Agricultural pumping efficiency in India : Role of standards.

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Abstract

End use efficiency of agricultural pumpsets in India is dismally low. The agricultural power tariff is highly subsidised and is usually linked to the connected load (not consumption). Hence, farmers have little incentive for efficient use of electricity. Nearly 500 thousand pumps are added each year, most of these are not efficient. This paper evaluates ways in which these can be made efficient. The role of efficiency standards in achieving this goal and the appropriateness of existing standards is evaluated. Implementability of modified standards and its possible benefits are quantified.

Pump efficiency standards need substantial improvements. Raising the minimum allowable efficiency, incorporating the effect of deterioration in pump efficiency with changes in operating conditions; are the important issues. Standards for pipe sizing need to be revised. Past work has not considered the full implications of better standards. Improved standards for agricultural pumps alone can save India, over US $ 129 million per year through the avoided expansion of power system and fuel saving. These savings are far more than largely believed. The incremental investment necessary for this is just over one tenth of the savings.

Introduction :

Indian power sector is facing severe capital and capacity shortage. Scheduled and unscheduled power cuts are common in most part of the county. The low power tariffs for IPS (irrigation pump sets) is said to be the major reason for the bad financial health of the power sector. The electricity subsidy for IPS was Rs 10,113 crores (US $ 2.89 billion) in 1995. The subsidised power tariff (based on the connected load) and poor efficiency of pumping systems is a cause of concern for the power sector. In last two decades, the growth rate of electricity use by IPS has been about 12% p.a.. This growth rate is twice as rapid as other sectors. In 1995, IPS consumption as claimed by the power sector was 28% of total sales (Planning Commission 1995).[1] And nearly 500 thousand IPS continue to add each year.

The efficiency of IPS is dismally low. Field studies and pilot projects have demonstrated that IPS electricity consumption can be reduced by 30 to 50%, by simple measures, such as use of higher efficiency pumpset and pipes with larger diameter. The payback period for such investments is 1 to 2 years (NABARD 1984, Patel S.M. and Pandey M.K. 1993). But the past efforts have been mostly directed towards rectification of old IPS and a lot needs to be done to ensure efficient installation of half a million new IPS added each year.

This paper evaluates the role of efficiency standards in ensuring installation of efficient IPS. First part of the paper describes the factors affecting the efficiency of IPS. The second and third part evaluates the appropriateness of the standards, i.e. whether standards are sufficiently stringent, or they need to be improved. Since, Indian efficiency standards are not mandatory, it is important to evaluate whether the improved standards would have a real impact on the field. The last two sections examine this issue and quantify the likely benefits.

1. Typical IPS installation and factors affecting efficiency

A typical configuration of IPS, as shown in figure 1, consists of piping system (footvalve, suction and delivery pipe) and the pumpset. The centrifugal monoblock pumpsets installed on open dug wells are most common. This paper mainly deals with the centrifugal pumps.

Figure 1 : Typical configuration of IPS on well.

[Figure not included]

Figure shows typical configuration of a monoblock IPS on a well. The suction and delivery pipe as well as the suction /delivery head (static) are also shown. The change in water level (draw down) during pump operation is indicated.

Efficiency of pumping system is a function of efficiency of the system components, i.e.

$$\eta_{\text{system}} = f(\eta_{\text{Pump-set}}, \eta_{\text{Piping}}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

1.1 Pump-set :

Pump efficiency characteristics are represented as total head v/s discharge, as shown in figure 2. The total head (the vertical axis in figure) is the sum of suction head, delivery head and the frictional head due to piping. With increasing total head, the flow rate decreases. The pump efficiency is also plotted against flow on the same graph. With increasing discharge (or decreasing head) the pump efficiency first increases and then falls. The highest efficiency point is referred as 'Best Efficiency Point' (BEP).

The efficiency characteristics of the pump also depend on the suction head. The broken lines in the figure show the pump characteristics at a higher suction head. It can be seen that pump efficiency deteriorates as suction head increases.

Figure 2 : Typical pump characteristics.

[Figure not included]

Figure shows the typical head-flow and efficiency-flow characteristics of centrifugal monoblock pump used for IPS. The solid lines indicate characteristics at suction head of 4.5 meters and broken lines for suction head of 7.5 meters. With increasing head, the efficiency of centrifugal pumps first increases and then starts declining. The highest efficiency, the rated pump efficiency, is indicated on efficiency curve by * mark. This is also called Best Efficiency Point (BEP). At high suction head, the pump performance substantially deteriorates.

In field conditions, due to changing water level and, at times, change in the water delivery point; the suction as well as the total head changes. Hence, most IPS operate with varying total head as well as suction head. Therefore, the on-field pump efficiency depend on,

a) BEP efficiency, and

b) the change in pump efficiency with changing suction and total head.

Usually, squirrel-cage induction motors are used for IPS. The difference in the efficiency of standard motor and the efficient motor (available in market) ranges between, 5 to 11 percentage points. The efficient motors are suitable for IPS operation but the standard motors are used for cost considerations.

1.2 Piping :

The piping efficiency can be defined as[2];

$$\eta_{piping} = \text{useful energy output} \div \text{total energy input}$$

$$= (H_s + H_d) \div (H_s + H_d + H_f) \qquad \text{.................} \qquad (2)$$

where : H_s = static suction head, H_d = static delivery head, and

H_f = Frictional head loss in pipe and accessories (in meters of water column).

The frictional losses in the pipe (H_f) can be estimated by following equation :

$$H_f = 1.213 * 10^{10} * (Q \div C)^{1.852} * (L \div D)^{4.87} \qquad \text{....................} \qquad (3)$$

Where: Q = rate of discharge in litres per second (lps)

C = Hazen William's constant; a function of pipe surface,

D = inside diameter of pipe in mm,

L = length of pipe in meters,

It can be seen that, for a given discharge and length of pipe; the piping efficiency can be increased (i.e. frictional loss can be reduced) by : (i) using a low friction pipe, such as rigid PVC (RPVC) pipe, (ii) Proper lay o ut to reduce the pipe length and most importantly by (iii) increasing the pipe diameter.

The foot valve (a non-return valve) is the most important accessory in piping. The loss of head due to frictional in the footvalve, (H_{fv}) is proportional to K and V^2.

where : K = foot-valve characteristics (determined by material, construction and design of footvalve), and V = flow velocity (meter/sec).

The K value of foot valve ranges from 13 to below 0.8 (Patel S.M. and Pandey M.K. 1993). For a given flow velocity the frictional loss is directly proportional to K value.

1.3 Efficiency standards for Agricultural pumping systems :

"Bureau of Indian Standards" (BIS) and "National Bank for Agricultural and Rural Development" (NABARD) have laid down standards / norms for various aspects of the pumping system.

BIS, a statuary body of government of India, has developed standards for number of industrial and domestic products. Adoption of BIS standards is voluntary for appliance manufacturers. BIS has prescribed elaborate standards and testing procedures for pump, motor, pipe and footvalves. Manufacturers conforming to BIS standards get ISI mark, a logo for quality product.

NABARD is a public sector developmental bank. It extends loans for agricultural schemes such as dig ging wells, installation of IPS or land preparation. It operates mainly by refinancing the loans extended by other commercial banks for these schemes. NABARD has also prepared norms for selection of IPS system components. All farmers availing NABARD credit have to abide by these norms. For the small pumping systems, NABARD has adopted the BIS norms. But for large pumping systems, NABARD has evolved its own norms for pipe sizing, layout, and pump selection.

2 Evaluation of BIS standards for pump

For achieving high operating efficiency of a pump, two factors are important : i) proper pump selection, and ii) high pump efficiency. This section analyses BIS norms for pump selection and pump efficiency.

2.1 Selection of pump

The pump selection involves specification of head as well as the flow rate. With the head selection being the most important aspect. The Indian standard for "Recommended pumping system for agricultural purpose" (IS 10804 : 1994) says :

> *"The pump should be selected in such a way that it shall operate at near maximum efficiency during peak demand period in the ranges of discharge and head. It should also be capable to discharge in summer season. (when the head is likely to be the maximum)"*

The standard does not specify a procedure for pump selection. And in practice, pump head selection is totally arbitrary. Farmers are rarely aware of the importance of proper pump selection or even the relation of head v/s flow. Our observations of pump purchase deals (at the pump dealer shops) revealed that farmer usually decide pump power (kW) and the pump dealer implicitly decides pump head. To determine the most suited pump, the dealer does not refer to pump literature. Where water levels are not too deep, a pump for 25 m head is sold by default.

For proper pump selection, which is one of the toughest and also the most important task, following conditions need to be satisfies :

- Farmers as well as pump dealers (authorised as well as un-authorised) need to be made aware of the importance of pump head selection;
- The technical literature made for this purpose needs to be simplified [3] ,
- And most importantly, farmers need a clear incentive for efficient pump use (such as consumption based power tariff),

Hence, the standards have a little role in proper pump selection.

2.2 Pump efficiency :

The BIS standards for minimum pump efficiency (for agricultural use) were introduced in late 1980's. Pumps are tasted at the design head (BEP head) with a suction head of 6 meters. This is a one point test. But, as discussed earlier, the on-field operating efficiency of pump depends on three aspects :

- Pump efficiency at the design head (at BEP),
- Change in efficiency with change in total head,

- Change in efficiency with change in suction head.

Following section deals with these three aspects.

2.2.1 Pump efficiency at design head : The BIS specified minimum pump efficiency varies from 55 to 70% depending on the rated duty point (of head and flow). The BIS standards were expected to be up-graded every 3 years. But the efficiency standard for monoblock agricultural pumps, IS-9079, has not been revised since 1989. About the appropriateness of these standards, the chairman of the 'Technical committee' of the Indian Pump Manufacturers Association (IPMA) says :

> *"There is a wide gap between the minimum efficiency required for ISI certification and achieved by reputed manufacturers, which are very near international efficiencies. So, there is a big scope for improving the efficiencies of pumps manufactured in the country" (Jain P.C. 1994)*

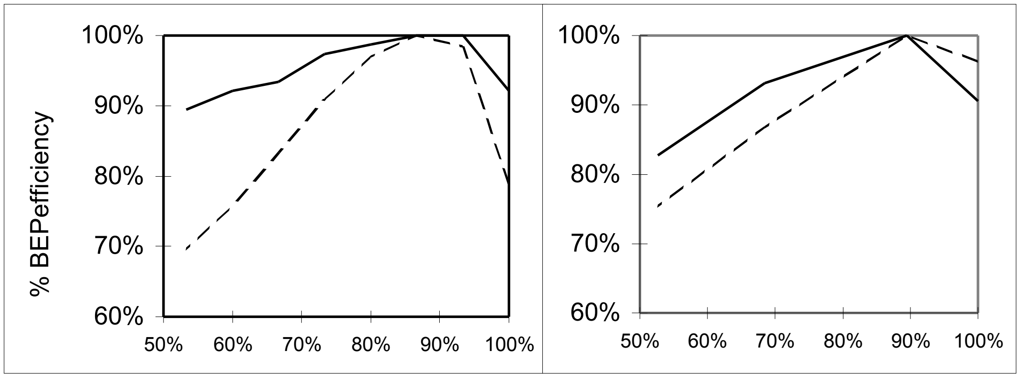
This gap in efficiency is 8 to 10 percentage points, implying an energy saving of 12 to 14% by the efficient pumps (Boothra K C, Bajaj N K, 1994).[4] The BIS standards need to be up-graded to remove this gap.

2.2.2 Change in efficiency with change in total head : The declared efficiency at BEP, represents the maximum achievable pump efficiency. When the operating head is different than head at BEP, the pump efficiency is lower than the declared efficiency. For well designed pumps such fall in efficiency can be small, i.e. the efficiency curve is flat in relation to variation in total head. Figure 3 shows the change in efficiency of two sets of pumps with change in total head. All four pumps confirm to the BIS standards. Pumps A-1 and A-2 are designed for low head, while pumps B-1 and B-2 are designed for medium head. The BEP efficiency of these pumps as well as their design heads are different from each other. To eliminate such differences, the figure shows efficiency as a percentage of BEP efficiency and the head as percentage of maximum head. It can be seen that pumps A-1 and B-1 show lower deterioration in efficiency compared to their counter parts (i.e. pump A-2 and B-2 respectively).

Considering pump operation evenly spread over the head range, pumps A-1 and B-1 would perform better. The average operating efficiency of pump A-1 and A-2 would be 95% and 87% of their rated efficiency (at BEP). Hence, even if the rated efficiency of both pumps (A-1 and A-2) was to be identical, pump A-2 would consume 10% more energy than A-1. For pump B-1 and B-2, the average efficiency works out to be 92% and 90%. Hence, pump B-2 would consume 2% more energy than B-1, just on the account of non-flat efficiency curve. [5]

Figure 3 : Change in pump efficiency with variation in total head.

Pump A1 —— and A2 - - -   Pump B1 —— and B2 - - -

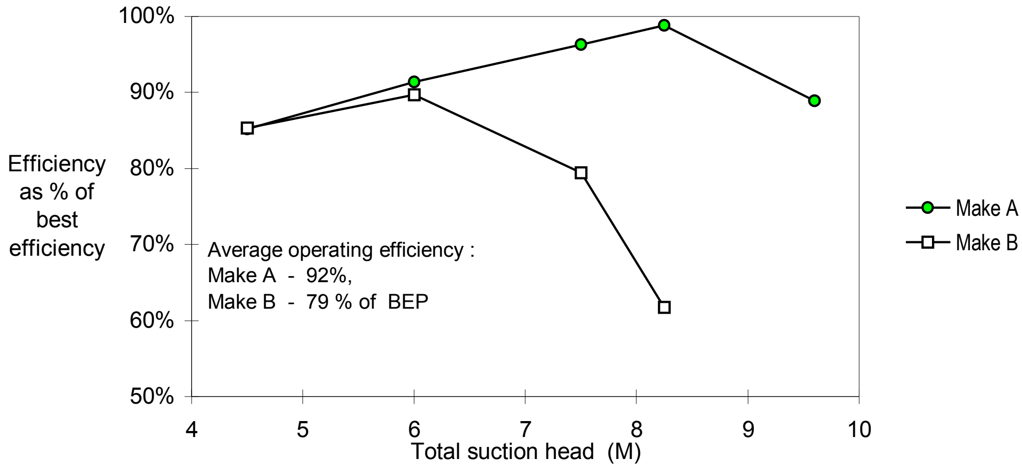


Head (as % of maximum head)   Head (as % of maximum head)

For a varying head operation, the average operating efficiency of A-1 and B-1 would be superior to their counterparts. This reflects in 2% to 10% more energy consumption by the inferior pumps, just on the account of non-flat efficiency curve. Data for pump A-1, A-2 is based on measurements reported by Bootra and Bajaj, 1995 and data for pumps B-1, B-2 from the manufacturer's literature.

<u>2.2.3 Change in efficiency with change in suction head</u> : As seen earlier, pump efficiency also deteriorates at high suction heads. The maximum suction head of a pump depends on its 'Net Positive Suction Head' (NPSH) characteristics. When suction head approaches the maximum suction head, the pump efficiency can dramatically fall. The maximum suction head of ill designed pumps can be substantially lower than that of the well designed pumps. For open dug wells, the change in water level (and hence the suction head) can frequently be 3 to 4 meters. Figure 4 shows the change in efficiency for two pumps, with change in suction head. To eliminate the difference in the rated pump efficiency (at BEP), here the efficiency is represented as a percentage of rated efficiency. In the shown range of suction head, the average (simple average) efficiency of pump A is 92% of its BEP efficiency. For pump B it is only 79%.[6] Hence, even if both pumps had same rated efficiency, pump B would consume 16% more energy than pump A for the varying head operation.

Figure 4 : Effect of suction head on pump efficiency.



With increasing suction head, efficiency of pump B declines faster than that of pump A. For an operation, evenly spread over the shown range of suction head, pump B would consume 16% more energy than pump A; just on account of bad suction characteristics. A delivery head of 7.5 meters was considered for both pumps. Pump performance data based on measurements reported by Boothra and Bajaj, 1995.

For agricultural operations total as well as the suction head is highly variable. Hence, operating efficiency can be substantially lower than the rated pump efficiency. For well designed pumps this deterioration in efficiency would be far less than ill designed pumps. The present BIS norms based one point test neglects the change in efficiency with change in total as well as suction head. Hence, in addition to increasing the minimum rated efficiency (at BEP), the BIS standards should also consider these issues.

As mentioned earlier, the problem of improper pump selection can only be addressed by education and incentive and not by standards. Even with improved BIS standards, improper pump selection can continue. But a pump with better suction characteristics and flat efficiency curve (in relation to head) would show better performance than an inefficient pump even in the case of improper selection. In other words, the inefficiency caused due to improper pump selection can be reduced by better pump standards.

3 Evaluation of BIS and NABARD standards for Pipe sizing :

Piping system efficiency mainly depends on the pipe size and also on the quality of accessories such as footvalve, bends and piping layout. This section evaluates the appropriateness of pipe sizing standards of BIS and NABARD. The issue of accessories and foot valve is covered at the end of the section.

For pipe sizing, the BIS as well as NABARD have a set of norms. Depending on the flow rate, BIS specification require the pipe frictional loss to be lower than 3.5 to 9.5 meters (of water column) per 100 meter of pipe length (IS 10804:1994). NABARD norms specify much higher pipe size; it allows frictional loss of only 3 to 4 meters per 1,000 meters of pipe length.(NABARD 1991) Hence, a 100 meter of pipe, sized as per the BIS norm would offer same frictional loss as a 1,000 to 3,000 meter long pipe sized as per the NABARD norm.

For a given flow rate, the frictional loss in pipe decreases if the pipe size is increased. And correspondingly, the electricity usage and the pump power needed to overcome the friction also decrease. Hence, with increasing pipe size, the running cost of electricity and investment cost of pump decreases but the investment cost of pipe increase. It is important to minimise the total cost, comprising of the running cost and the annualised investment cost (of pump and pipe). There exists an optimum pipe size at which the total cost is minimum. Following sections calculates such optimum pipe size for various flow rates and compares it with the BIS and NABARD piping standards.

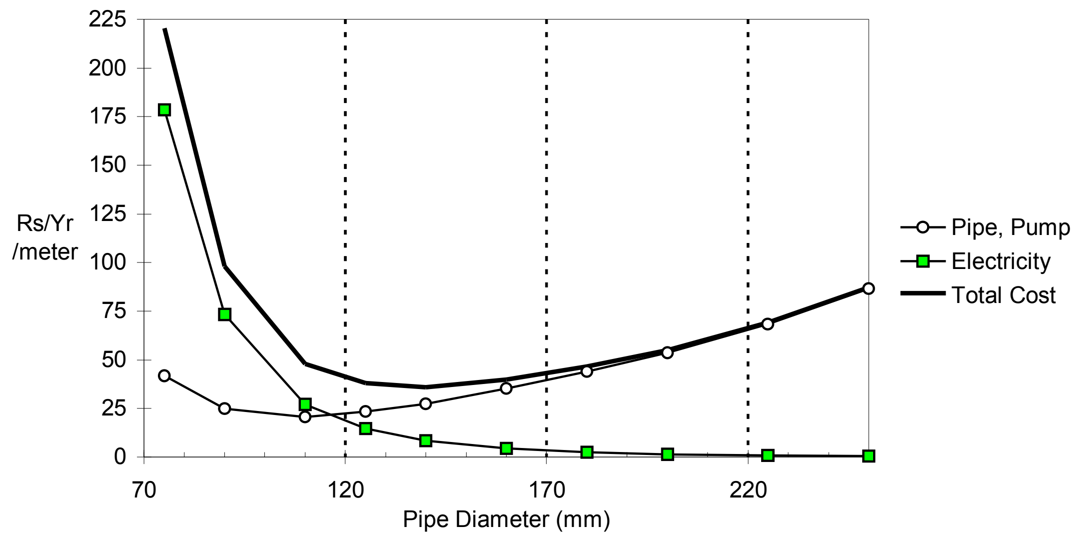
3.1 Calculation of optimum pipe diameter

Figure 5 shows the calculations to arrive at the optimal pipe size for a flow rate of 20 litre per second (lps). For this flow, the frictional head loss per meter of pipe is calculated using equation 3. The electricity usage to overcome the frictional loss is calculated for the typical pump efficiency, and annual pump operation of 2,000 hours per year. The running cost (of electricity) is calculated for the average cost of electricity supply in Maharashtra. The investment cost has two components; namely, the pipe cost and the incremental cost of pump to overcome pipe friction. The pipe cost is based on the prevailing price of RPVC (rigid PVC) pipes. The investment is annualised to make it comparable to the annual running cost.

Figure 5 shows the change in (a) annualised investment cost (of pipe and pump), (b) running cost of electricity use, and (c) the total cost, (i.e. a+b). The costs are shown as a function of pipe size. With increasing pipe diameter, electricity cost decreases rapidly, but the investment cost increases. The optimum pipe size, which minimises total cost can be arrived from the figure. This calculation is based on the average cost of electricity supply (in Maharashtra) but farmers do not pay full cost of electricity. Hence, above calculation reflects the optimum pipe size from the societal point of view. The assumptions made are listed below :

(i) economic life of RPVC pipe and pump = 10 years, (ii) pumpset cost = Rs. 1,876/- (US $ 50.7) per kW, (iii) pumpset efficiency = 60%, (iv) electricity cost Rs. 1.73/KWh (US 4.7 cents/kWh) (Planning Commission 1994), (v) 12% (real) discount rate.

Figure 5 : Societal cost as a function of pipe diameter and selection of optimum pipe diameter



For a flow of 20 lps, the optimum pipe size is 140 mm, while, the BIS recommends a pipe size of 110 mm. The total cost rises rapidly if smaller pipe is used. Most farmers use pipes smaller than even the BIS recommendation. Such decisions result in marginally lower investment for farmer and substantially higher electricity cost for the society.

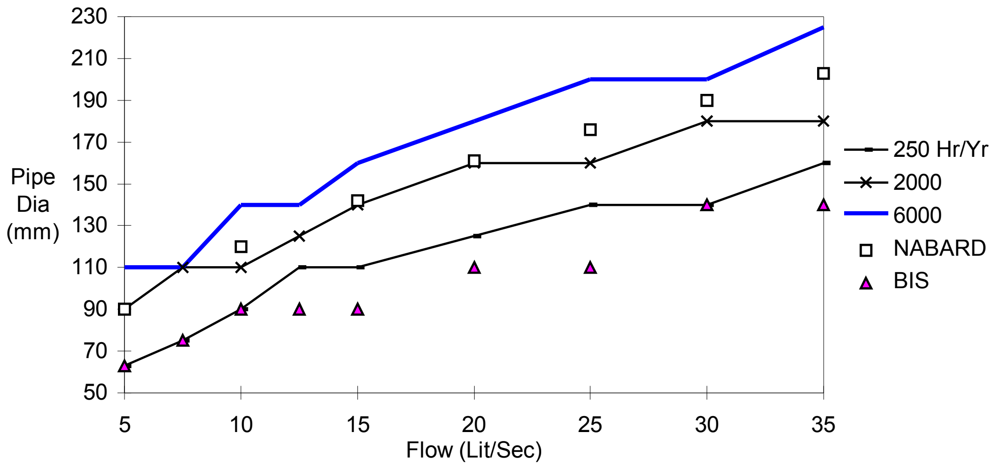
The optimum pipe size calculated above considers the average cost of electricity for the power utilities. But Indian farmers do not pay full cost of electricity. Hence, have no incentive to use the optimum pipe size. But the standards need to be consider the social perspective and should try to minimise the total cost from this perspective. In other words the BIS norms for pipe size should be same as the optimum pipe size calculated above.

3.2 Comparison of BIS and NABARD piping norms with optimum pipe size :

Based on the above calculation, the optimum pipe sizes for different flow rates are arrived at after considering commercially available pipe sizes. The BIS and the NABARD piping norms are compared with the calculated optimum pipe size.

The running cost of electricity use, is a function of duration of pump usage. Hence, the optimum pipe size also depends on the pump usage. For a give flow, optimum pipe size at different levels of pump usage have been calculated. The pump usage of 250, 2000 and 6000 hours per year have been considered. The results are shown in figure 6.

Figure 6 : Comparison of optimum pipe size with NABARD and BIS norms



The square and triangular marks indicate the NABARD and BIS recommended pipe sizes for different flows. The lines indicate the optimum pipe sizes at three levels of pump usage. The BIS norms for pipe sizing are appropriate for pump operation of 250 hr/year. Considering the Indian average pump usage of 1,750 hr/yr, BIS norms need to be revised upwards. The NABARD norms applicable for lift irrigation schemes, which usually operate for over 3,000 hr/yr, seem appropriate.

The NABARD has evolved piping norms for the lift irrigation schemes, which usually operate for more than 3,000 hours per year (NABARD, 1991). For this level of operation, NABARD norms are close to the optimum. The BIS norms are targeted at small pumps. These norms are suitable for pump operation below 250 hours per year. Considering the national average for pump usage of 1,700 hr/yr the BIS norms need to be substantially up-graded.

3.3 Accessories and pipe layout :

The foot valve is the most important accessory in piping. The BIS norms for foot valve specifies that K value of footvalve should be less than 0.8. Footvalves made by small non-standard manufacturers, have k value between 2.5 to 13 (Patel S.M. and Pandey M.K., 1993 pp 31). Researchers and manufacturers have developed ISI marked footvalves. These efficient footvalves (of RPVC) are widely available in sizes up to 100 mm. Efficient metal footvalves are available in higher sizes also.

As regards the pipe lay-out, the BIS standards specify that, low loss accessories such as ‘long radius bends’ should be used; number of bends and length of pipe should be reduced. Hence, the BIS specifications are appropriate.

4. Possible impact of standards and norms in reducing IPS consumption

Technical knowledge required for proper selection of pumpset and pipe sizing is clearly out of knowledge reach of farmers, who is the final consumer. Moreover, farmers have no incentive to reduce electricity consumption, on the contrary for reducing the first cost, farmers can resort to cheap, low quality equipment. In addition, the BIS norms are not mandatory for IPS manufacturers. Due to these factors, it is usually believed that standards and norms have little role in improving the efficiency of new IPS installations. Even the World Bank expresses same opinion (World Bank, 1996). This section, evaluates if this belief is correct.

About 350 pump manufacturers in India have opted for the ISI mark and do follow BIS standards. Most low friction (PVC) pipes in the market carry ISI mark. ISI marked foot valves are widely available. As such, availability of ISI marked IPS system components is not a problem.

Most large pumping schemes avail of NABARD loans and are designed by NABARD approved consultants. Hence, the NABARD norms are usually followed. The small pumping systems are usually not designed by consultants. An internal study conducted by NABARD observed that, the small pumping systems usually install ISI marked pumpsets but BIS norms for pipe size are not followed (Nabard 1995). Our discussion with farmers and dealers in Maharashtra also revealed that farmers do ask for ISI marked pumps. Hence, improved BIS standards would have a direct effect on new pump installations[7]. But no information or analysis was available as to how the pipe size is decided. This issue was studied further leading to the analysis given below.

Discussions with the pump dealers revealed that farmers rarely select the pipe size. Usually, the dealer simply gives him a pipe that fits the pump flange size. This is also confirmed through analysis of data for 100 IPS. Maharashtra Energy Development Agency (MEDA) has carried out thousands of IPS piping rectification and has data for these IPS. Analysis of randomly selected 100 pumps was carried out. In 99% cases, the pipe used was of same size as that of the pump flange. Table 1 shows details of the analysis.

Table 1 : Analysis of pipe size data collected during rectification projects.

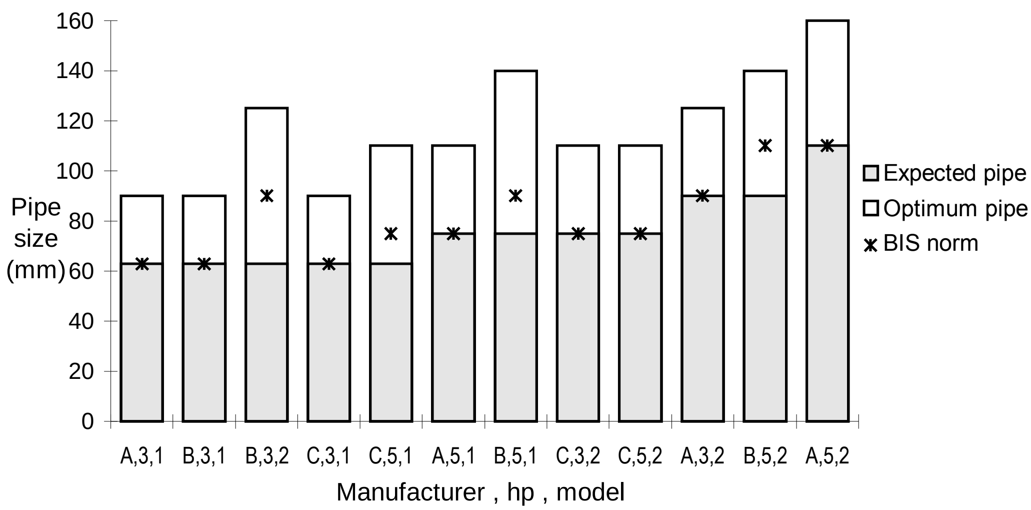
Number of IPS analysed	100
3.7 kW pumps	9
2.2 kW pumps	91
Pipe size same as Flange size	99
Pipe smaller than BIS recommendation	
- Before rectification	94
- After recommendation	12

In case of small pumping systems it can be generally assumed that farmers use pipe of same size as that of the flange. Hence, implementability of BIS piping norms depends on the pump flange sizes. And in turn evaluation of the pump flange sizes becomes important. An analysis of flange sizes of 12 pumps (four pumps of three manufacturers each), was carried out.

The pipe fitting the pump flange size is assumed to be used. Most farmers now use RPVC (rigid PVC) pipes, hence, use of RPVC pipe is assumed. The likely pipe size used is compared with the BIS recommended pipe size (at BEP flow condition).[8] The pump operation of 2,000 hr/yr and the average cost of electricity supply for the utility has been considered for this calculation. Figure 7 shows the expected pipe sizes by bars and the BIS recommended pipe sizes by square points. In case of 4 pumps, the flange is smaller than the BIS recommendations. As mentioned earlier, if the pump is improperly selected and operates at a head substantially lower than the BEP head, then the situation would worsen. Pump discharge would increase, requiring a higher pipe size as per the BIS standards. In that situation, the likely pipe size would be smaller than BIS recommendation for 9 of 12 pumps.

In light of the earlier conclusion that BIS piping norms need to be upgraded; it is important to compare the expected pipe size with the optimum pipe size. The calculated optimum pipe size (for the discharge corresponding to the pump BEP conditions) are shown in figure 7 by hollow columns. For all pumps the flange sizes and hence the likely pipe to be installed is significantly smaller than the optimum size.

Figure 7 : Comparison of pump flange size with BIS recommended pipe size and the optimum pipe size.



The filled columns in figure represent the smallest RPVC pipe that fit on the flange. This is the most likely pipe size to be used by farmers. The * marks represent the BIS recommended pipe size for flow at the BEP condition of pump. The hollow columns indicate the optimum pipe size (for BEP discharge), that minimises the total cost. In all cases flange size is smaller than the optimum size, while, in four cases it is smaller than even the BIS specified pipe size.

Government sponsored projects have rectified the problem of under sized pipes in more than one hundred thousand pumps in India. But it is urgent to prevent piping in-efficiency in new pumps. Undersized piping seems to originate, primarily from the inappropriate flange sizes. Hence, this problem can be largely solved by upgrading the BIS norm for pipe and flange sizes. The pump flange size should correspond to the improved BIS recommended pipe sizes.

5. Economic Implications of Improved Standards

This section evaluates the expected increase in efficiency of new IPS due to the improved standards and the corresponding avoided expansion of power supply infrastructure. The modified BIS standards can improve the efficiency of only new IPS. Nearly half a million new pumps are added each year in India. It is assumed that benefits of improved efficiency standards (pump efficiency and higher pipe sizes) can be achieved for only half of new IPS.

Upward revision of BIS standards for minimum pump efficiency would reduce pump consumption by 12 to 14%. The benefits of improved suction characteristics and flattening of head-efficiency curve would be added benefits. Thus it can be safely assumed that improved pump efficiency standards can result in 15% energy saving. Considering such improvement in half of new pumps, total saving would be 140 million kWh/year. This is equivalent to the useful energy generation of 26 MW (base load) power plant. [9]

Installing pipes sized as per the BIS standards can frequently reduce the electricity consumption by 20% or so (Jain P C, 1994; Patel S M and Pandey M K, 1993). After improvement of BIS standards, flange sizes would be same as the optimum pipe sizes, which would be higher than present BIS standards. If half of new pumps reduce consumption by 20%; the national saving works out at 186 million kWh per year. This is equivalent to saving of a 35 MW (base load) power plant each year.

Against such savings the incremental cost of efficient pump and higher sized pipe would be about Rs 2,000 per IPS.[10] Hence, the incremental investment cost for 250 thousand efficient pumps would be Rs 500 million (US $ 14 million). Where as, the total saving for power sector would be 61 MW of installed capacity; implying an avoided investment of Rs 3.05 billion (US $ 87 million). A cost benefit ratio of over 1 : 6.

In addition, the power sector will also save fuel corresponding to the energy not consumed. At present prices, the fuel cost of 326 million kWh/yr, is Rs 260 million per year. Considering a pump life of 10 years, and an discount rate of 12% (real), the net present value of fuel saved is Rs 1,470 million (US $ 42 million). Which takes the cost benefit ratio to 1 : 9 !

In other words, each year's delay in improving the BIS standards for IPS efficiency is costing India US $ 115 million !

6. Conclusion

The BIS norms for pumpset efficiency need substantial improvements on following accounts : (i) upward revision of minimum efficiency, (ii) accounting for changing pump efficiency with changing suction and total head, (iii) upward revision of recommended pipe sizes, and (iv) appropriate flange sizes for pumps.

Contrary to the common belief, the improvements in standards can result is substantial reduction in IPS electricity consumption. Improvements in standards, would result in 326 million kWh reduction in electricity consumption of the new IPS added each year. This amounts to avoided capacity expansion of 61 MW each year. Each year's delay in improving the BIS standards for agricultural pumps is costing India US $ 115 million ! The benefit would be higher if BIS standards are also made mandatory for all pump manufacturers.

The government, funding agencies, the Multilateral banks and the power sector, in general, needs to appreciate the importance of standards and norms. Considering such a favourable economics, the government and the power utilities should spare no effort in upgrading the BIS standards.

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[1] Most IPS are not metered. The tariff is linked to the connected load (kW). Hence, the sales to IPS are estimated by the power sector and has been a controversial issue.

[2] This definition assumes no water leakage and neglects the velocity head of water, which is usually small.

[3] The present literature specifies pump characteristics for total head. In effect, it expects the farmer/pump dealer to estimate the required flow, static head, and calculate the frictional loss to arrive at the total head. This is too complicated even for the pump dealer. Some manufactures already distribute simplified literature based on standard piping lay out and corrections for deviation from the assumed lay out.

[4] This assumes a base efficiency of pump to be 60%.

[5] For a detailed discussion, see Sant, Dixit, 1996.

[6] For a constant delivery head of 7.5 meters considered here, pump B cannot achieve its BEP efficiency.

[7] The pump manufacturers may need financial and technical support to improve the pump quality quickly. The utilities can easily give this support. And would actually benefit substantially from this.

[8] The pump discharge is a function of head. At low heads, discharge is high and at high heads it is low. For simplicity only the flow rate at BEP condition has been considered in the figure.

[9] This calculation assumes average pump usage of only 1,000 hrs/year (against the national average of 1,770 hrs./yr claimed by the power sector). It is further assumed that base load power plant has a PLF of 80%, auxiliary consumption of 8% and T&D losses are 18%. The investment for generating plant and distribution network is assumed at Rs 50 million/MW (US $ 1.4 million/MW).

[10] This assumes an incremental cost of (i) 20% for efficient pump (i.e. Rs 1,000/- per pump) and (ii) Rs 1,000 for higher sized pipe (corresponding to an average pipe length of 30 meters).

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