able to state separately the price paid for base plate since it was purchased along with the engine. Hence the life of base-plate was also assumed to be 10 years. In case of such engines where pumpshed was also constructed, a separate depreciation charge is computed on the basis of its expected life, which in turn, depended upon the quality of construction. As in the case of electric motor, the cultivators using sample engines were asked to state their expectation about the life of pumpshed, wherever constructed. Since these locations were actually visited, it may be pointed out here, that the expectation of life as stated by the cultivators was observed to be mostly in conformity with the type of construction. Table 5.4 depicts the cost of construction of pumpshed and the expectation of life of pumpshed as stated by the cultivators using the engines.

Table 5.4 : Investment costs of pumpsheds and their expected lives.

(Cost in Rs.)

Cost of construction of pumpshed (Amount in Rs.)	No.of engines reporting pumpshed cost	Average cost per pumpshed	Average expectation of life (In years)
0-99	10	62.50	5.00
100-199	6	124.50	10.00
200-350	15	255.30	15.33
351-600	6	450.00	20.83
100 and above	1	1175.00	30.00

As in the case of electric motors, the different size-groups of expenditure represent different types of construction and hence the expectation of life is different for different size-groups. For example, the first size-group (0-99) represents a pumpshed made of wooden planks on all sides with a thatched roof. The second one also represents a "kutcha" construction with the mud walls and a thatched roof. The third and the fourth size-groups represent relatively stronger construction with single brick-walls having no plaster and plaster, respectively. The last size-group (1000 and above) however, consists of masonry construction with reinforced cement structure. It may, therefore, be observed from the above table that the average expectation of life of pumpshed increases with the expenditure incurred thereon which indicates improvement in the quality of construction.

As against the variety observed in the case of construction of pumpshed, there were very little quality differences found in the types of trollies employed by cultivators to shift the engine from one place to another. For one thing, all the trollies were cast in iron although there were minor differences in shapes, sizes and mechanical devices. Since all were permanently attached to engine, it is assumed that the life of trolley is co-terminus with the life of engine. It is, therefore, assumed that the trolly would last for ten years only. The depreciation for the year 1965-66 is therefore charged at the rate of one-tenth of the purchase price of the trolley. The prices of trolly ranged between Rs.95 and Rs.150, depending upon the year of purchase, the size of the trolly and the mechanical devices incorporated in the trolly. Out of 19 trollies attached to engines, 18 were iron-cast while only one was a wooden trolly. The life of the wooden trolly is assumed to be 6 years, based on the estimate of its life as stated by the respondent using this trolly.

Computation of Interest Costs

The various assumptions involved in computation of other component of fixed costs, i.e., interest costs for the use of capital during the year 1965-66 are described below :

Sources of Finance of Oil Engines

As in the case of electric motors, here also, borrowed and owned sources of funds played equally important role in financing the installation of oil engines. Out of 62 engines of 5 HP, 25 were financed entirely out of owned sources while 12 were financed entirely out of borrowed sources of funds. The remaining 25 engines were financed partly out of borrowed funds and partly out of owned funds (details in Table 5.5). The share of each source in the category of mixed finance was as follows : In 18 out of 25 engines, the share of borrowed finances was more than 75 per cent. In another 5 engines, the share of borrowed finance was between 60 and 75 per cent, while in the remaining two it was between 50 and 60 per cent. It may, therefore, be observed that while in 40 per cent of sample engines (25 out of 62), the owned finance had the largest share, in 60 per cent ofsample engines, borrowed finance had a large share in their installation. There is, therefore, every reason to have discriminatory rates of interest for computing interest costs for the use of capital, depending upon the sources of finance of engines.

Table 5.5 : Distribution of Engines by age and source of finance.

No.of years completed by engines on 1st June 1965	Number of engines				
	Borrowed Finance		Own finance	Mixed Finance	
	Interest @5.5%	Interest @4.5%	Interest @ 3.5%	Interest @5.5& 3.5%	Interest @4.5 & 3.5%
Less than 1	3	2	-	2	4
1-3	3	4	4	-	5
3-5	-	-	6	-	6
5-7	-	-	5	-	6
7-10	-	-	4	-	2
Above 10	-	-	6	-	-
Total	6	6	25	2	23

As in the case of electric motors, the actual borrowing rate of interest is charged for the borrowed source, while for the owned sources of finance, the rate of interest considered is lower than the borrowing rate. As stated earlier, for engines of a particular make (Kirloskar) installed after November 1963 and financed out of institutional borrowings (from Land Development Bank), the rate of interest charged by this agency was 5.5 per cent per annum. For other engines, the subsidized (for loans ffom LDB) rate was 4.5%. For own funds, the rate of interest is taken to be 3.5% as discussed earlier.

In case of mixed sources of finance (owned and borrowed funds), the interest costs are computed for two parts separately at two different rates of interest and then added to arrive at total interest costs. Lastly, in case of self-financed engines, the depreciated value of the equipment is taken as the basis of calculating the interest costs, whereas in case of borrowed finance, the outstanding amount of loan is taken as the basis for interest costs. Usually, the outstanding amount of loan was found to be more than the depreciated value of the equipment, mainly because the depletion of hose-pipes was rather fast. Out of 37 engines financed out of borrowed funds, the divergence between outstanding loan amount and depreciated value was observed in respect of 25 engines. The remaining 12 engines were using galvanised pipes at both the ends. However, the absolute difference between the outstanding loan amount (considered for computation of interest costs) and depreciated value of the equipment ranged between Rs.42 and Rs.127, depending upon the age of engine and quality of hose-pipe.

Table 5.6 presents the interest costs and Table 5.7 presents their proportion to fixed costs and total costs.

With particular methodology adopted for computation of interest costs as described above, the trend of average interest costs for engines included in the sample follow certain pattern as could be seen from the Table 5.6. For instance, for engines having similar source of finance, the average interest costs per engine vary invesely with the

Table 5.6 : Age of engines and interest costs per engine by category of finance.

(In Rs.)

No.of years completed by engines on 1st June 1965	Interest costs per engine by category of finance				
	Borrowed @5.5%	Borrowed @4.5%	Own @3.5%	Mixed @5.5 & 3.5%	Mixed @4.5 & 3.5%
Less than 1	205.46	155.29	-	210.19	141.77
1-3	168.66	102.54	70.72	-	105.34
3-5	-	-	61.64	-	66.47
5-7	-	-	37.76	-	39.28
7-10	-	-	19.74	-	23.99
Above 10	-	-	7.32	-	-
Total	187.06	120.12	38.58	210.19	78.92

number of years completed by them as on 1st June 1965. Likewise, for engines in the same age-group, the average interest costs vary with the rate of interest considered for computing such costs which is dependent on source of finance.

As can be observed from Table 5.7, the contribution of interest costs to the total fixed costs of engines was around 20 per cent on the whole, and its share in total fixed costs varied between 6 to 33 per cent depending upon the age of engines and sources of finance. The contribution of interest costs to total costs of irrigation by engines was 9.9 per-cent on an average. However, it may be noted here that

Table 5.7 : Age of engines and proportion of interest cost per engine to their average fixed and total costs by category of finance.

(In percentage)

Number of year completed by engines on 1st June 1965	Proportion of Interest Cost to Fixed and Total Costs by Category of Finance									
	Borrowed @5.5%		Borrowed @4.5%		Owned @3.5%		Mixed @ 5.5 and 3.5%		Mixed @4.5 & 3.5%	
	Fixed costs	Total costs	Fixed costs	Total costs	Fixed costs	Total costs	Fixed costs	Total costs	Fixed costs	Total costs
Less than 1	31.07	21.00	28.88	17.24	-	-	32.79	16.48	27.94	14.73
1-3	29.87	23.27	24.70	14.57	16.72	7.24	-	-	23.04	9.98
3-5	-	-	-	-	15.93	7.27	-	-	15.17	6.22
5-7	-	-	-	-	11.72	5.10	-	-	12.39	4.46
7-10	-	-	-	-	6.45	3.02	-	-	8.32	2.21
Above 10	-	-	-	-	10.41	2.37	-	-	-	-
Total	30.47	22.13	26.09	15.46	12.37	4.96	32.79	16.48	18.78	7.87

since variable costs (operation costs) have greater share in the total costs of irrigation by an oil engine, the contribution of interest costs not only depends on above-mentioned factors (age of the engine and source of finance) but also on number of hours for which the engine is operated.

Variable Costs

As in the case of electric motor, the variable costs of oil engine are divided into two broad groups, (i) operational costs (ii) maintenance costs. In respect of electric motors, the basic fabric of operational costs being electricity, its quality was the same for all motors. However, in respect of engines, the quality of fuel varied between engines. It is, therefore, necessary to describe various types of fuel used by engines in the sample.

Operational Costs : Types of inputs used

The oil engines require lubricating oil besides fuel for its operation. The lubricating oil circulates within the engine when it is operated and wards of the friction between liner and piston (parts of engine) and bearings of engines. The quality of lubricating oil used by sample engines was found to be of different types. The limitations of data on the quality of fuel and oil used by sample engines may be pointed out here. As far as the fuel was concerned, only two types of fuel were observed to be in use, i.e., (a) diesel

(b) crude oil or LSD. The cultivators using engines were, therefore, in position to state the type of fuel used by them. The price of diesel was observed to be varying between 77 paise to 90 paise per litre during 1965-66. This variation was on account of difference in the prices of diesel between the villages. There was no variation in the price per litre of diesel reported by the engines belonging to the same village. The price of crude oil was observed to be varying between 50 paise to 58 paise per litre. Here the variation in the price was reported by the engines belonging to the same village. This was due to the fact that crude oil was sometimes mixed with petrol by their users to reduce its harmful effect on the engine. The cultivators using this fuel, therefore, reported the price of crude oil after adding a margin of 2 to 3 paise to account for the mixture of petrol.

Fuel Consumption : In the Table 5.8, the data on average hourly rate of consumption of two types of fuel (diesel and crude oil) used by engines in the sample are presented. Since the age of the engine is also likely to affect the hourly rate of consumption, the engines have been classified by the number of years completed by them as of end of May 1966.

Table 5.8 : Hourly Rate of consumption of fuels (diesel and crude oil) used by sample engines.

Age of the engines	No.of engines using diesel	No.of engines using crude oil	Average No.of hours worked by engines using diesel during the year	Average No.of hours worked by engines using crude oil during the year	Average hourly rate of consumption of diesel by engine (In litres)	Average hourly rate of consumption of crude oil by engines (In litres)
0-3	13	7	351.54	533.43	1.15	1.25
4-6	14	5	590.80	695.70	1.27	1.53
7-9	7	9	620.13	759.50	1.34	1.50
10 and above	5	2	444.90	60.50	1.29	1.36
Total	39	23	497.61	616.04	1.25	1.43

It may be observed from the table that at the aggregative level, the hourly consumption of low quality fuel, i.e., crude oil was more than the hourly consumption of diesel by roughly 15 per cent. Furthermore, it can be observed that for all the size-groups of age of the engine, the hourly rate of consumption of low quality fuel was higher as compared to the hourly rate of consumption of diesel. Although the hourly rate of consumption of the same quality fuel (diesel and crude oil) does appear to increase with the increase in the age of engine for the first 3 size-groups, the hourly rate of consumption of diesel and crude oil, respectively, of engines having completed 10 years was below the hourly rate of consumption of diesel and crude oil of engines in the age-group 7-9 years. This was due to the following two reasons : (i) The table averages out the hourly rate of consumption of engines of different makes;[1] (ii) The number of observations in the age-group of 10 and above are not enough to portray true picture of average hourly rate of consumption. For instance, there were only 2 engines in this age-group using crude oil.

As the price per litre of crude oil was roughly 35 per-cent lower than the price per litre of diesel, while the hourly rate of consumption of crude oil was only 15 per cent higher than that of diesel, the above table might give an impression that it was economical to operate engine with low quality fuel. However, from the analysis of the per hour maintenance cost of engines in the latter parts of this chapter, it could be seen that for engines using low quality fuel, such costs were almost double of per hour maintenance cost of engines using diesel, particularly in respect of older engines, which more than offset the gain in the operational cost of engines using low quality fuel.

1 The different makes of engines included in the sample were Kirloskar, Cooper, Imani, Jawahar, Pacco, Testtool, etc. The number of Kirloskar engines in the age-group of 10 years and above were as many as 5 whose performance in respect of fuel consumption was generally rated better than other engines.

One more observation may be made on the basis of table 5.8. It can be observed that average number of hours worked by engines during the year increased upto the age-group 7-9 years and then it fell down for the age-group of 10 years and above. The fall is precipitated in the case of engines using low quality fuel. It may be noted in this connection that 5 out of 7 engines in this age-group reported frequent break-downs in the year June 1965 to May 1966. These break-downs, in fact, prohibited greater use of engines during the year. Thus, it can be seen that though the engines can be operated beyond 10 years, the economic life of engine only extends upto 10 years. The assumption of economic life of an engine as 10 years, therefore, stands to reason.

Lubricating Oil

In respect of oil engines in the sample, varying prices of lubricating oil were observed. The price per litre of lubricating oil ranged between Rs.2 and Rs.3.60. This was due to different qualities of oil being used namely, fresh oil and reclaimed oil. The price of fresh oil ranged between Rs.3.10 to Rs.3.60 per litre, depending upon its viscosity or grade.[1] On the other hand, the price of reclaimed oil varied between

1 The different grades of oil used were No.30, 40, 50 and 60. Normally, the grade of oil to be used is recommended by the manufacturer. It may be mentioned here that grade and quality are not synonymous, since grade identifies its viscosity while quality refers to its lubricating nature at varying operating temperatures.

Rs.2 to Rs.2.70 per litre, depending upon the extent of dissolved or suspended impurities which the oil might have had before reclaiming. Out of 63 engines in the sample, 25 engines used fresh oil, while the remaining 38 used reclaimed oil.

It is a common knowledge that use of reclaimed oil causes excessive wear and tear on engine due to its poor lubricating quality. Before analysing the impact of the use of two different types of lubricating oil on the maintenance cost of engines, it may be relevant to describe the methodology adopted for computing maintenance cost of oil engines.

Maintenance Cost

As in the case of electric motors, in the case of engines, too, the maintenance cost has been divided into three parts viz., (i) greasing, (ii) minor repairs and overhauling, and (iii) major breakdowns and spare parts. The method of computation of costs for the year 1965-66 coming under first two heads is different than the method of computation of costs under the third head.[1]

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1 In respect of engines jointly owned, the maintenance expenditure such as, for minor repairs, overhauling, spare parts, etc. incurred on the engine was shared by all the partners having ownership rights in the engine. Hence it was possible to ascertain the expenditure incurred on these items by contacting one of the partners in the engine. This was not the case with the expenditure on greasing, which was separately incurred by all the partners. However, the expenditure on greasing formed less than 1 per cent of the total expenditure on maintenance and operation of the engines.

(i) Greasing : In Table 5.9, the hourly expenditure on greasing of engines and pump for different levels of operation of engines are presented. To facilitate comparison of costs of greasing of engines with trose of electric motors of 5 HP, the hourly expenditure of motors under this head is also depicted.

Table 5.9 : Expenditure on greasing of oil engines and pumps. Oil engines classified according to their levels of operation.

(Cost in Rs.)

Size-group of hours of operation of engine during 1965-66	No.of engines in the size-group	Per engine: Average hours of operation	Average quantity of grease consumed during the year (In kilo grams)	Average cost of grease during the year (In Rs.)	Per hour cost of grease during the year (In Rs.)	Per hour cost of grease for electric motors oof 5HP during the year (In Rs.)
0-200	15	120.21	0.20	0.42	.0206	.0423
200-400	15	287.73	1.00	2.87	.0097	.0137
400-600	13	484.73	1.00	3.05	.0064	.0106
600-800	9	676.11	1.15	3.50	.0052	.0052
800-1000	3	879.50	1.00	2.30	.0025	.0057
1000 & above	8	1535.19	2.25	6.76	.0044	.0037
Total	63	530.57	0.98	2.88	.0063	.0083

Note : The price of one kilogram of grease was reported to be varying between Rs.2.25 to Rs.3100.

The following observations may be made on the basis of the above table : (a) At the aggregative level, per hour consumption of grease for oil engine was less than per hour consumption of grease for electric motor. This was due to greater amount of grease required for electric motor at the time of overhauling in comparison to that required for oil engine. (b) For engines operated in the range of 200 to 1000 hours, the amount of grease consumed was reported to be the same, while in respect of first and the last size-group of hours of operation, the consumption of grease reported during the year was conspicuously low and high, respectively, as compared to other size-groups. In this context, it may be mentioned here that in most of the cases, the cultivators purchased grease of fixed quantity (0.25 Kg, 0.50 Kg or 1 Kg) once or twice a year and there was tendency among the respondents to state that the quantity bought during the year was consumed. In respect of first size-group of hours of operation (0-200 hours) of engine, it may be noted that 10 out of 15 engines were installed during the course of the year and, therefore, were not overhauled. The consumption of grease in these cases was reported to be very low, i.e., 0.25 Kg or less. Also, in case of 3 other engines in this size-group, which were more than 10 years old, the consumption of grease was reported to be low (0.25 Kg. in respect of 2 engines and nil in respect of one engine) since they were operated for less than 100 hours during the year on account of frequent breakdowns. In respect of engines in the last size-group (over 1000 hours), the consumption of grease was inflated due to (a) preponderence of jointly-owned engines in this size-group, and (b) the method[1] adopted for estimating the consumption in respect of such engines.

On the whole, it could be seen that per hour cost of greasing declined with the increase in the number of hours of operation of engine, since, in most of the cases, the expenditure on this count was of a fixed nature.

(ii) Minor Repairs and Overhauling : Minor repairs are defined as those repairs, which could be done without replacing the major spare parts such as liner, piston, crank-shaft, pump-shaft, head valves, bearings, rings, nozzle etc. They, therefore, include such repairs which were comparatively less time consuming such as cleaning and repairs of fans of pump, repairs of oil tube and its replacement, cleaning the valves, replacement of rubber bushes etc. The limitations of the classification of maintenance cost between minor repairs, overhauling etc. and major breakdown and spare parts may be observed here. The classification of actual expenditure incurred between these two heads of maintenance cost was to

1 Assuming that the consumption of grease by each partner is in proportion to his ownership right.

some extent, overlapping for the following reasons :

(a) 34 out of 63 engines were overhauled during the year. In a way, therefore, it was routinous expenditure for majority of engines. Overhauling of the engine involved opening the cover of the engine, and greasing and oiling different parts. Sometimes for oiling purpose, certain parts were disintegrated from the main body and cleaned before they were oiled. They were then integrated again. This entire process of overhauling consumed three to four hours and it was mostly done during summer when engine had a lay off. However, in respect of some of the engines, some spare parts (such as bearings or rings) were replaced at the time of overhauling. Many of the cultivators were not able to say whether certain parts of the engine were replaced or not at the time of overhauling. For this reason, large variations (Rs.10 to Rs.30) are observed in the overhauling charges paid to the mechanic for different engines.

(b) The replacement of certain parts like liner, piston, crank-shaft or its head necessarily led to opening up of the body of engine and disintegrating different parts. Since different parts of the engine lay exposed at the time of replacement of spare-parts, overhauling was possible at such time. It may be noted that out of 29 engines which did not report overhauling during the year, as many as 16 had either replaced major spare parts such as liner and piston or had undertaken the head - repairs during the year. However, the cultivators using sample engines were not able to say definitely whether the overhauling was done or not at the time of replacement of spare parts. It may also be noted that in respect of 20 engines in the sample, permanent mechanic was employed by the cultivators to look after the maintenance of the engine. The cultivators, therefore, appeared to have lesser details about the maintenance cost of the engines than desired.

Hence the division of expenditure between these two heads of maintenance cost is not perfect. However, the magnitude of transfer of expenditure from one head to the other head of maintenance in case of these sample engines is small since purely overhauling charges came to Rs.10 to Rs.15 and the least priced spare parts like rings or bearings cost Rs.10 to Rs.12.

Of the 63 sample engines of 5 HP, the expenditure on minor repairs and overhauling was incurred in respect of 46 engines. 12 out of these 46 engines did not report overhauling being done in their cases. In other words, the expenditure in case of these 12 engines related to minor repairs such as replacement of oil-tube or rubber bushes or fixing nut-bolts etc. The average expenditure per engine on minor repairs was Rs.5.26. The cost of oil tube was Rs.3 to Rs.5, that of rubber bush Rs.0.30 to Rs.0.50. It may be noted that out of these 12 engines, which did not report overhauling during the year, 4 had worked for only about 260 hours each during the year, while other 5, which had worked for more than 400 hours each, had undertaken replacement of major spare parts during the year.

The expenditure on overhauling per engine (for 34 engines reporting this expenditure) during the year ranged from Rs.10 to Rs.91. The average expenditure was Rs.32.38. This wide variation in the expenditure reported by different engines was due to (a) some (in all 6) engines undertaking overhauling more than once,[1] and (b) the increased cost per overhauling[2] reported by some engines. In certain cases this increased cost was also due to replacement of rubber bushes which went off frequently. Two engines in the village Narayangaon, and one in the village Ranjangaon reported expenditure on this count, i.e., replacement of rubber bushes, to the tune of Rs.25/- each.

Finally, 17 engines did not report either minor repairs or overhauling during the year. 11 engines out of these 17 engines had not completed one year during the year 1965-66.

1 All the engines reporting cost Rs.50 and above were overhauled twice during the year, with one engine being overhauled thrice.

2 Most of the engines reported cost per overhauling (including charges paid to mechanic) as Rs.10 to Rs.15/-. But some engines reported the cost per overhauling as Rs.20 to Rs.25. The plausible reasons for this increased cost is discussed earlier.

All the other six had undertaken replacement of major spare parts during the year.

(iii) Major Breakdown and Spare Parts : Under this head of maintenance cost, most of the items pertained to replacement of spare parts, the number of engines reporting breakdowns due to bursting of engine-head being 4 only.

As in the case of electric motors, in case of engines also, the total replacements of different parts and their costs from the date of installation till the time of survey were listed and apportioned on annual basis to compute the cost of maintenance under this head. Different items of spare-parts covered under the list are :-

(1) Liner (2) Piston (3) Crank-shaft (4) Pump-shaft (5) Headvalves (6) Piston rings (7) Head rings (8) Bearing (9) Nozzle (10) Connector, Governor etc. The spare-parts which were replaced mostly were liner and piston. 39 sample engines reported replacement of liner and piston. It may be noted that all the engines reporting its replacement stated that it was replaced at a fixed interval of time, such as one year, two year, and so on. It is because of this infrequent and discrete nature expenditure on spare-parts that it was thought to be better to take an average over all the years since installation.

As stated earlier, commonly replaced spare-parts were liner and piston. On the other hand, the spare part which was found to be rarely replaced was crank-shaft. Only 2 engines in the sample reported its replacement. It was incidentally the costliest part to replace. The cost reported for its replacement was Rs.500 to Rs.700. These engines exploded due to pressure of accumulated gas generated due to the use of inferior fuel and the failure of water-cooling system. The replacement cost of other spare parts as reported are as follows : Valve packet (Rs.25), Pump Bearing (Rs.12), Engine-bearings (Rs.22), Piston rings (Rs.30), Nozzle (Rs.27 to Rs.30). Most of these parts, except Nozzle, were reported to be replaced at an interval of 1.5 years to 2.5 years by different engines. It is not possible to probe more into the analysis of expenditure under this head of maintenance cost because for 20 engines their owner-cultivators were not able to specify the particular spare parts replaced at regular intervals, since they had employed a permanent mechanic for the servicing of the engines. They could only state the amount spent on the replacement of spare parts but could not specify the items.

Thus, the total expenditure on maintenance is sum of expenditure on (i) greasing during the year 1965-66, (2) On minor repairs and overhauling during the year 1965-66, (3) and apportionable per annum expenditure on spare parts and breakdowns.

Impact of use of different types of lubricating Oils and Fuels on maintenance cost

An attempt is made below to analysis the influence of different types of lubricating oils and fuels used on the maintenance cost of engines. Similarly, attempt is made to bring out the impact of age of the engine on its maintenance cost.

In Table 5.10, the engines have been classified by the type of lubricating oil used and by the type of fuel used.

Table 5.10 : Impact of type of lubricating oil and fuel used by oil engines on their maintenance cost.

(Per hour cost in Rs.)

Type of Lubricating oil used by engines	Number of engines of which			Per hour maintenance cost of engines reporting use of		Per hour maintenance cost for all engines
	Total	Using diesel	Using crude oil	Diesel	Crude oil	
1	2	3	4	5	6	7
Fresh oil	25	16	9	.14	.20	.17
Reclaimed oil	38	24	14	.16	.16	.16
Total	63	40	23	.15	.18	.16

Both, the quality of lubricating oil as well as the quality of fuel used, had bearing on the maintenance cost of the engine. Between the two, the impact of type of lubricating oil on the maintenance cost was less discernible, as revealed by the last column of the Table 5.10. As could be gauged from columns (5) and (6) of the above table, the impact of the quality of fuel used on the maintenance cost of the engine was more visible.

It may be mentioned here that age of the engine is one more contributory factor in its maintenance cost. Since the above table averages out per hour maintenance cost of engines over different age-groups, it does not bring out fully the impact of the type of fuel used on the maintenance cost. Table 5.11 would help understand the impact of age of engine on its maintenance cost.

Table 5.11 : Ageoof the engines and their maintenamce cost.

(Cost in Rs.)

Age-group of engines	No.of engines	Average age of the engines (In Rs.)	Average no.of hours of operation (during 1965-66)	Average per hour maintenance cost (In Rs.)
Less than 3 Yrs.	20	1.80	401.30	0.17
More than 3 Yrs. but less than 7 years	19	4.95	618.41	0.13
More than 7 years but less than 10 years	16	8.12	698.52	0.15
10 years & above	7	13.29	335.07	0.42
Total	62	5.69	537.06	0.16

Note : In respect of one engine, its age could not be determined by its user. Hence, it is not considered for the purpose of analysis.

Age of the Engine & Its Maintenance Cost

In table 5.11, the engines covered by the sample have been classified into 4 age-groups based on their number of completed years as of end-May 1966. These age-groups in descending order represent fairly new engines, moderately old engines, fairly old engines and very old engines. For engines in each of the size-groups, average maintenance cost per hour of operation is computed.

As could be seen from the table 5.11, the average per hour maintenance cost declines between the first two age-groups, perhaps reflecting that the cultivators took some time to adopt to mechanical mode of irrigation. Thereafter, the maintenance cost per hour of operation had gradually started rising, but in the last size-group, per hour maintenance cost had shown steep increase, thus bringing out impact of age. The decline in periodicity of replacement of spare parts and the increase in frequency of minor repairs had contributed to steep rise in the maintenance cost of engines in the size-group of 10 years and above. It is also to be noted that the average number of hours of operation of engines in this size-group shows a sharp decline as compared to the hours of operation of engines in the preceding size-group. 2 out of 7 engines in the size-group had worked for less than 100 hours during the year. In fact, the frequency of breakdowns had prohibited their greater use during the period of reference. It might be of interest to note that in the last age-group, per hour maintenance cost of engines using diesel at Rs.0.29 was roughly half (i.e., Rs.0.55) of those using crude oil.

Hours of Operation of Engine during the year

The limitations of the data on the hours of operation of engines during the year are stated below.

As stated earlier, in the case of electric motors, only such schedules were accepted for analysis in respect of which the estimates of hours operated by electric motor during the year as obtained from the interviews of cultivator (hours of irrigation of different crops during the years plus hours operated for sale of water, if any, reported by the user) tallied more or less with the estimates of hours arrived at from the units recorded for the same period by the meter. In other words, in case of motor, an independent cross-check on the total of hours of irrigation of different crops during the year reported by the cultivator, was available. In case of engine, there was no such cross check available on the hours of irrigation reported by the cultivator.

The only possible of having a cross-check on the hours of operation of engines in a year reported by the cultivators was to work out the estimate of hours of operation of engine based on the reported total consumption of fuel by engine during the year. Knowing the hourly rate of consumption of fuel by the engine, the estimate of total hours of operation of engine during the year could be had, provided data on annual consumption of fuel (in litres, or in gallons or in barrel) was obtained. In short, if the details of total purchases of fuel during the year and the stock at the beginning and at the end of the year were known, an independent estimate of the hours of utilisation of engine during the year could be formed. Unfortunately, it was not possible to have the details of the purchases, stocks etc. of the fuel of the engines. This was mainly because, excepting for three engines, the cultivators using the engines had purchased the fuel at retail whenever the need arose and that too in different quantities. They were not, therefore, able to state even approximately total quantity purchased during the year. The only cross-check that could be had on number of hours reported by an engine was to compare the hours of irrigation for each irrigation for certain major crops by an engine of 5 HP with the reported hours for each irrigation for the same crops by an electric motor of 5HP. Such checks were made and found to be satisfactory. Details pertaining to these checks are presented in a later chapter.

It may be worthwhile to state here a distinguishing feature of total hours of operation of an engine, as against total hours of operation of an electric motor in a year. In respect of motor, which is essentially an immobile unit, total hours of operation in a year related to one source of irrigation, i.e., one well. However, in case of an engine, which could be moved from one well to another, total hours of operation in the year were sum of total hours of operation on all the wells on which the engine was operated during the year.

Variable costs at different levels of operation

Table 5.12 depicts behaviour of per hour variable costs at different levels of operation of engines. It may be observed from Table 5.12 that, by and large, per hour variable costs show declining trend with the increase in level of operation of oil engines. However, it is relevant to note that per hour operation cost (i.e., fuel cost) does not show large variation with the increase in hours of operation of engine. This is mainly because per hour consumption of fuel by an engine was reported to be constant irrespective of its scale of operation. The difference in per hour operation cost over the size-groups is largely due to different types of fuel used, as also price differential of fuels.

On the other hand, maimtenance costs per hour of operation show consistent fall with the increase in level of operation. This is on account of replacement of certain items of spare parts (such as liner and piston) and overhauling of engines being undertaken at regular interval of time irrespective of their levels of operation. However, it is significant to note that the rate of fall in per hour maintenance cost declines beyond the level of 1000 hours of operation. This was due to reduction in periodicity of replacement of spare parts as well as increase in frequency of minor repairs, and overhauling in respect of engines operated at these levels.

Table 5.12 : Per hour cost of working of oil engines of 5 hours power. (Cost in Rs.)

No.of hours of operation during 1965-66 (size-group	No.of oil engines	Average No. of hours of operation during 1965-66	Per hour maintenance cost				Per hour operation cost	Total per hour variable cost
			Greasing	Minor repairs and overhauling	Major breakdowns and spare-parts	Total maintenance cost		
0-200	15	120.21	0.0206 (1.62)	0.1745 (13.75)	0.1492 (11.76)	0.3443 (27.13)	0.9248 (72.87)	1.2691 (100.0)
200-400	15	287.73	0.0097 (0.66)	0.0666 (4.59)	0.2255 (15.56)	0.3018 (20.81)	1.1482 (79.19)	1.4500 (100.0)
400-600	13	484.73	0.0064 (0.48)	0.0460 (3.39)	0.1771 (13.07)	0.2295 (16.94)	1.1255 (83.06)	1.3550 (100.00)
600-800	9	676.11	0.0052 (0.46)	0.0432 (3.80)	0.1194 (10.49)	0.1678 (14.75)	0.9704 (85.25)	1.1382 (100.0)
800-1000	3	879.50	0.0025 (0.21)	0.0192 (1.68)	0.0782 (6.83)	0.0999 (8.72)	1.0452 (91.28)	1.1451 (100.00)
Above 1000	8	1535.19	0.0044 (0.42)	0.0131 (1.26)	0.0477 (4.57)	0.0652 (6.25)	0.9786 (93.75)	1.0438 (100.0)
Total	63	530.57	0.0063 (0.53)	0.0409 (3.43)	0.1160 (9.73)	0.1632 (13.69)	1.0291 (86.31)	1.1923 (100.0)

Note: Figures in brackets indicates share (in percentage) in total.

Total Costs of Irrigation

As mentioned in the previous chapter, total costs of irrigation during the year consist of (a) fixed costs (i.e., depreciation charges and interest costs); and (b) variable costs (viz., operation and maintenance costs). Table 5.13 presents total costs of irrigation by sample oil engines for different levels of operation during 1965-66.

Table 5.13 : Cost of irrigation by oil engines - 5 H.P.

Hours of operation during the year (In size-group)	No.of oil engines	Average No.of hours of operation	Cost of Irrigation per oil engine			Cost per hour of operation
			Fixed	Variable	Total	
0-200	15	120.21	388.17 (71.78)	152.57 (28.22)	540.74 (100.00)	4.50
200-400	15	287.73	336.09 (44.62)	417.21 (55.38)	753.30 (100.00)	2.62
400-600	13	484.73	419.26 (38.96)	656.77 (61.04)	1076.03 (100.00)	2.21
600-800	9	676.11	360.27 (31.89)	769.54 (68.11)	1129.81 (100.0)	1.67
800-1000	3	879.50	364.16 (26.56)	1007.05 (73.44)	1371.21 (100.00)	1.56
Above 1000	8	1535.19	391.64 (19.64)	1602.44 (80.36)	1994.08 (100.00)	1.30
Total	63	530.57	377.50 (37.37)	632.56 (62.63)	1010.06 (100.00)	1.90

Note : Figures in brackets indicate share (in percentage) in total cost.

It may be observed from Table 5.13 that trend in two components of costs of irrigation of oil engines at different levels of operation is similar to the one noticed in these components of costs of electric motor in the previous chapter. Thus, in respect of oil engines also, economies of scale of operation can be perceived from declining per hour operational cost (total costs of irrigation) at higher levels of operation. Scale-economies are obtained through (i) distribution of fixed costs over larger number of hours, as also (ii) distribution of certain variable costs incurred at fixed interval of time (such as overhauling or replacement of liner and piston, etc.) over larger number of hours.

However, it may be noted that whereas in respect of electric motor, average variable cost of the motors also showed declining trend at higher levels due to tariff structure for consumption of electricity, in case of oil engines, these costs remained more or less constant because of fixed hourly rate of consumption of fuel reported at all levels of their operation. The above-mentioned features of cost of operation of oil engines are reflected in the slope of the cost-function fitted for them in the following section.

Cost functions of oil engines

Cost functions have been fitted for oil engines of 5 HP, taking hours of operation as independent variable and cost per hour of operation as dependent variable. As in the case of electric motor, both double log function and quadratic function were fitted. The results of two fits are presented in Annexure 5A. The comparison of two fits yields similar results as in the case of electric motors, i.e., larger percentage variation is explained by double log function than the quadratic function. It may also be noted that the values of 't' and 'f' were found highly significant for double log function.

The shape of the curve (graph presented in Annexure 5B) is asymptotic to both the axes, with a steep fall upto around 500 hours of operation. Beyond this level of operation, the curve starts smoothening out gradually, and after 1700 hours of operation almost runs parallel to x-axis. This is reflected in the lower order constant term as also high exponential value of the independent variable in the double log function, in comparison to double log function of 5 HP electric motor.

As discussed in the preceding sections, there are no economies to scale in cost of operation (fuel cost) of engine due to constant rate of consumption of fuel by engines. Also, it is seen earlier that there is decline in the rate of fall in per hour maintenance cost of engines at higher levels of operation. The shape of the curve conforms to the above-mentioned behaviour of variable costs.

In the latter chapters, we have compared the cost functions for different modes of irrigation and brought out their implications for choice of mode of irrigation at various levels of operation.

ANNEXURE 5A

COST FUNCTIONS

I. Double log - 5 HP oil engine.

Number of observations = 63

x = Independent variable - Number of hours operated (In log)

y = Dependent variable - cost per hour of operations (in Rs.) (In log)

	Coefficient	t-test
Constant (log a)	3.9297	
Regression coefficient (b)	-0.5136	15.89 t_{61}=1.96 at 5% level (normal table)

Analysis of Variance

Source	Degrees of freedom	Sum of squares	Mean E.S.S.	F-test
Regression	1	15.8384		252.52
Error	61	3.8260	.0627	$F_{1,61}$=4.00 at 5% level (table value)
Total	62	19.6644		

$r^2 = 0.8053$

Percentage variation explained = 80.53

Function : log y = log a +blog x

Fitted function: log y = 3.9297 - .5136 log x

$$y = 50.886x^{-.5136}$$

II. Quadratic Function = 5 HP Oil Engine

No. of observations = 63

x = Independent variable - Number of hours operated

y = Dependent variable - Cost per hour of operation (In Rs.)

	Coefficient	t-test	
Constant (a)	+5.8693		
Regression of b_1	-0.0084	6.28	t_{60}=1.96 at 5% level (Normal table)
Coefficients b_2	+0.0000031	4.61	

Analysis of Variance

Source	Degrees of freedom	Sum of squares	Mean E.S.S.	F-test
Regression	2	160.77		26.32
Error	60	183.27	3.05	$F_{2,60}$=3.15 at 5% level (Table value)
Total	62	344.04		

$r^2 = 0.46729$

Percentage variation explained = 46.73

Function $y = a + b_1 + b_2x^2$

Fitted function $y = 5.8693 - .008419x + .0000031x^2$