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Review

Power consumption pattern based on fuzzy method

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The experience of many countries worldwide shows that one of the appropriate ways that can make power subscribers (clients) to maintain the consumption power coefficient within the allowed limit is to apply consumption partitioning by controlling electricity consumption power coefficient. In this article, a trial has been made to examine a new method in which we can limit the clients whose consumption power coefficient is less that the allowed limit by fuzzy logic in order to partition it equally in the whole distribution system and reduce black-out significantly.

Key words: Power coefficient, fuzzy logic, refining consumption pattern.

INTRODUCTION

Providing reliable and high-quality electricity for all customers at minimum cost and regarding macroeconomic plans is the most important actions taken by the power companies. One of the major opportunities to supply client's consumer needs in the current circumstances is to adjust load pattern. Adjusting load pattern means replacing consumption components in such a way that results in the least amount of difference between consumption maximum and consumption minimum day and night or during the year. Load control is tools extensively used in recent years in most countries across the world, especially in the developing countries which face a dramatic growth in using electricity.

In this process, the purpose of controlling consumption load voluntarily during different hours and seasons by the domestic customers is done through coordination with power companies (Rezaei, 2008).

Since domestic consumption element allocates more than 50% of consumption at the peak load to itself, adjusting consumer pattern has a significant role in the productivity of power industry. Regarding the high potential of saving, this solution offers reduction of costs related to preparing the load control equipment, applying this method is really effective.

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Control methods in this field are different which range from compulsory limitations to dynamic fluctuating tariff rates and they vary based on the kind and level of the necessities to produce electrical energy (Yaghouti, 2004).

Fuzzy logic is our proposed method to achieve this control, which is a method to represent nonlinear systems mathematically that has a numerous practical application in forming approximate costs of logics due to its capacities.

FUZZY SET AND FUZZY LOGIC

Fuzzy logic is the mathematical representation of human concepts. In recent years, fuzzy logic has been used to overcome practical problems in controlling and making decision, which includes the wrong reasoning process by human or is similar to that. And this mathematical method is promising in modeling traffic control processes which are described by internality, vagueness and inaccuracy.

Fuzzy set is stated by a membership function which shows the belonging of one element of the universal set to the fuzzy set. Every fuzzy logic system can be divided into 3 elements (Figure 1): Fuzzy making, fuzzy presumption and defuzzy making.

Fuzzy presumption is based on fuzzy law principle that includes if-then fuzzy rules set. Numerical fuzzy law is shown in Figure 1 (Shamshirband, 2008).

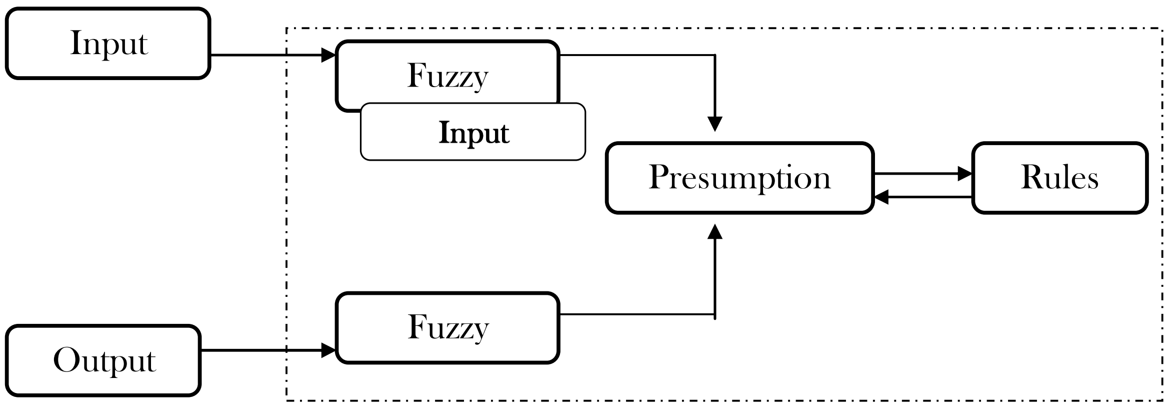

Figure 1. Fuzzy logic system.

Fuzzy model is known as one of the effective methods to model nonlinear and complicated systems.

Assume that U$\in R^n$, U=U$\times U_2 \times \dots U_n \subset R$, f is a multi input-single-output nonlinear complicated relationship from U to V in which $(x^1, x^2, \dots x^n)$ T $\in U$, y$\in V$ of nonlinear function f can be stated as a set of if-then laws whose rth law is like this: If (x_1 is A_1^2& x_2 is A_2^2 & x_n is A_n^2) then y_2 is B^2 with certainty factor a^2 where A_i^2 is a fuzzy set in $U_i \subset$R & B^r is a fuzzy set in $V \subset R$. Let's take the number of laws as m, that is, $r = 1,2,\dots M, a_r$ is a number between 0 and 1 which shows that y is the important degree or certainty factor of rth law. It proved that by choosing the appropriate fuzzy sets and absolute laws set, the fuzzy system with the mentioned laws set, product deduction motor, fuzzy making. Center mean defuzzy making can be used to approximate every derivable continuous function with certain accuracy (LI-XIN, 1997).

FUZZY (MAMDANI)

Professor Ebrahim Mamdani was at Mary Queen College. His work led to fuzzy systems known today. Professor Mamdani built the first fuzzy system in early 1970 to control a steam engine and a little later developed and examined fuzzy traffic light. Later he described his work method this way. The main idea behind this method is using the "experiences" of the expert operator in designing controller. Based on a language laws set which describes the control strategy, where words have been defined according to fuzzy sets, a system controlling pattern is built. It seems that the main advantage of this method is the execution possibilities of "perception laws" of experience, thought, subjectivism and a fact that needs no model of a system.

PROBLEM DEFINITION

Power factor (Keith and Gerald, 2009) is a term referring to actual power to apparent power and ranges from 0 to 1. The actual power is in fact the ability of a consumer to transform electrical energy to other forms of energy while the apparent power is created as the result of the difference between voltage and current. Regarding their load kinds and their level of reactive power, their apparent power can be higher than their actual power. The low value of power factor (the high value of apparent power to the actual power) in a circuit increases the current in the circuit and as a result raises the losses in the circuit.

Generally, in an AC circuit, it's possible to divide the consumers into 2 categories in terms of the kind of electrical energy use:

1. Reactive (resistance) consumers.
2. Reactive (capacitive or inductive) consumers.

Active consumers convert all electrical energy received to other forms of energy but the reactive consumers save the received electrical energy in the capacitor which creates trouble for AC circuits but not for PC circuits.

In an absolutely resistance circuit, the shape of the current wave and voltage are synchronized (that is, they get zero or maximum at the same time)(Keith and Gerald, 2009). The flowing AC power has 3 aspects in a consumer as seen in Figure 2:

(1) Actual power shown by p and its unit is watt.
(2) Apparent power represented by s and its unit is volt-Ampere.
(3) Reactive power indicated by Q and its unit is reactive. Volt ampere.

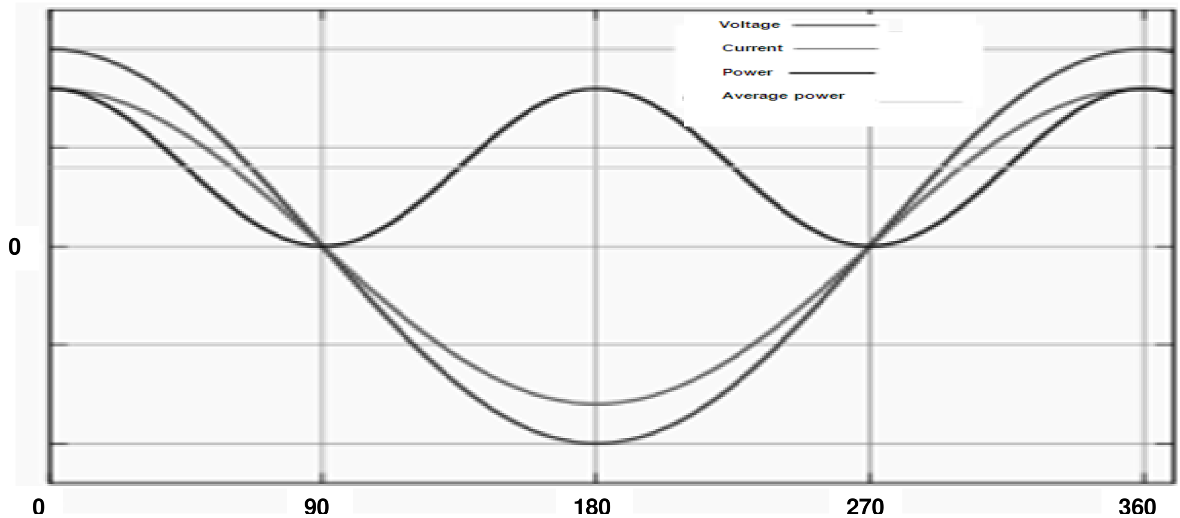

Figure 2. The current wave shape, voltage, power and average power factor.Ø=0.

Now we can obtain the power factor by the following Formula 1:

$$\text{Power factor} = \frac{P}{S} \tag{1}$$

If the shapes of the waves are fully census form, a, p, s can be taken as the 3 sides of a triangle and therefore such a relation can be obtained among the powers by Formula 2:

$$S^2 = P^2 + Q^2 \tag{2}$$

If is taken as the angle between current and voltage, then to obtain power factor or |cos |, we will have:

$$P = S|\cos^{\emptyset} \quad | \quad \emptyset^{\emptyset} \tag{3}$$

Modifying power factor is a technique that is used to neutralize the negative effects of reactive loads in an AC network. In this technique, by using reactive loads with reverse power factor, the load sent to network (for instance, using capacitor to neutralize the effects of inductors in the network) in huge utilities like factories and to reduce current in domestic utilities (to discharge appliances from the circuit), they try to modify power factor or make it close as much as possible to 1.

PROPOSED METHOD

Fuzzy logic is our proposed method to gain control over high-consuming customers it's a method to represent nonlinear systems mathematically which has various practical applications due to its capacities to formulate the approximate aspects of logics that is examined from two points of view:

1. Designing fuzzy logic algorithm to control high-consuming customers in terms of time and the amount of consumption load factor.
2. Evaluating fuzzy logic algorithm to decrease domestic consumers' consumption at the time of peak load is the major goals power distribution companies have.

We can apply appropriate control over high-consumption customers regarding the season and peak time in a year (Figure 3) and load level (Figure 4) used during these time intervals. This control is done in such a way that decreases the input current level to the customer by increasing the load at peak hours of consumption. For example, a customer increases his consumption load level at peak consumption hours in spring.

Cos Ø < 0.85 is the result. (Bakamali and Heidari, 1990).

This result in increase losses and black-out in other parts. Considering the fuzzy system inputs (time) and load factor (CosØ) divided into the following (spans) and current system output, we gain the power. We consider the parameters as follows, as seen in Figures 5 and 6

CosØ: High (0, 0.5), medium (0.5, 0.85) and low (0.85, 1).
Time: Autumn (17, 21), winter (18, 22), spring (19, 22:30) and summer (20, 23).
1: Normal (1, 15), limit (13, 15) cut off (15).
0: Household consumer load factor.
High: The load factor level is too close to zero; in other words consumption is high (Cos Ø).
Medium: The load factor level is closer to standard level.

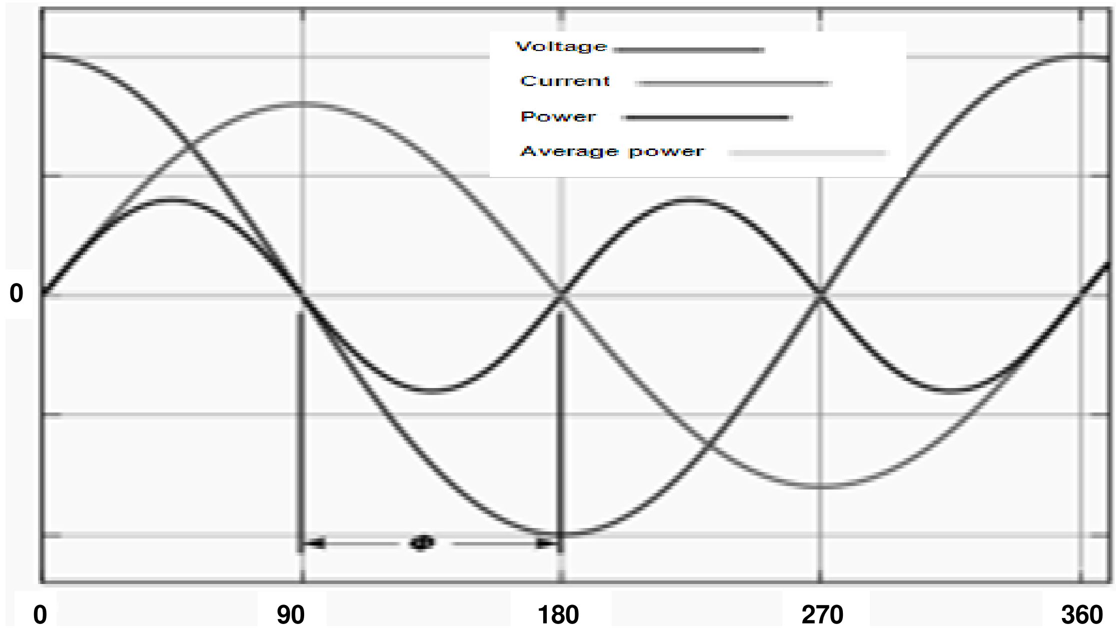

Figure 3. The current wave shape, voltage, power and average power by power factor. Ø =45.

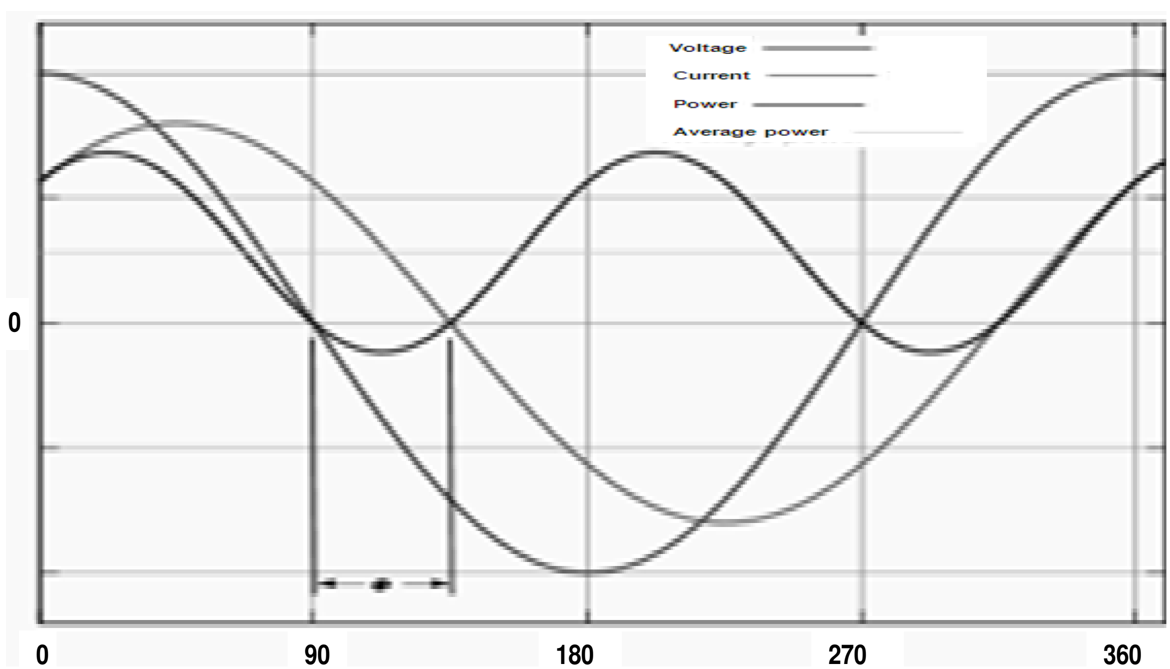

Figure 4. The current wave shape, voltage, power, average power by power factor.Ø= 90

Low: The load factor is within standard limit.
Time: Peak time dispersion in different Seasons:

Autumn: Peak hours in autumn.
Winter: Peak hours in winter.
Spring: Peak hours in spring.
Summer: Peak hours in summer.

I: Output current from the circuit (Figure 7).
Normal: The consumption level at the peak time of consumption is suitable and the customer can use the whole current.

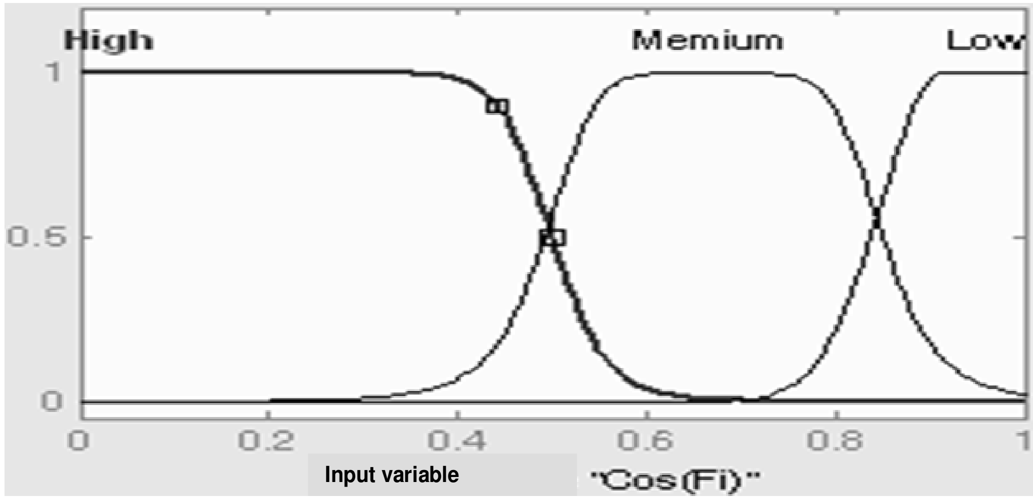

Figure 5. Input in terms of cosØ.

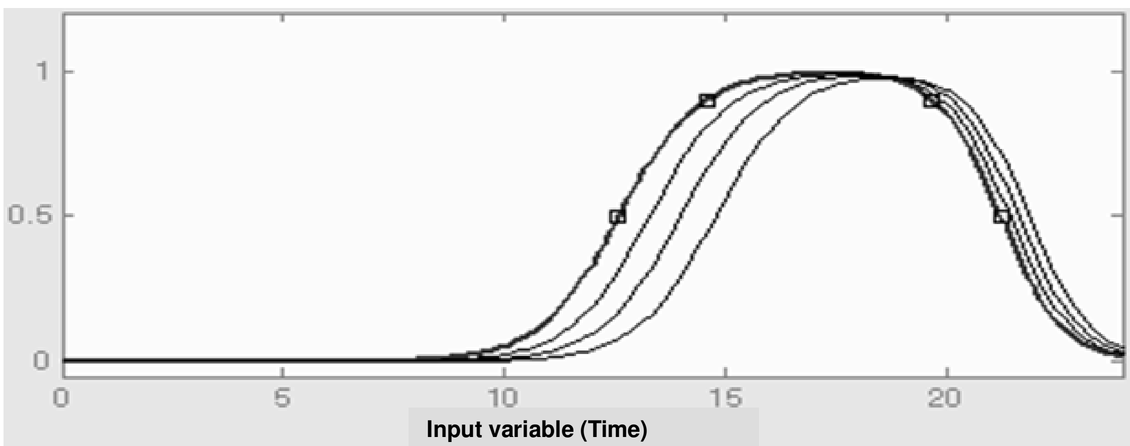

Figure 6. Consumption dispersion round the clock.

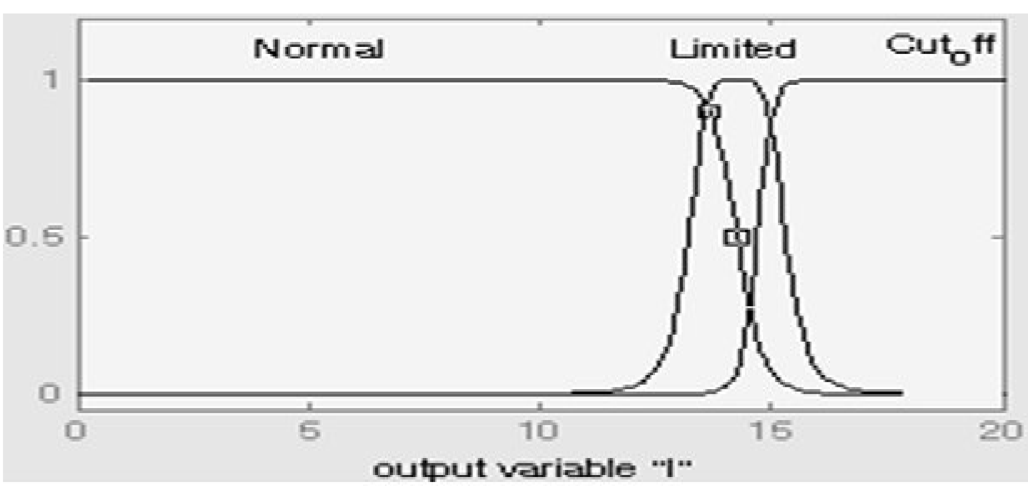

Figure 7. (output in terms of current).

Table 1. Current level based on the inputs.

Season	Time	Cos(fi)	I
Spring	19,22:30	High	Cut off
Spring	19,22:30	Medium	Limit
Spring	19,22:30	Low	Normal
Summer	20,23	High	Cut off
Summer	20,23	Medium	Limit
Summer	20,23	Low	Normal
Autumn	17,21	High	Cut off
Autumn	17,21	Medium	Limit
Autumn	17,21	Low	Normal
winter	18,22	High	Cut off
winter	18,22	Medium	Limit
winter	18,22	Low	Normal

1. If (Season is Spring) and (Time is Sp) and (Cos(Fi) is High) then (I is Cut_Off) (1)
2. If (Season is Summer) and (Time is Su) and (Cos(Fi) is High) then (I is Cut_Off) (1)
3. If (Season is Autumn) and (Time is A) and (Cos(Fi) is High) then (I is Cut_Off) (1)
4. If (Season is Winter) and (Time is W) and (Cos(Fi) is High) then (I is Cut_Off) (1)
5. If (Season is Spring) and (Time is Sp) and (Cos(Fi) is Memium) then (I is Limited) (1)
6. If (Season is Summer) and (Time is Su) and (Cos(Fi) is Memium) then (I is Limited) (1)
7. If (Season is Autumn) and (Time is A) and (Cos(Fi) is Memium) then (I is Limited) (1)
8. If (Season is Winter) and (Time is W) and (Cos(Fi) is Memium) then (I is Limited) (1)
9. If (Season is Spring) and (Time is Sp) and (Cos(Fi) is Low) then (I is Normal) (1)
10. If (Season is Summer) and (Time is Su) and (Cos(Fi) is Low) then (I is Normal) (1)
11. If (Season is Autumn) and (Time is A) and (Cos(Fi) is Low) then (I is Normal) (1)
12. If (Season is Winter) and (Time is W) and (Cos(Fi) is Low) then (I is Normal) (1)

Equation1. (Fuzzy system in the defined problem)

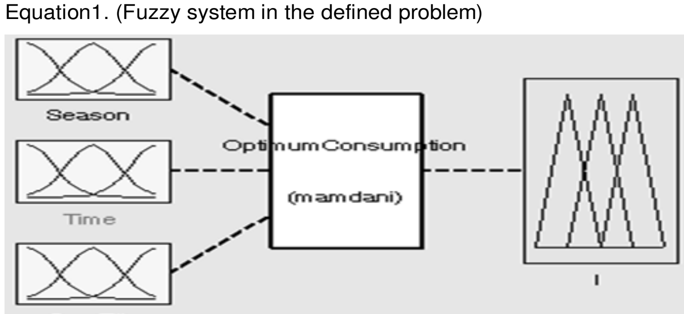

Figure 8. Fuzzy system in the defined problem.

Limit: The consumption level at peak consumption time is within the permitted limit that is, in this state customer's current level will be limited.

Cut off: In this case, the customer's consumption is more than the permitted limit that brings about black out in other areas and power cut is the result. The Table 1 shows the current level based on the inputs:

The results gained by simulating this system in the subject software based on Mamdani fuzzy logic are as follow:

The fuzzy set of input and output parameters is like Equation 1.

The subject program code is shown in Figure 8.

Figure 9 shows current changes in relation to Consumer load factor in different seasons of the years:

Figure 10 indicate current changes level to the consumer load factor at different hours of day and night.

Figure 11 represent the level of current changes to different hours of day and night in different seasons of the year.

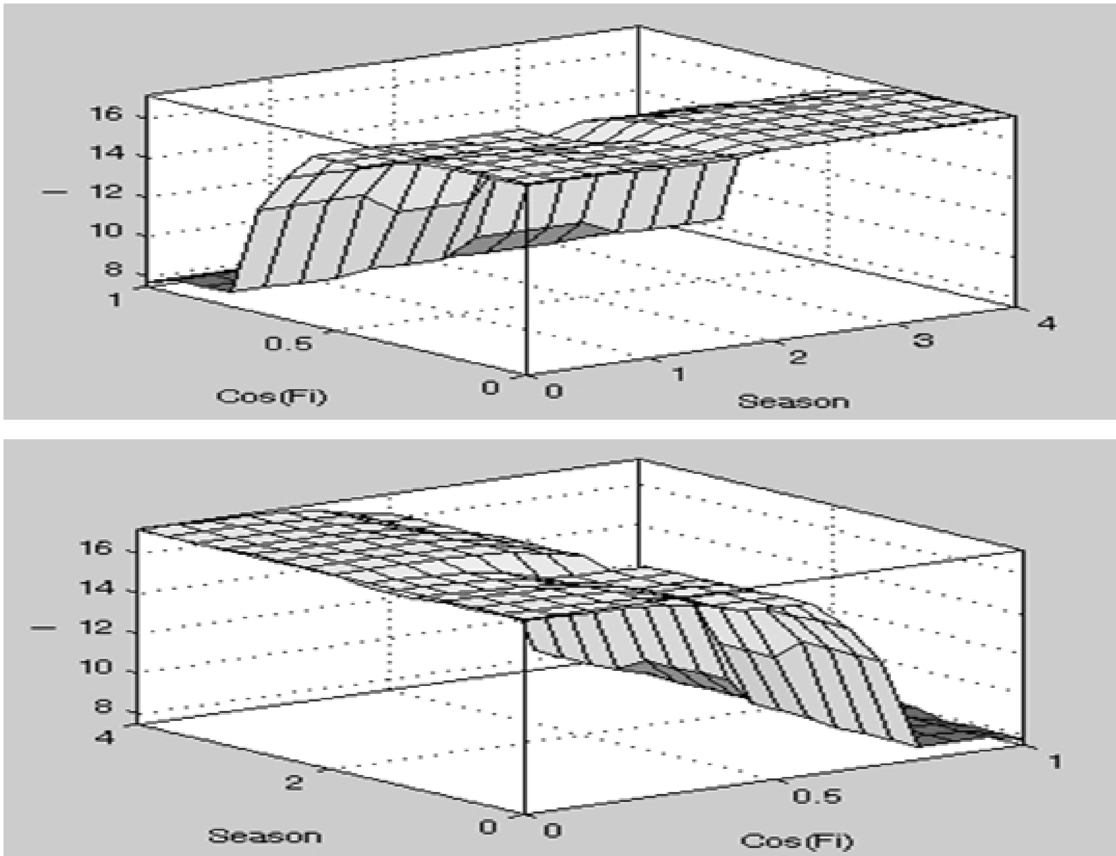

Figure 9. Current changes in relation to consumer load factor in different seasons of the years.

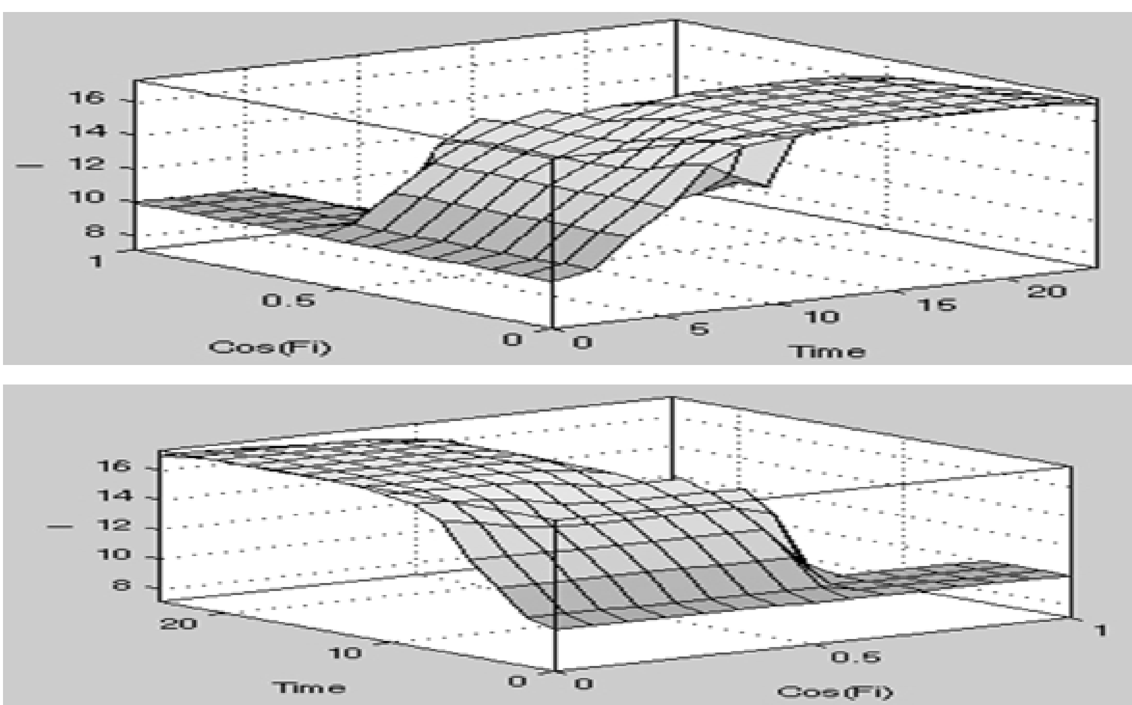

Figure 10. Current changes level to the consumer load factor at different hours of day and night.

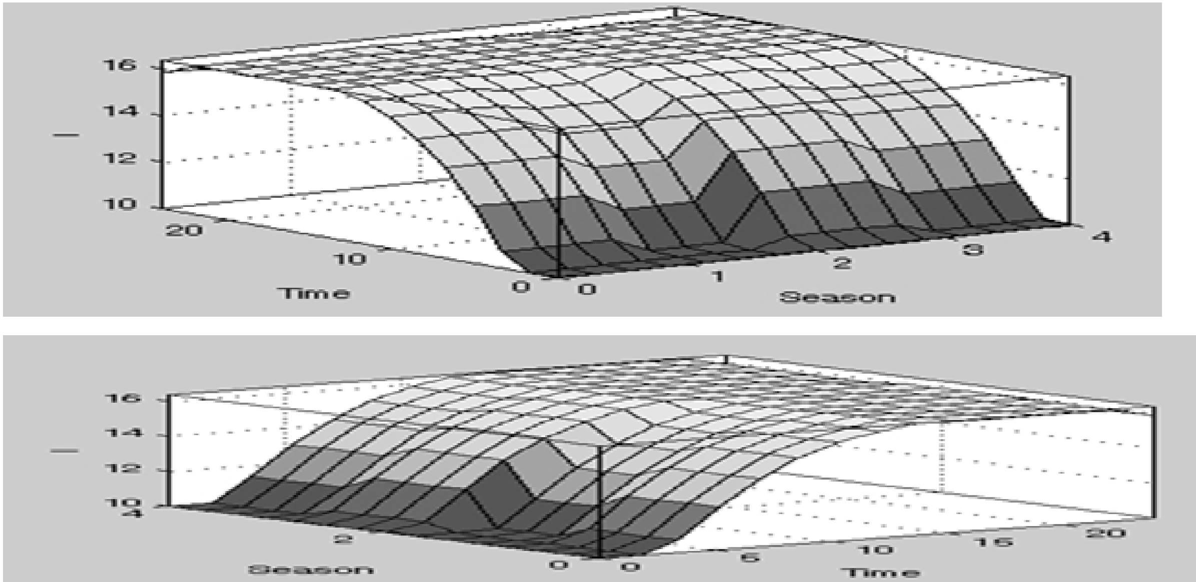

Figure 11. The level of current changes to different hours of day and night in different seasons of the year.

Conclusion

Our purpose of introducing this article is to prevent powercut in different parts of the country and to control high-consumption customers by applying laws based on Mamdani fuzzy for every customer's electricity use. Though all these methods are to create a pattern process for use, which is hoped to be achieved.

Our purpose of introducing this article is to prevent power cut in different parts of the world and also to control high-consumption clients by applying rules based on fuzzy on each customer's power. However, all these methods intend to create a pattern process for consumption which we hope to be accomplished someday.

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