Irrigation Load Management

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Abstract-- **This paper discusses various methods in practice for irrigation load management, their merits & demerits and suggests a new approach for irrigation load management, which is a combination of remote controlled load management scheme, installation of amorphous metal distribution transformers coupled with use of automatic LT capacitor panels at transformer terminals for power factor correction, supported by a case study of KAMPEL DISTRIBUTION CENTER, Madhya Pradesh Electricity Board, Indore region.**

Index Terms--**Amorphous metal distribution transformers, automatic LT capacitor panels, pump load and remote controlled circuit breakers.**

I. Introduction

ELECTRIC power is one of the key inputs for economic and agro-industrial development all over the world. Per capita consumption of electricity has been invariably considered a prime index to judge the progress in a given time frame. In developing countries due to limited resources it is extremely difficult to meet the fast growing demand of power.

The problem of development of power is whenever discussed the stress is given on expansion of generating capacity, however, it is a costly proposition. In view of this it has now become necessary to make maximum use of existing facilities by their efficient utilization, renovation & modernization. The demand of energy has to be curtailed by adopting energy conservation measures.

With rapid growth of electrical network in rural and urban India the transmission & Distribution losses are also increasing. Adequate investment has not gone to this sector due to resource crunch. Properly planned T&D systems particularly distribution systems could not be created to keep pace with the demand of irrigation pump sets in rural areas. Long & overloaded distribution lines with low power factor due to a large number of irrigation pump sets contribute towards low voltages at load terminals and high T&D losses.

T&D losses in Indian power system are constituted by technical and non-technical losses. Technical losses are inevitable due to inherent resistance of the line and can only be reduced by continued research in the area of conductor material. The non-technical losses are mainly due to pilferages of energy, defective metering, and billing at slab rates without metering.

The T&D losses are calculated on the basis of difference between energy sent out from generating station and energy sold to various consumers. The energy sent out from a generating station is metered fairly accurate wherever the energy sold is not. The energy sold to the irrigation pump sets, which is not metered, accounts for 2 to 50% of total in different states [1]. The bill in this case is computed on the basis of average horsepower of the pump set & the number of hours they work in a year. With such a large quantum of energy unmetered one can understand the accuracy of T&D losses arrived at. The power consumption by the irrigation pumps will also increase every year, due to lowering ground water level and multiple cropping in a year. Therefore, the losses should be reduced, with increased demand of power in irrigation sector, to ensure reliable power supply. Also the load should be properly distributed to give a good load factor.

II. Present Practises

Presently the load management is done either by switching off 11 KV feeders in rotation or single phasing of 11 KV feeders by rotation. Because of these methods power supply gets interrupted even for domestic, commercial and industrial loads. But, many consumers still run pump sets using single phase to three phase converters therefore overloading the two phases of the distribution transformer, which may lead to winding failure. Further, for voltage improvement and loss reduction, electricity board is creating more & more 33/11KV substations to reduce the length of 11KV lines. However, it is a costlier proposition and time consuming also.

Since the electricity supplied to the irrigation sector is free, the pumps used for irrigation are mostly local made or re-wound and low cost type therefore having low efficiency and poor power factor. The inductive load of transformer further deteriorates the power factor, resulting in increased current & hence increased T&D losses for the same power transmitted.

III. Proposed Scheme

The proposed scheme is a combination of remote controlled load management scheme, installation of amorphous metal distribution transformers and use of automatic LT capacitor panels at transformer terminals for power factor correction. This scheme will ensure round the clock supply to the villages for domestic, commercial and industrial loads whereas the pumping loads can be subjected to a definite

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load roistering plan, besides providing additional power for expansion and reduced T&D losses.

The remote controlled load management scheme will require Remote controlled circuit breakers (specifications are mentioned in Table I); Master control unit at 33/11 KV substations for communication & control of automatic roistering plan and also to change the schedule whenever desired; Communication system including interfacing equipments for the operation of remote controlled circuit breakers and comprehensive transformer protection scheme [4]. The master control unit will have computerized control system with display unit and printer. It will operate on 100% hot standby basis to ensure reliability of power supply.

To facilitate local maintenance or checking on the site, the manual mode will take priority over the automatic control system of circuit breakers. Suitable pad-lock arrangement for the circuit breaker operating rod shall be provided as a safety measure. Breaker and the communication equipment are housed in a metallic enclosure out side the distribution transformer, forming an integral part of it. The metallic enclosure is lined with FRP or other suitable insulating material to avoid direct contact of sunrays on the metallic body. Suitable louvers fitted with wire gauze are provided to ensure circulation of air and to prevent ingress of rainwater. It should be ensured that the temperature inside the enclosure does not exceed 70°C under extreme operating conditions. However, for additional safety the entire equipment in the enclosure should be designed to withstand 75°C for at least 8 hours along with 95% RH. An operating handle is also provided outside the enclosure in such a way that "ON" and "OFF" operation of the circuit breaker can be conveniently performed from the ground level by means of an operating rod.

The communication between the master control unit and remote-controlled unit shall be through radio (VHF/UHF) communication. Getting a requisite frequency band allocated by the competent authority shall be the responsibility of the SEB. Remote controlled unit shall be capable of carrying out ON/OFF operation of the circuit breaker as per command received from master control unit. In case of failure of communication, the unit shall be capable of maintaining the load roistering locally as per preset schedule till such time communication is restored.

The no load losses in the transformers constitute a significant proportion as it continues to incur even if pump load is switched off as per proposed load management scheme. Therefore, these losses must be reduced for improving the system efficiency. The conventional CRGO transformers can be replaced by amorphous metal transformers in a phased manner. Because the amorphous metal transformers have no load losses around 75% less than the conventional CRGO transformers (see Table II).

The use of automatic capacitor panel on LT side of transformers will improve the power factor thereby reducing the load losses and enhancing power delivery capacity of transformer as well as transmission line. The automatic capacitor panel has a load current sensing device coupled with control system, which has preset values of current for a particular power factor. The control system switches "ON" or "OFF" the capacitor steps so as to maintain the desired power factor. The above-discussed scheme shall result in reliable power supply, reduced system losses and enhanced power delivering capability coupled with monetary benefits as well.

IV. CASE STUDY

This approach for management of irrigation pump load is applied to the actual network of KAMPEL DISTRIBUTION CENTER, Madhya Pradesh Electricity Board, Indore region. This distribution center has two numbers of 3.15 MVA, 33/11 KV transformers out of which one transformer is connected to two feeders named as PIVDAI feeder (20.5 Km. Long) and PIPLDA feeder (14 Km. Long) and other is connected to only one feeder called KAMPEL feeder (30.3 Km. Long). The PIVDAI feeder has 26 distribution transformers out of which 18 transformers are having pump load only and other eight transformers are having mixed load, the PIPLDA feeder has 13 distribution transformers out of which 10 transformers supply pump loads only and the KAMPEL feeder has 41 distribution transformers out of which 28 transformers supply pump load only. Cumulatively these feeders are supplying to eighty transformers of different KVA ratings and 11/0.4 KV for irrigation pump sets and other general load (Table III).

Total load on this substation is 7625 HP out of which 4283 HP is supplied through transformers having pump load only. These transformers (with pump load only) are divided into two or three groups, which will be supplied in rotation through remote switching. Table IV & V show the scheme for implementation at the preliminary stage. By the implementation of the proposed schedule total load on the distribution center at any time shall never exceed 5127 H.P. This will result in power saving of around 1863 KW (2498 HP), which can be utilized at some other place. Assuming 30 % utilization factor for the above saved demand the savings are around Rs.1.22 crores per annum @Rs.2.5 per KWh. It will also save the investment required for setting up a power plant of the same capacity besides saving its gestation period.

The average cost of installation of this system is around Rs. 75,000 per transformer. Therefore total cost involved will be Rs. 60 lacs, which can be paid back within 6 months.

Further, with this reduced load the line losses will also reduce to one third of the previous one and introduction of LT capacitor panels for power factor correction can be carried out effectively resulting in additional savings. Also old transformers can be changed with amorphous metal transformers in phases to realize savings in no-load losses.

It is observed that some transformers (having pump load only) are very lightly loaded therefore some pump load from nearby transformers having mixed load can be transferred on these transformers so that those pumps can also be controlled and the transformer will also operate at higher efficiency. These transformers can be replaced by amorphous transformers in a phased manner to save the no load losses. The cost benefit analysis shows that the losses saved can pay back the additional cost of the amorphous transformers within three years.

The power factor of the distribution center varies between 0.5 and 0.6 lagging which is primarily due to the pump load. If it can be improved to 0.98 lagging, considerable amount of energy can be saved. The payback period for this option only is around 1.5 months.

Investment required for the proposed scheme (combination of all three schemes) is Rs.85 lacs and resultant saving would be Rs.1.93 Crores, resulting in payback period of around 5 months. This makes the scheme attractive for implementation.

V. Conclusion

The above scheme is under implementation at the MPEB Indore region. The estimated savings for this scheme has shown attractive payback period (5 months). This system can handle 200 transformer with one master control unit therefore these savings can be further enhanced. However repeater/ rebroadcast stations are required for an air distance more than 20 KM. This will not only effectively reduce the peak demand on the system but also reduce power losses in the line with improved power capability of the distribution network on a permanent basis by flattening the load curve.

VI. Tables

TABLE I
SPECIFICATIONS OF CIRCUIT BREAKER

Rated voltage & Frequency	415 V A.C., 50 Hz
Rated thermal current at 40°C for various ratings of transformers	40 A for 25KVA 100A for 63KVA 160 A for 100KVA
Control Supply Voltage	180 V to 255 V
Endurance (No. of C/O per cycle)	At rated thermal current & 0.8 power factor
i) Mechanical	15000 cycles
ii) Electrical	10000 cycles
Rated Short Circuit Breaking Capacity	5 KA or more
Rated Short time Withstand Current	5 KA or more for 1 Second

TABLE II
COMPARISON OF NO-LOAD LOSSES IN TRANSFORMERS

Ratings in KVA	CRGO Silicon	Amorphous Metal
25	100	25
63	180	45
100	260	60
160	480	110
200	510	120

TABLE III
SUMMARY OF FEEDER LOAD

PIVADAI FEEDER

Rating (KVA)	No.of Transformers	Total KVA capacity	Total Load (HP)
25	1	25	25
63	7	441	308
100	6	600	409
150	1	150	124
200	11	2200	1194
TOTAL	26	3416	2060

PIPALDA FEEDER

Rating (KVA)	No.of Transformers	Total KVA capacity	Total Load (HP)
63	3	189	146
100	6	600	463
150	1	150	259
200	3	600	537
TOTAL	13	1539	1405

KAMPEL FEEDER

Rating (KVA)	No.of Transformers	Total KVA capacity	Total Load (HP)
25	1	25	10
63	12	756	587
100	22	2200	1736
150	2	300	253
160	1	160	135
200	3	600	439
TOTAL	41	4041	3160

TABLE IV
LOAD SCHEDULE FOR TRANSFORMER NO. 1

Feeder	From 04AM to 04PM	From 04PM to 04AM
PIVADAI	Group A 653 H.P.	Group B 656 H.P.
PIPALDA	Group C 415 H.P.	Group D 417 H.P.

TABLE V
LOAD SCHEDULE FOR TRANSFORMER NO. 2

Feeder	From 4AM to 12PM	From 12PM to 8PM	From 8PM to 4AM
KAMPEL	Group X 717H.P.	Group Y 712H.P.	Group Z 713H.P.

VII. References

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