Some practical ways of electrical energy conservation in small integrated paper mills

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SUMMARY

To summarise we can say that with continued efforts, with the resources available & by adopting the most practical ways supplemented by moderate capital expenditure we can achieve around 20—30% savings in electrical power consumption.

I wish to point out that whatever energy savings have been achieved by us in our mill is primarily due tc the efforts, insistance, support (both financially as well as morally) & questioning of our Managing Director & Technical Director.

We could reduce the electrical energy consumption from Average 1150 KWH/Ton for low quality kraft paper in 1981 to Average 950 KWH/Ton for good quality kraft paper in 1984, that too with added HP of the equipment for improvement in quality & reduction of other utilities like water. We could establish the maximum demand on an average to 1300 KVA and the power factor to 0.95 (In occasional cases 1225 KVA & 0.98 respectiveiy).

IMPORTANCE OF ENERGY CONSERVATION :

Importance of any thing is felt when it is absent or is in shortage. One eyed man only can understand the importance of two eyes. Importance of the hand thumb is felt only when one loses it. Similar is the case with energy. So long as it was available in abundance in good old days, no body realised its importance and that is why one did not really think about it's conserved usage. However, the conditions are no more the same now. Availability of fuel is decreasing with time & the need is increasing multifold due to continuous developments in industrial as well as other fronts. There have been continuous developments in industrial as well as other fronts. There have been continuous increase in the fuel prices, especially from 1973 onwards.

For developing contries like India, the problem is two fold. On one side, we have to increase the per capita energy consumption to match with the developed countries where as on the other side the biggest problem is the shortage of fuels.

In power intensive industries like paper plants, with increased energy prices the energy cost is becoming the major part of the cost of manufacturing and the profit margins are very much governed by the energy usage.

Annexure 1 shows the price trend of electrical energy from 1980 onwards and fig 1 shows it in the graphical form. It can be observed that from 1980 to 1984 in 4 years the price of electrical energy has doubled due to revision in tarrif & revision in fuel cost adjustment cost.

In light of these facts, energy conservation is the most crying need of the day especially for the energy intensive industries like paper plants.

IMPLEMENTATION OF THE IDEA ON ENERGY CONSERVATION :

We have been talking about energy conservation for last quite a few years. But how many have really given serious thought to it ? It is really the time that we move from awareness stage to "Implementation stage".

Of late, some have started working on the implementation, but there is still lot to be done in this respect.

It must be kept in mind that energy conservation is not something which is done once and for all. It is a continuous process and there is a scope of about 40% reduction in the energy costs with continuous efforts. Of course the fact remains that this can not be achieved overnight.

In this paper, I shall deal

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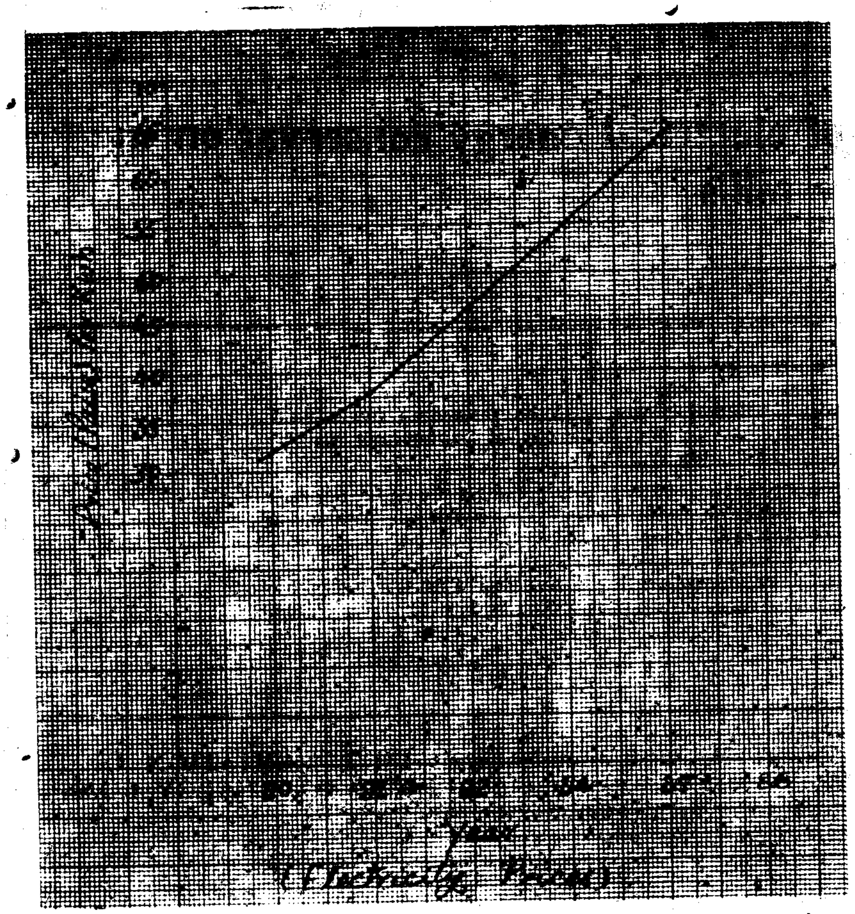


(This is based on Electricity Bills of Nath Paper Mill)

Fig. 1

only with electricity. There are various possible ways of electrical energy conservation. In Nath paper, we are practising some ways and have achieved substantial reduction in power bill. While discussing some practical ways electricity conservation in small integrated paper mills, I shall also illustrate the way how we are trying to practicise it at Nath paper.

Maximum Demand :

Normally for the H.T. consumers the tariff includes separate maximum demand charges per KVA.

The rate of energy consumption at any time is called the power demand. The maximum of all such rates of consumption during a particular period, which is one month for the purpose of revenues, is called the maximum demand. There will be maximum demands for KW, KVA or KVAR. The supply authorities consider KVA max. demand for the purpose of billing.

As you are aware, for billing purposes the instantaneous demand is not metered but it is an average rate over a period of half hour. In a 30 days month there will be such 1440 half hour periods over which average rate is measured. The maximum of all these power demand is the monthly maximum demand.

The load in any industry is fluctuating type & the maximum demand will be established to a value depending on what was the maximum simultaneous load during one of the half hour periods. In case, we can monitor switching off of some equipments or feeders during the peaks, we can establish a reduced energy charges. For this purpose, it is necessary to monitor the maximum demand.

There are some MD monitoring equipments available in the market. I am not fully aware of their performance but one problem with them is they have to be synchronised with the electricity boards meter which creates problems. Moreover, even if they can be synchronised with the electricity boards meter, a little error in the timer will again put it out of synchronisation. In addition to this problem, another problem is that electricity boards won't allow the cores of their metering CT/PT unit to be used for this, which will need additional capital investment in the CT/PT units.

Without installing additional monitoring instrument and without addition in the CT/PT we can manually monitor the maximum demand by recording half hourly readings of the trivector meter every time the MD pointer resets after half an hour. The substation operator can do this job. As already mentioned the demand is average rate of power consumption measured for the preiod of half an hour. Hence, if we divide by half (or multiply by two) to the consumptions of these half hour intervals, we get the demand established during that period.

For the purpose of illustration, see Annexure 2 which shows readings in our mill for a particular shift which have been copied from substation operator's Log Book. Let us now try to see how M.D. can be monitored. We are interested in KVA MD. Let us say we have to maintain it to 1170 KVA. If the multiplication factor of the meter is 9 then the KVA difference in any half hour interval should not exceed $\frac{1170}{9\times2}$ i.e. 65. What the operator has to do is after every reseting he should see the KVA difference after exactly 15 min If it is say 27 then he knows that in remaining 15 min he is left with (65—27=38) He need not cut any load in this case because chances of achieving consumption of 38 in 15 min. will be remote. Whereas if the difference in first 15 min was say 34 then he is left with 65—34=31). If the same load continues for next 15 min then there are chances of MD crossing the limit. Looking at the load current he should get some load cut which can be restored after half an hour resetting of the meter. In marginal case, he should take one more reading after 25 min. It is likely that in quite a few cases cutting some loads in last 5 minutes suffices. With practice this will become his normal routine and he can very well monitor the maximum demand. These half hourly demand calculation will also help in plotting the load demand curve. Fig. 2 shows a typical KVA demand curve for 20th Dec. 1984 in our mill as plotted from the readings. This can also help us in studying the load demand behaviour.

Power Factor :

This is one thing which also forms the part of electricity bill. Electricity boards charge bill by way of penalty for power factors below a particular limit. In some it is 0.9. Some electricty boards even have an incentive clause for power factors above prescribed limit. Hence it is essential to maintain the power factor atleast upto statutory limit & even above it if there is an incentive. Other advantages of good power factor are reduced current strains on the distribution system with reduced losses. Moreover with improved power factor, the maximum demand will also be reduced.

For improvement of power factor the most widely used method is installing capacitor Banks. Now the question arises as to where exactly these capacitors or capacitor Banks should be installed. There are various methods like.

(1) Individual compensation.

(2) Group compensation.

(3) Centralised compensation.

In the individual compensation the advantage is reduced strain on motor cables & in the group compensation the advantage is reduced strain on feeder cables to the MCC or switch boards. However in all practical cases these gains are not really very attractive because as such for feeder cables we are generally choosing the size in view of voltage drop which results in a size higher than the minimum required from load point of view. In addition, factor of safety is also kept which results in choosing a higher size both in case of feeder cables & motor cables.

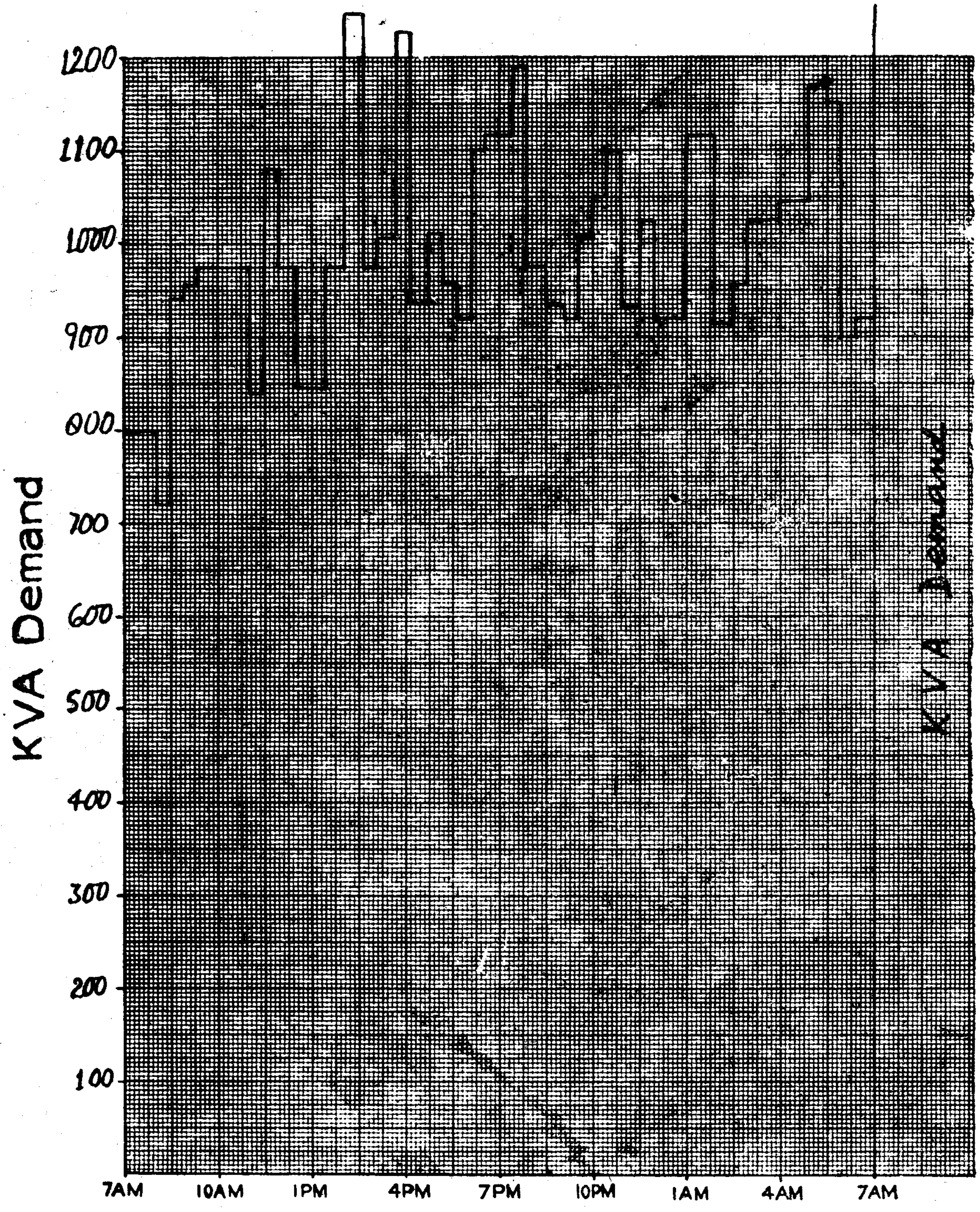
In individual compensation if the particular equipment is stopped the capacitor also gets switched off which results in its poor utilisation. Moreover in individual as well as group compensation there could be other difficulties like space shortage unfavourable conditions like too high temp., polluted air, acid or alkali pollution, dirt, oil etc. Moreover in these cases the capacitors or capacitor banks do not get attention.

The ultimate result is that inspite of installing good number of capacitors the PF improvement is not satisfactory. The most practical way would be to have centralised compensation as near to the load centre as possible or at the most to have it in two or there convenient groups. All these capacitor banks should have ammeters provided for measuring currents of all the phases. A capacitor log book can be maintained which will record at decided ntervals the currents of all the phases. A capacitor log book can be maintained which will record at decided intervals the currents of all capacitor banks & also the voltages at which they are operating. This will help in confirming whether all the banks are functioning effectively or if there is any deterioration. Immediate remedial action can be taken in case of deviations. with this, power factor will be very well maintained. With centrallised compensation one more advantrge is some banks can be switched off in case of over compensation.

In addition to installing the power factor correction capacitors the best way is not to let the equipment run on bad power factor. One way would be to run the induction motors on voltage as close to the rated voltage as possible. Normally the induction motors are designed for 415 Volts. Hence the transformer taps should be so selected that at the feeder end we get around 415 volts In case of fluctuation in incoming supply voltage there are good chances that we can get it corrected from the electricity board's substation because normally they have on load tap changer. If these practices are religiously adopted, there will be substantial improvement in the power factor.

Optimisation of Motor Capacity :

Normally the motors chosen



KVA DEMAND CURVE OF NATH PAPER MILLS FOR 20- 2-84

Fig. 2

in any Industry at the time of erection are in view of extreme load conditions and/or in view of some expansions in mind. Because of this it so happens that we find quite a few oversize motors in the plant. Some times the oversize motors are also a result of too much of factor of safety at the time of selection. These oversize motors when run on partial loads, certainly work on low efficiency causing increased power consumptions & cause very low power factor.

For installing at such location where motors are not running on full load or at locations where the motor runs on full load only for a small time & part load on most of the times there are electronic power savers available which give reduced voltage to motor terminals when on part load.

This, however, is a capital cost intensive proposal. There could be some practical solutions as under :

1. By permutations whereever possible we can change the motors of higher capacity with those of lower capacity from the existing motors only by internal changes where practicable & possible.

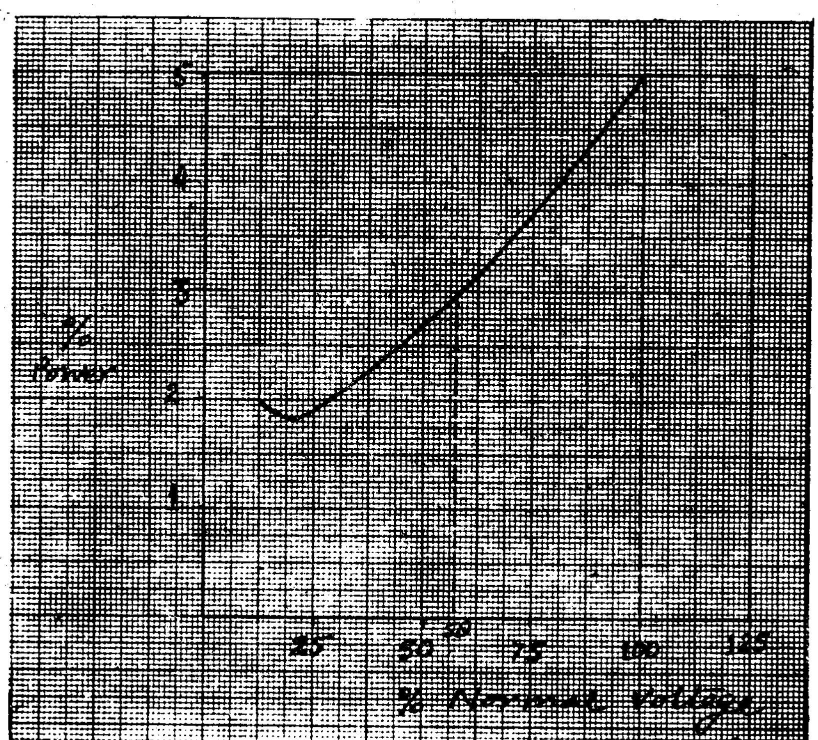
2. Where the motors are permanently underloaded to the extent of about 60% of the full load the motors can be permanently connected in star so that the windings get 57.7% of the rated voltage. In Nath Paper we have connected about 30 motors, permanently in star. This has reduced the total current by about 300 to 325 Amps & have improved the power factor and reduced maximum demand, which otherwise would have required installation of about 250 KVAR capacitor banks. The motor heating also gets reduced.

3. Where the motors are underloaded for most of the time to the extent of 60% of full load and only occasionally it has to work on full load, we can provide a starter with selector switch with an option to put it in star as well as delta as desired. The change over from star to delta can be done under the circumstances of all load operation.

To see the effect of voltage on core loss we can study the no load power curve for various voltages. The no load power largely indicate magnetic losses. The power curve is nearly parabolic at voltages near normal (fig. 3) since the core losses are proportional to the square of the flux density and therefore of the voltage. In star connection the winding voltage is $1/\sqrt{3}$ of that delta hence the core losses in the former will be almost 1/3 those. of later Hence at partial loads the efficiency of motor will get improved in star connection. Typical efficiency curves for star & delta running would be as in fig. 5 & power factor curves would be as in fiig. 4.

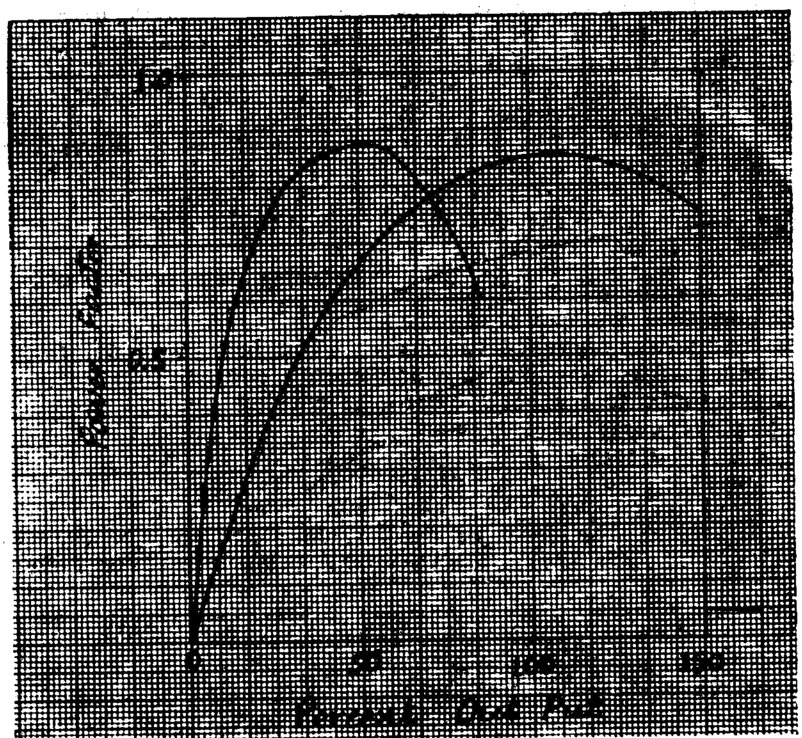
Reducing Idle running of Equipments :

The best way of reducing energy consumption is by way of curbing the idle running of electrical equipments when not required. In every Industry there are some equipment which run idle. In paper industry various agitators of the chests and tanks constitute the major



No Load Loss curve for Ind. Motor for various Voltage (Magnetic loss is the major part of the no load loss)

Fig. 3



Star Delta Behavior of Induction Motor with reference to P. f.

Fig. 4

part of idle running equipments. These agitators are required to be run only during pumping operation and slightly before pumping to ensure that proper mixing is done. However, practically it so happens that operator puts off pump and conveniently forgets to put off the Agitator or even if he puts off the Agitator he restarts it very much in advance of pump starting. This leads to heavy unproductive electrical energy loss. This idle running can be curbed by introducing interlock between pump & Agitator. A typical interlock could be such that Agitator will get automatically shut if the pump is stopped and it can't be again restarted for a time period t'. After this period operator can restart it as per his need. However, once restarted it will again stop automatically after time period t2, if the pump is not started during this time. Timers can be used for such interlocking. The actual interlocking can be incorporated as per needs which will vary from place to place. In nath paper, we have achieved on an average 25--30% saving in Agitator's power consumption. In some typical cases it is even as high as 45 to 50%.

Electrical Energy Audit :

Energy Audit is the most fundamental requirement for Energy conservation.

A pre-requisite of an energy audit is to quantify energy distribution & where possible to relate it to production or other activities.

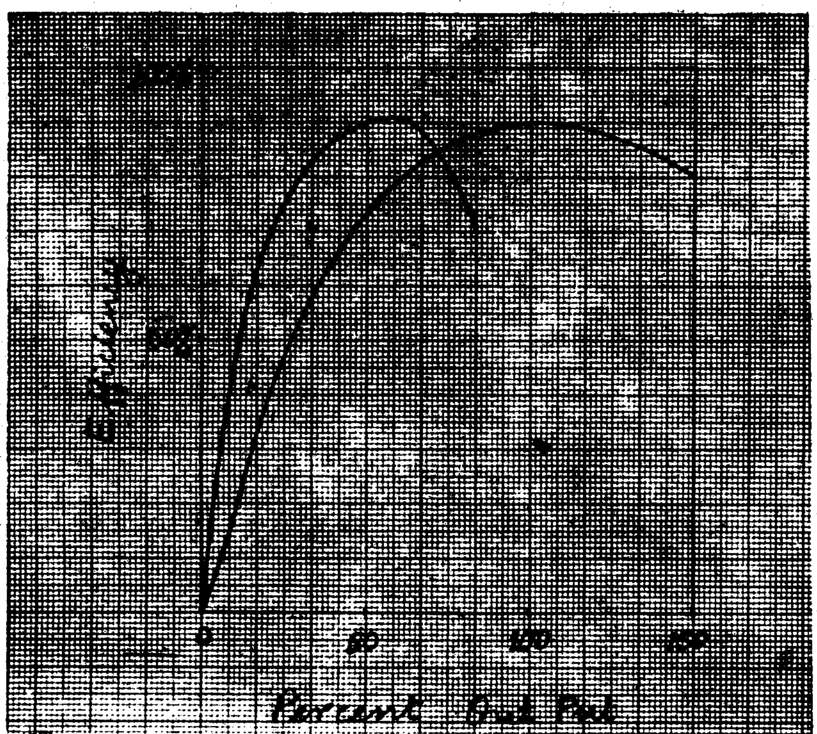
For doing this divide the consumption in various sections, then fixu the 'norms' or 'targets' at each location & compare with the actual consumption. Also examine the areas of high energy consumption.

Analyse the cause for deviation in fixed targets and actual consumptions. In case the power consumption has increased find out the cause & take remedial action. In case there is reduction, identify the reasons & try to maintain.

Now the most common question is as to how to fix the norms or target or budget. There are no outside references. The only reference is our own power consumption. See our own actual consumptions & then set a target lower than that. Think of some means for achieving these targets. It is likely that for this some capital expenditure might be necessary. In that case proposals should be made with a pay back period of acceptable limis. Energy Auditing & fixing norms is therefore a continuous process.

Discussions at various levels after doing the energy audits is most important because the discussions will lead to solutions.

Power consumption per unit of production will also vary with the actual production. The power consumption will be having some part which is almost constant irrespective of the quantum of production & some part varying with production. After studying the pattern we can even plot the curve of power consumption per unit of production v/s production. We can also device a formula for this behaviour. While fixing or revising the budgets we can take reference of achieved curve & then plot another curve or device another formula as target or budget.



Star Delta Behaviour of Induction Motor with reference to efficiency.

Fig. 5

Fig. 6 shows a typical revised curve being followed by us in Nathpaper. A curve slightly below that could be a new target. The graph is plotted between kwh/ton of finished paper v/s average finished production in tonnes per day.

Metering :

The prime necessity for energy audit is provision of separate meters for each area or production location for measuring the energy used in that area or location.

In the first instance therefore, our step should be to provide energy meters in such a way that we can find out the section wise power consumption.

It would be worthwhile if we can also provide energy meters to individual power intensive equipments (High H.P. motors) and also the time totalisers. Providing three phase C.T. operated energy meters to individual equipment may become very expensive. The most practicable way would be to prove single phase meters for one phase & multiply the consumption by 3, the currents being balanced. Domestic single phase watt hour meters of 2.5—5 Amps can be used for this purpose on one C.T. operation by slight modification of the meter terminals. One such single phase energymeter installation along with one C.T. may not cost more than Rs. 250/- By providing sub meters to such individual equipments and also the time totalisers we can study the performance of these equipments with reference to power consumption & control the power consumption more effectively.

The summary regarding effective energy audit and its use for taking steps for energy saving is as under :

1. Keep daily records of meter readings.
2. Check the meter readings from time to time. If the readings contain errors they are of no use in energy monitoring.
3. Keep on thinking : meter readings are not statistics to be filed. They are tools for monitoring energy usage & savings.
4. Fix up targets on revising the norms or targets depending on the scope or potential.
5. Maintain the meters in working condition.
6. Compare the energy usage to the norms or targets fixed and find out the reasons for deviation. If there is a downward deviation find out the reason for that. If possible make the revision in the norms in such cases. Take action if for some reason energy usage is excessive, after finding out tbe reason.

The Electrical energy audit proforma which is being followed by us presently in Nath paper mills is shown in the Annexure—3

Throttle Pumps :

It is well known that throttling the delivery of the pump or fan for flow control causes tremendous loss in pump or fan efficiency and in turn loss of power. For this purpose, it is advised that variable speed AC motors(converter-inverter drives) be used for lowering the motor speed for reduced flow require-

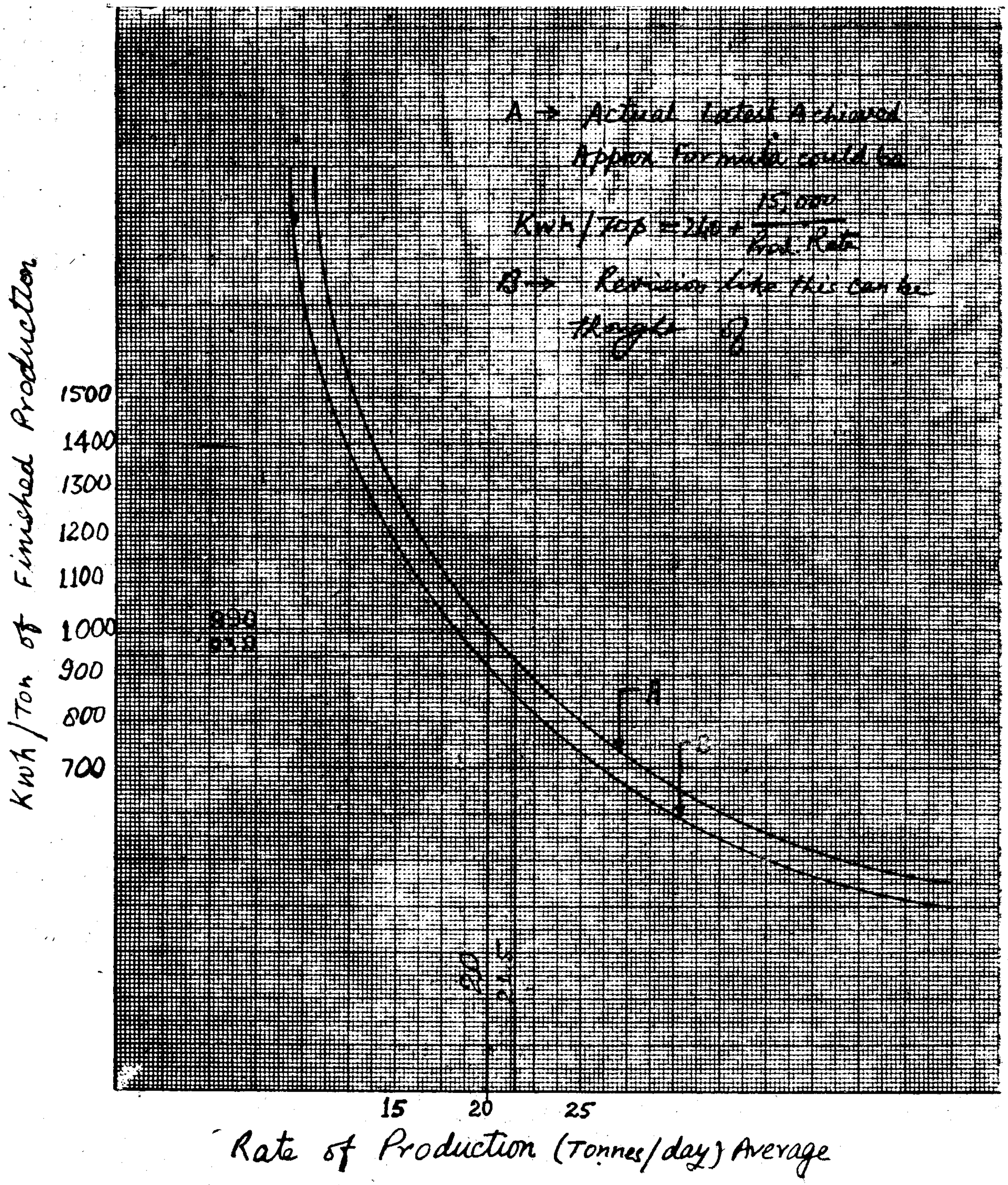

A → Actual latest Achieved
Approx Formula could be
Kwh/TFP = 240 + 15,000 / Prod. Rate
B → Revisions like this can be
thought of
Kwh/Ton of Finished Production
1500
1400
1300
1200
1100
1000
900
800
700
A
B
15
20
25
Rate of Production (Tonnes/day) Average

Fig. 6

ment instead of throttling the valve or controlling the damper. This also involves tremendous capital expenditure.

In the plant there will be atleast some locations where the valve or damper is permanently throttled for the pumps or fan. At such locations if there is a belt -drive we can change the pulleys & run the pump or fan forever at reduced speed instead of using variable speed drive there & try to obtain the best possible efficiency.

Lighting :

There are lot of ways of saving power in lighting. One way would be replacing the fittings with more efficient ones. For example for lower bay heights where normally twin tubelight fittings are used they can be replaced by 83 W HPMV lamps. The quantity & hence the power consumption will be halved. In Nathpaper we have replaced all the industrial twin tubelight fittings of the Breaker Beater House with 80 watt HPMV fittings one third in quantity.

ANNEXURE 1

YEAR		Avg. Electricty price per KWH
1980	—	32 Paise
1981	—	38 Paise
1982	—	48 Paise
1983	—	55 Paise
1984	—	64 Paise

The figures are based on the electricity bills of Nath Paper Mills.

ANNEXURE 2

Date : 20. 12. 84
Shift : 'A'

(Trivector meter reading of
Nath Pulp & Paper Mills for 20. 12. 84)

Time	KWH	Diff	KW Demand Diff × 2 × MF	KW M D Established	KVAH	Diff	KVA Demand Diff × 2 × MF	KVA MD Established
7.05	1601236	44	792	1080	17148[illegible]4	44	792	1360
7.35	1601280	44	792	,,	1714804	44	792	,,
8.05	1601320	40	720	,,	1714888	40	720	,,
8.35	1601371	51	9.18	,,	1714940	52	936	,,
9.05	1601423	52	936	,,	1714993	53	954	,,
9.35	1601475	52	936	,,	1715047	54	972	,,
10.05	1601528	53	954	,,	1715101	54	972	,,
10.35	1601581	53	954	,,	1715155	54	972	,,
11.05	1601625	44	792	,,	1715202	47	846	,,
11.35	1601681	56	1008	,,	1715262	60	1080	,,
12 05	1601735	54	972	,,	1715316	54	972	,,
12.35	1601782	47	846	,,	1715363	47	846	,,
1.05	1601829	47	846	,,	1715420	47	846	,,
1 35	1601883	54	972	,,	1715474	54	972	,,
2.05	1601946	63	1134	,,	1715543	69	1242	,,
2.35	1602000	54	972	,,	171597	54	972	,,

M. F. — Multiplicate factor for meter — 9

ANNEXURE—3

ELECTRICAL ENERGY AUDIT PROFORMA OF NATH PAPER MILLS

Note : This budget is for average 20 T/day production. Formula for other rates of production is Total Kwh/ton $= 240 + \frac{15000}{\text{Avg. prod. Rate/day}}$

Production (Finished) :
Kwh :
Period of Audit :

Sl. No.	Section	Actual Kwh	Actual Kwh/T finished (After error adjustment)	Budget Kwh/ton	Deviation
1.	Stock preparation (4 chests & fan pump)	—	—	115	—
2.	Stock prep. Refiners	—	—	75	—
3.	Disc Refiner (Pulp Mill)	—	—	40	—
4.	Paper M/c Auxilliaries (Vac. Pumps, Centricleaners Back water pumps & others)	—	—	230	—
5.	Blow tank	—	—	20	—
6.	Black liquor reuse	—	—	12	—
7.	Mech. Workshop	—	—	3	—
8.	All chests of Pulp Mill excluding those of stock preparation	—	—	80	—
9.	Breaker Beaters	—	—	125	—
10.	Pulp Mill washers, thickners etc.	—	—	8	—
11.	Effluent Treatment	—	—	30	—
12.	Boiler & Coal processing	—	—	68	—
13.	Main Drive	—	—	65	—
14.	Raw material cooking	—	—	15	—
15.	Raw material preparation	—	—	5	—
16.	Broke processing	—	—	13	—
17.	Finishing section	—	—	9	—
18.	Pump House	—	—	51	—
19.	Lighting (Factory Office area & Guest House).	—	—	26	—
20.	Error	—	—	—	—
				990	

SUPPORTING DATA FOR ENERGY AUDIT & REMARKS :

1. Gunny pulp made
2. Bagasse pulp made
3. Straw pulp made
4. Waste paper pulp made
5. Broke processed
6. Disc Refiner running hours
7. Mechano Refiner running hours
8. Conical 1 Refiner running hours
9. Conical 2 Refiner running hours
10. Machine Production
11. Finished Production
12. Average Production per day
13. Any other points
14. Broad assumptions while budgeting.
15. Remarks on deviation.