Proceedings of the 10th WSEAS International Conference on CIRCUITS, Vouliagmeni, Athens, Greece, July 10-12, 2006 (pp350-354)

The Comparison of Three Common Methods for Reducing the Amount of Dissipation in a Feeder

MOHSEN HAYATI– BEHNAM KARAMI
Electrical Engineering Department
Faculty of Engineering
Razi University
Kermanshah
IRAN

Abstract: Every year, a high amount of the best and most valuable kind of energy, i.e. electrical energy, is dissipated before received by consumers. Although, it is not possible to remove this fact thoroughly; but research on this area can be a start point for reducing this dissipation. As we know, in Iran, about 30 percent of electrical industry investment is on distribution part. In general, 20 percent of the overall produced electrical energy is dissipated before received by consumers; and the most significant part of this dissipation is related to the distribution part. Considering the development limitations such as economic and time limitations, and the increasing rate of electrical energy demand, it will be of high importance to do some research on reducing the amount of dissipation in energy transmission. It must be mentioned that the most important factor in decreasing the amount of dissipation is attaching high significance to scientific and engineering view in the design session. In this paper, we are to consider three common methods for decreasing the amount of dissipation applied to a feeder in Kermanshah city, being method of improvement of cross section, load balance and capaciting(capacitor placement). Finally, we propose a novel method which is a combination of these three methods to decrease the dissipation with a higher efficiency.

Keywords: Feeder , load balance , capacitor placement(capaciting) , profile , power flow , power factor

1 Introduction

Although calculation of losses in power distribution network seems simple, but practically according to the variation of transmitted power, load factor, voltage drop and resistance of conductors it is very complicated. In distribution and transmission lines, electrical energy will be lost due to different reasons such as ohmic losses, corona losses and current leakage. But in this paper, we have focused on ohmic losses which have less dependence on weather and geographic conditions of feeder's path. Although ohmic losses also can be changed by variations in line voltage (can change current line), consumer needs (can change power factor) and temperature (can change conductor's resistances).
Also in this paper, the voltage drops caused in the line will be studied. This voltage reduction and losses can be changed with the length of feeder, type and cross section of the conductor, network topologies and load distribution on low power feeder which will be established on each phase and improper connections.

The selected feeder for studying is the west air feeder network beginning from Zand transformer located in Zand Street in Kermanshah city. This transformer with 100 KVA power, is fed with 20 KV North Height line. This transformer consists of two feeders one of which is our proposed feeder. The total length of the feeder is 899 meters and its main length is 498 meters. The number of consumers is 60, most of which are domestic. The physical condition of the feeder and the path of this feeder are shown in Fig.1

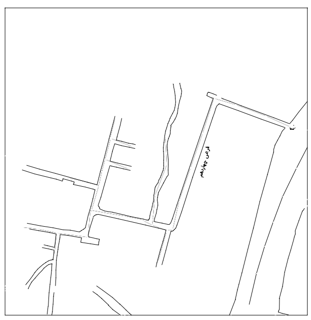

Fig.1 - physical conditions of the sample feeder

Proceedings of the 10th WSEAS International Conference on CIRCUITS, Vouliagmeni, Athens, Greece, July 10-12, 2006 (pp350-354)

2 Explanation of the paper

As described before, the importance of loss reduction problem, voltage drop compensation and keeping the line voltage within the standard limits was clarified. In this paper utilization of three practical methods for solving this problem will be studied and by mixing them, an optimized method for reaching the standard voltage limit and minimum loss will be issued.

Distribution networks are generally designed in a radial form. This would results in using the direct method for calculating distribution load. In the applied software, first by applying direct method to all nodes, the voltage of the beginning of the feeder will be declared. By using this voltage and the load amount, the current that is drawn by users will be calculated and will give the sum of currents from the end of the feeder toward the beginning. Then according to the current of the first piece of the feeder and the voltage of the beginning of the feeder, voltage in the next node could be calculated and in the same way, voltages are calculated and this process will repeat until the deviation between two last stages is less than predetermined error. It should be noted that in load distribution, because of asymmetric load on phases mutual effect between lines is considered in calculation. Accordingly, primary distribution load results in proposed feeder and its voltage profile are shown below.

Table.1- results of first load flow

Loss (%)	Loss (KW)	Voltage drop (%)	Minimum voltage
8	3.58	14.9	187.3

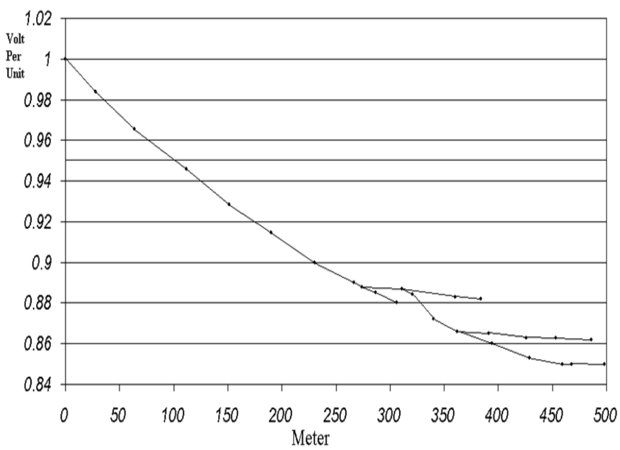

Fig.2 - First voltage profile

As it is shown in Table.1 and related voltage profile (shown in Fig.2) it will be seen that the percentage of voltage drop at the end of line is 14.8%. This value is much more than the standard (5%). Also the percentage of loss due to injection power in the first part of feeder is 8%. This value is regardless of the losses resulting from current leakage, connections and transformer losses; which regarding the desired limit, is not in the accepted interval.

To obtain voltage drop and power losses in the desired limits, first, three methods of cross section modification, load balanced by consumers exchange and capaciting will be studied separately and finally these three methods will be compared with the optimized method which is a mixture of these three methods.

3 Cross section modification

Applied conductor's cross section in the prototype feeder is usually 10, 16 and 25 mm^2. The first solution of the voltage drop is increasing the cross section area, Using the proposed software, after changing available phase cross section to 35 and those of the nulls to 25, power distribution was simulated with the results shown in Table 2 and Fig.3

Table.2- Results of load flow after the cross section modification

Loss (%)	Loss (KW)	Voltage drop (%)	Minimum voltage
4.7	2.05	11	195.7

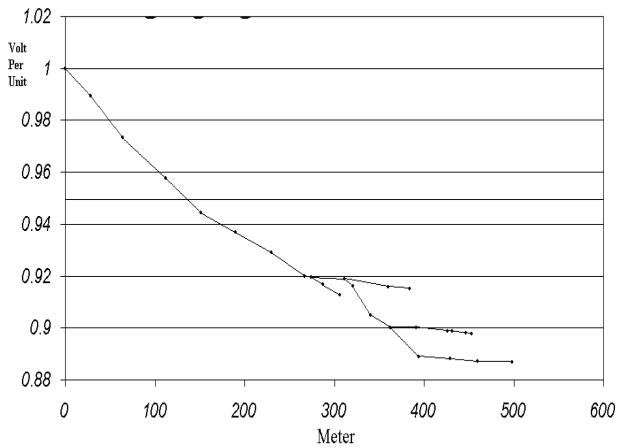

Fig.3 - Voltage profile after the cross section modification

As we can see the minimum voltage is 195.7 V and the power loss has reached 2.05 KW.

4 Capaciting(capacitor placement)

Capacitors are elements which must definitely be used in distribution and power networks either in shunt or series. Their main task is to control voltage and transmitted reactive power. In distribution networks, shunt capacitors will be used to modify the power factor, now considering economic conditions and the high prices of such capacitors, it should be investigated how much it affects the voltage drop and how much reduces the reactive current, to decide on released power lines for transmitting reactive power.

In software first we put capacitors in the prototype feeder. Results showed that in order for the power factor to change from 0.82 to 0.92 we should put two equal sized 12.5 KVAR capacitors in points A and B as shown in figure 1m far from this we distributed the load again, results and the voltage profile are shown below.

Table.3- Results of load flow after Capaciting

Loss (%)	Loss (KW)	Voltage drop (%)	Minimum voltage
5.9	2.58	12.7	192

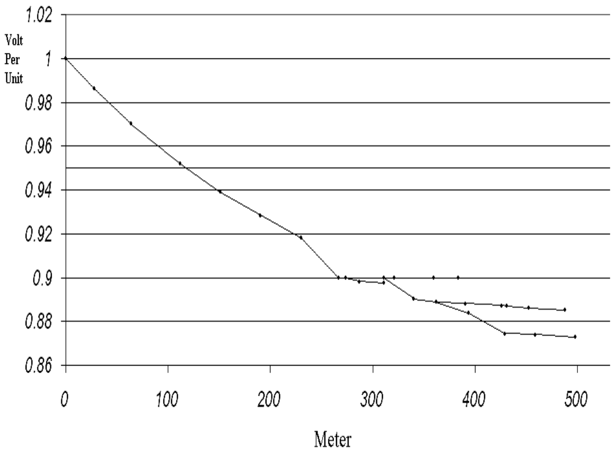

Fig.4- Voltage profile after Capaciting

As it is shown in Table 3 and figure 4, the minimum voltage has reached 192.4 volts and the loss is reduced to 2.58 KW.

5 Load balance

In ground distribution networks 3 phase system with four wires is used, in which three of wires are phase and one is the null wire. In such networks, the loads are mostly single phased connected between one of the phase wires and the null wire. Since the number of branches on each phase is not equal, or even when equal, their power usage are different, the null wire is usually carrying some current.

Therefore, distribution networks are generally unbalanced. The unbalance will cause: increasing the voltage drop loss, danger of current flow in null and finally the reduction of power quality for end users. On the prototype feeder, using software, we analyzed the load balance with a proper pattern-which will be shown later and the results are presented as the phase variation of users.

The software program by considering the amount of used currents, consumption and synchronization factors, will choose the best feeding phase such that first of all, establishes the maximum balance in each base and second, minimizes the number of load switchings between the phases.

The overall procedure of this program can be classified in 3 steps:

1-Finding the last base to which the load balance has not been applied.

2-Creating all possible combinations of load feedings and selecting the best one according to:

2-1-minimum deviation of balance state

2-2-minimum number of load switchings between phases

3-Repeating the above steps for all bases(from the end to the beginning of feeder).

After analyzing the prototype feeder with software the results turned out to be the switching of 15 users (the report for user's phase variation is available in appendix).

After applying changes in user's feed phase, the load distribution is done again and the results are given in the table below:

Table.4- Results of load flow after load balance

Loss (%)	Loss (KW)	Voltage drop (%)	Minimum voltage
6.2	3.31	10.9	196

As it can be seen, with balancing the network, the end line voltage has reached 196 volts and the loss has reduced to 3.37 KW.

6 Combination of the 3 Methods (section modification, load balance and capaciting)

In distributing systems with high voltage drops and high loses, using only one of the above methods can not lead to the desired condition, so a

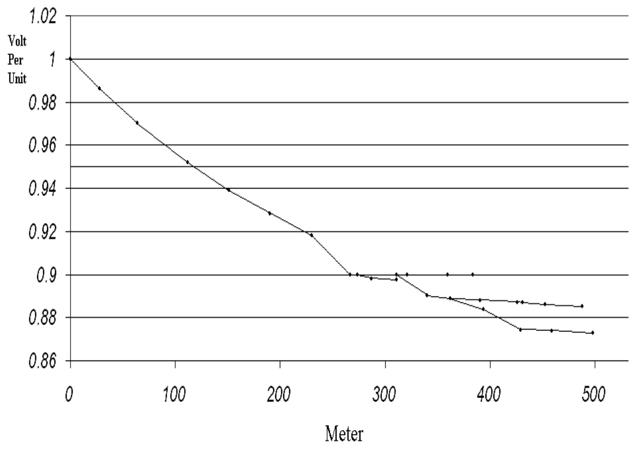

Fig.5- voltage profile after load balance

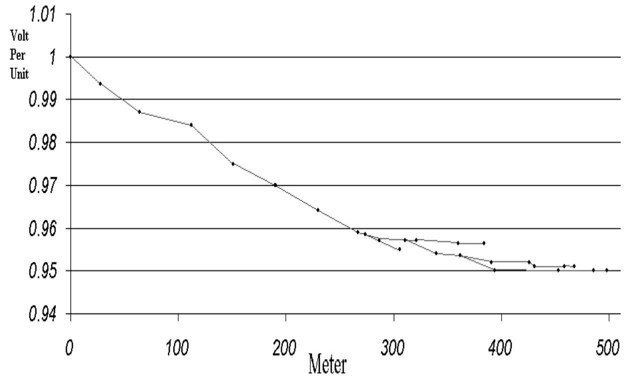

Figure 6- voltage profile after optimization

combination of these methods usually yields the optimum condition.

As it was shown in previous sections, none of these methods can compensate the loss and the voltage drop by themselves; in this section by combining these methods we are trying to achieve the desired conditions.

In this stage, we first make the prototype feeder in all of the distances, four wired and also increase the section of phases to 50 mm^2 and section of null to 25 mm^2 and then run the program again. After doing these two steps and applying necessary changes on user phase feeds as below, we run the capaciting program on the network with modified section and maximum load balance.

So the software suggests a 12.5 Kvar capacitor in A to increase the power factor to 0.9.

After placing a capacitor in A, we run the program again and the results shown in Table 5 are achieved.

Table.5: Results of the optimum condition load flow

Loss (%)	Loss (KW)	Voltage drop (%)	Minimum voltage drop
3	1.32	4.9	209.2

The feeder voltage profile after the implementation of combination method is shown in Fig.6.

As illustrated, the minimum voltage in this stage is 209.2 V and the loss is reduced to 1.32 KW both of which are in the standard range.

7 Economic considerations

In economical modifications of the projects, initial investment capital and returned interest ratio in a specific period of time is usually investigated.

Since the goal of this paper is to minimize the losses in order to improve the quality and reliability of the provided energy to the end user, the value of each kilowatts of energy compared to loss costs has been investigated.

Considering the installation of DATA LOGGER on the sample feeder, the load factor and loss factor have been calculated according to Fig.7 and then the economical evaluation of each method has been performed.

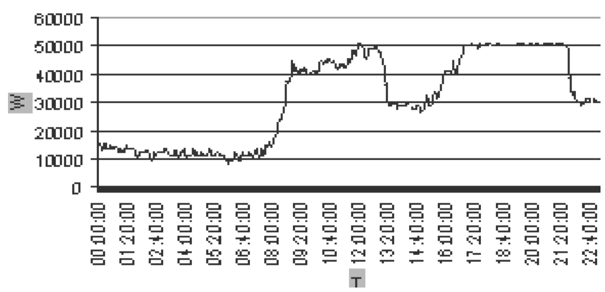

Figure 7- sample feeder load plot

7.1 Power and loss factor calculation

The ratio of average hourly energy consumed in specific period of time to the load peak in that period, is the load factor and can be calculated from the following equation:

$$L_{.f} = P_{av} / P_{max} \quad (1)$$

According to Fig. 7 which shows the measured sample from the feeder in period of five minutes, by using equation (1) the load factor of the feeder can be calculated as:

Number of measuring =24*12=288

Sum of power measured in different measurements= 8948600 watts
Maximum measured power=50800 watts
Load factor = 8948600 / (50800*288) =0.611

Loss factor is the ratio of average loss to the loss in peak time and can be calculated from the following equation:

$$L._{sf} = 0.3\ L._{f} + 0.7\ L^{2}._{f} \qquad (2)$$

Considering the load factor, loss factor can be calculated as below:

Loss factor=0.183+0.261=0.444

In computerized calculations, the loss factor has been considered as calculated above. (The loss factor has been considered in the results mentioned in software report).

For determining the energy and power loss ratios in distribution network (which is located at the end of the installations and is responsible for providing the users with electrical energy) the initial investment in relation to the reduction of losses in the installation from the generation end to the consumer end, is taken into consideration.

Since there are various parameters in installed systems such as generation, transmission, master distribution and distribution, and each has its own loss, the investigations show that we need 2KW of power in the plant to compensate 1KW of loss at the end user.

Now considering the same ratios for annual benefit and inflation and using loss comparison table, the saving will be as follows:

1- Investment saving: for providing required power in one year, there is a need for twice the investment for each kilo watts that costs $1600 with exchange ratio of 1.06$ for average life time of 20 years and amortization ratio of 5%.

2- Final energy costs Saving (generation + transmission + distribution): considering the annual energy saving, 5.85 cents for each KWH (according to specific electrical energy tariffs for 2005, TAVANIR Co.)

As shown in Table 5, despite the longer time for capital returns in combined method, keeping the feeder in standard situation technically and economically justifies the method.

Table 5- Economical considerations

methods of Loss reduction	amount of Loss reduction (KW)	Project implemen tation cost ($)	Invest ment Saving ($)	Energy saving ($)	Return (day)
Cross section	1.53	13021	3501	7841	456
Capacitor placement	1	4925	170	5125	263
Balancing (leveling)	0.27	50	459	1384	11
combination	2.26	23253	4663	11582	548

8 Conclusions

In this paper, we investigated three practical methods to reduce the losses and showed that each of these methods can help reducing the loss of valuable electrical energy, how ever due to the age of the network and length of the feeder the combined method is the only one that can reach voltage and feeder losses to the standard limits.

By implementing the optimization project, the ohmic losses of feeder can be reduced to 5% and also all parameters of the network managed within the standard range and factors. This will help us to improve the network both from economical and technical point of views and also the quality and the reliability of power provided to the end users and their satisfaction.

References:

[1]Mazandaran power consulting En .co , Report of Loss reduction project of Chaloos city,,june-2005.

[2]Ali Faiaz, research regarding causes of transformer burning and methods for its solution ,2005

[3]IEEE Guide for safety in AC Substation Grounding ,2004,pp.232-245.

[4]Electrical transmission and distribution reference book, Westinghouse electric corporation ,USA , 1994.

[5]W.W.Hogan.Cotract networks for electric power transmission. Journal of regulartory Economics, Nov. 1992,PP.211-242.

[6] M.Hsu.An introduction to the pricing of electric power transmission .Utility policy 63,Sep. 1997,PP. 257-276.