

Risk Estimation of Induction Motor Fault in Power System

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Abstract: - In this article is proposed the method of induction motor fault risk estimation with the account of induction motor technical condition and EPS subsystem regime. For the induction motor technical condition appreciation is developed the fuzzy model. This model uses the expert knowledge and parameters, which could be obtained without the switching off the motor from grid. For the definition of induction motor fault probability in the case of accident in EPS subsystem probabilistic statistical approach is used. Obtained results could be used for organization the effective risk-oriented management of EPS subsystem for providing its reliability.

Key-Words: - induction motor, EPS subsystem, fault, risk, probability, fuzzy model.

1 Introduction

At present time, one of the most important problems in Ukrainian Electrical Power System (EPS) is the reliability of EPS subsystem, such as power stations auxiliaries and power supply of industrial enterprises which includes powerful induction motors. More than 70% of Ukrainian EPS electrical equipment spent its resource and the tendencies for its replacement and modernization are weak.

As a result, in Ukrainian EPS and its subsystems are growing the number of accidents, including the induction motors faults, which consist the great part of industry load. Induction motors faults lead to the technology processes failures with great damages. For the damage estimation and the effective management providing is proposed to use the risk as index, which takes into account random character of accidents in EPS, ways of accident development and imperfection and limited of input information [1].

Present tendencies of providing the reliability EPS operation show that the role of risk-management in EPS and its subsystems is growing [2–4]. Risk-management using for the providing of induction motors reliable operates requires risk estimation as integral parameter which takes into account all listed above factors.

2 Model for the risk estimation

As reliability index of induction motor operates the risk of its fault is used. Risk includes object fault probability and damage cost [2, 3]. It is very important to choose the approach of risk estimation.

The deterministic approach to the risk estimation is quite simple, but it has a number of lacks, such as:

- does not consider probabilistic effect of equipment fault;
- does not define fault conditions;
- does not fully account of fault damages.

For the risk estimation of induction motor fault in EPS subsystem is offered probabilistic

statistical approach with Monte-Carlo method using [5, 6]. This approach allows taking into considerations the above mentioned uncertainties.

Risk of induction motor fault is defined by next equation [4]:

$$Z = p \cdot V, \tag{1}$$

3 Definition of induction motor fault probability at the time interval

For the risk estimation it is necessary to know the induction motor fault probability at the time interval. For this aim are used next events:

- H_1 – event of induction motor fault at the time interval Δt ;
- H_2 – event of induction motor non-fault operates at the time interval Δt ;
- B – event of induction motor technical condition at the moment of time t_1 is S ;
- D – event of accident appearing in EPS subsystem at the time interval Δt .

In the case if the event B is now, the conditional probability of event H_1 is defined by Bayes theorem [7]:

p is the probability of induction motor fault at the time interval $\Delta t = t_2 - t_1$, V is the damage cost.

Total risk of induction motors faults in EPS subsystem, which includes n motors is defined as [4]:

$$Z = \sum_{i=1}^n p_i \cdot V_i. \tag{2}$$

$$p(H_1/B) = \frac{p(H_1) \cdot p(B/H_1)}{p(H_1) \cdot p(B/H_1) + p(H_2) \cdot p(B/H_2)}, \tag{3}$$

$p(H_1)$ is the priori probability of event H_1 , $p(H_2)$ is the priori probability of event H_2 , $p(B/H_1)$ is the conditional probability of event B if the event H_1 is now, $p(B/H_2)$ is the conditional probability of event B if the event H_2 is now.

The priori probabilities of fault and non-fault operate of induction motor in the case of its efficient condition at the moment of time t_1 are defined from statistical function of induction motor faults distribution (Fig.1):

$$p(H_1) = \frac{F(t_2) - F(t_1)}{1 - F(t_1)}, \tag{4}$$

$$p(H_2) = 1 - p(H_1). \tag{5}$$

problem, which solving with the limited number of diagnostically parameters. These parameters may be determined by operating machine without its switch-off from grid. In this case, for the induction motor technical condition definition fuzzy-model is used.

The conditional probabilities $p(B/H_1)$ та $p(B/H_2)$ are defined by expert estimations with using Saaty method [8] and Zadeh compositional rule [9]:

$$P = R \circ S, \tag{6}$$

$$p_j = \max \min(s_i, r_{ij}) \tag{7}$$

\circ – is maximum-minimum composition, $R = [r_{ij}]$, $i = 1..m$, $j = 1..n$ – is fuzzy relation matrix between the vector of input attributes $S = [s_i / x_i]$, $i = 1..m$ and the vector of output alternatives $P = [p_j / y_j]$, $j = 1..n$.

Solution is defined as the center of alternatives y_j with the corresponding membership degree value p_j :

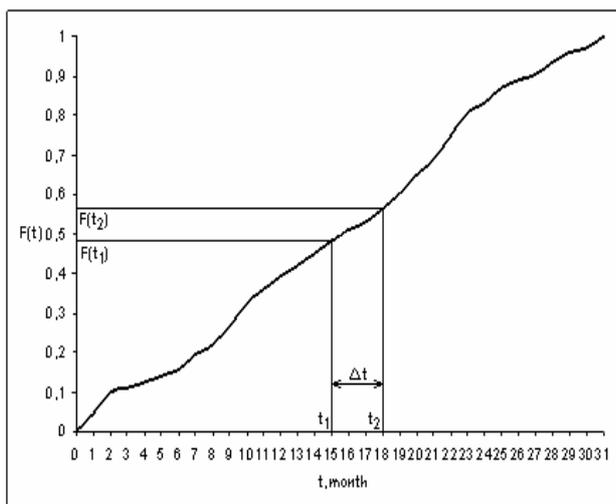


Fig.1. Statistical function of induction motor faults distribution

As the measure evaluation of induction motor technical condition is taken the value S , which is the quantity characteristic of induction motor recourse. Induction motor technical condition definition is a complicated

$$y_0 = \frac{\sum_{j=1}^n p_j \cdot y_j}{\sum_{j=1}^n p_j} \quad (8)$$

Value of probabilities $p(B/H_1)$ та $p(B/H_2)$ are founded by next equations:

$$p(B/H_1) = y_{0P}, \quad (9)$$

$$p(B/H_2) = y_{0Q}. \quad (10)$$

For the definition of induction motor fault probability in the case of accident in EPS subsystem probabilistic statistical approach is used [6]. In this case, the probability of induction motor fault is defined as:

$$p(H_1/D) = \frac{n}{N}, \quad (11)$$

N – the total number of simulated by Monte-Carlo method regimes of EPS subsystem, n – the number of simulated regimes with induction motor fault.

Obtained probabilities $p(H_1/B)$ and $p(H_1/D)$ are the conditional probabilities of induction motor fault at the time interval with the account of induction motor technical condition and EPS subsystem regime respectively. Events B and D are independent and compatible. So, probability of induction motor fault at the time interval with the account of induction motor technical condition and EPS subsystem regime is defined by the theorem of compatible probabilities addition [10]:

$$p(H_1/B, D) = p(H_1/B) + p(H_1/D) - p(H_1/B) \cdot p(H_1/D) \quad (12)$$

4. Fuzzy model for induction motor technical condition definition

Fuzzy model has the next structure [9]:

- membership functions for inputs and output;
- expert rule base “IF-THEN” type;
- Mamdani type output algorithm;
- defuzzification method.

According to the statistical data, the most frequently breaking nodes of induction motors are [11]:

- bearings;
- stator winding insulation;
- rotor winding bars;

- air gap eccentricity.

Technical conditions of these nodes may be estimated by next parameters, which can be measured without switching off the motor from grid:

- bearings temperature – allows to evaluate the resource of bearings;
- stator winding temperature – allows to evaluate the resource of stator winding insulation;
- negative sequence of phase stator currents – is the indication of non-symmetry magnetic pole of motor, which is a consequence of broken rotor bars or air gap eccentricity.

Thus, fuzzy model has three inputs:

- A = “Worked resource of stator winding insulation” with terms A_1 = “Low”, A_2 = “Middle”, A_3 = “Big”;
 - B = “Worked resource of bearings” with terms B_1 = “Low”, B_2 = “Middle”, B_3 = “Big”;
 - C = “Negative sequence of phase stator currents” with terms C_1 = “Low”, C_2 = “Big”.
- Membership functions of input terms are determined by experts’ estimations with using the Saaty method (Tab.1).

Tab.1. Experts’ estimations for input values

A = “Worked resource of stator winding insulation”						
$R_{ISO}, \text{ p.u.}$	0	0,2	0,4	0,6	0,8	1,0
A_1	10	4	0	0	0	0
A_2	0	6	10	10	9	4
A_3	0	0	0	0	1	6
B = “Worked resource of bearings”						
$R_{POD}, \text{ B.O.}$	0	0,2	0,4	0,6	0,8	1,0
B_1	10	3	0	0	0	0
B_2	0	7	10	9	2	0
B_3	0	0	0	1	8	10
C = “Negative sequence of phase stator currents”						
$I_2, \%$	0	2	4	6	8	10
C_1	10	10	9	3	0	0
C_2	0	0	1	7	10	10

Membership functions of input terms are represented at the Fig.2.

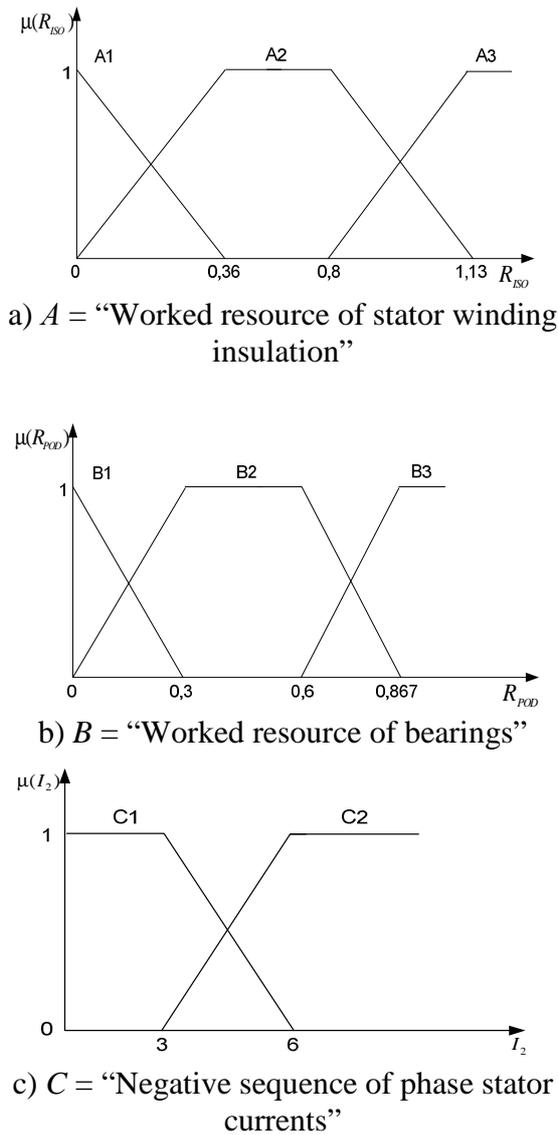


Fig.2. Membership functions of input terms

As the fuzzy model output is taken value $S = \text{“Total worked resource of induction motor”}$ with terms $VB = \text{«Very big»}$, $B = \text{«Big»}$, $M = \text{«Middle»}$, $S = \text{«Small»}$, $VS = \text{«Very small»}$. Membership functions of output terms are determined by Harrington scale intervals. Membership functions of output terms are represented at the Fig.3.

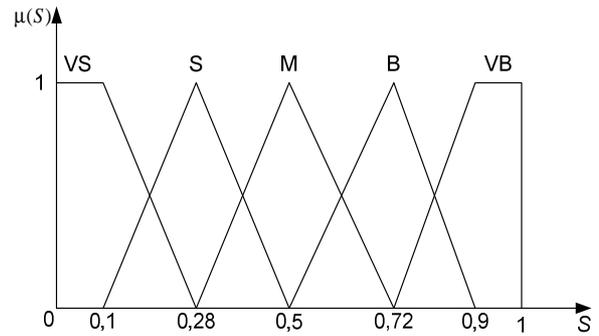


Fig.3. Membership functions of output terms

Rule base consists of “IF-THEN” type rules, which are formed by expert (Tab.2).

Tab.2. Fuzzy model rule base

$I_2=C_1$	$R_{POD} \backslash R_{ISO}$	A_1	A_2	A_3
	B_1	VS	S	B
	B_2	S	M	B
	B_3	B	B	VB
$I_2=C_2$	$R_{POD} \backslash R_{ISO}$	A_1	A_2	A_3
	B_1	M	M	VB
	B_2	M	B	VB
	B_3	VB	VB	VB

To determine the conditional probabilities $p(B/H_1)$ and $p(B/H_2)$, according to the technical condition S , obtained by fuzzy model, are formed Zadeh matrices R_p and R_Q . For the formation of Zadeh matrix Saaty method is used. Zadeh matrices R_p and R_Q are represented in Tab.3,4.

Tab.3. Zadeh matrix R_p for the determination of conditional probability $p(B/H_1)$

R_p	x_1	x_2	x_3	x_4	x_5
y_{p1}	0,85	0,093	0,004	0,004	0,005
y_{p2}	0,082	0,837	0,064	0,036	0,018
y_{p3}	0,04	0,05	0,815	0,078	0,044
y_{p4}	0,022	0,014	0,105	0,802	0,109
y_{p5}	0,006	0,007	0,012	0,08	0,825

Tab.4. Zadeh matrix R_Q for the determination of conditional probability $p(B/H_2)$

R_Q	x_1	x_2	x_3	x_4	x_5
y_{Q1}	0,005	0,004	0,004	0,116	0,835
y_{Q2}	0,02	0,031	0,07	0,811	0,103
y_{Q3}	0,048	0,091	0,817	0,054	0,037
y_{Q4}	0,106	0,808	0,096	0,014	0,02
y_{Q5}	0,82	0,076	0,013	0,005	0,005

5 Example

Determine the risk of induction motors M1 and M2 fault in the EPS subsystem test scheme [12] at the time interval $\Delta t = 3$ months. Test scheme consists of 14 bundles and 20 branches (Fig.4).

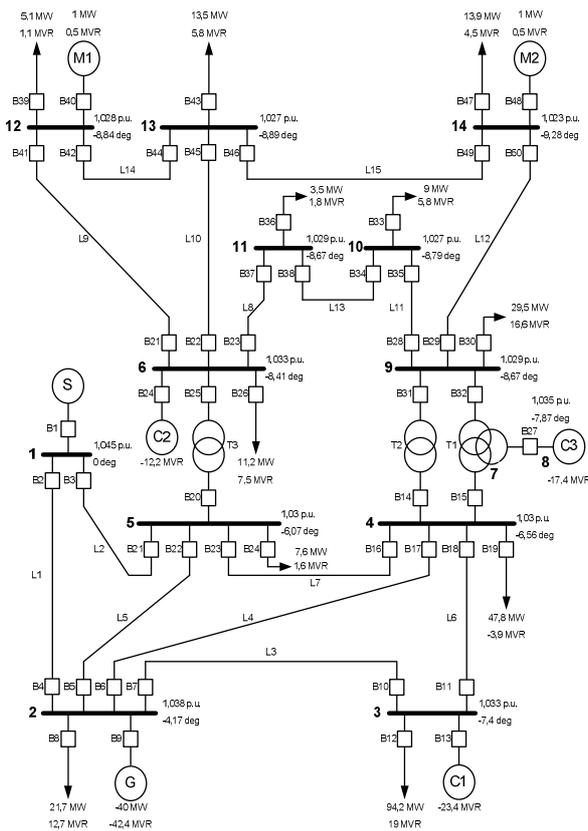


Fig.4. EPS subsystem test scheme

Parameters of test scheme elements are represented in Tab.5, 6.

Tab.5. Branches parameters

Numbers of bundles		Name	R, p.u.	X, p.u.
1	2	L1	0,019	0,059
1	5	L2	0,054	0,223
2	3	L3	0,047	0,198
2	4	L4	0,058	0,176
2	5	L5	0,057	0,174
3	4	L6	0,067	0,171
4	5	L7	0,013	0,04
4	7	T1	0	0,209
4	9	T2	0	0,556
5	6	T3	0	0,252
6	11	L8	0,095	0,199
6	12	L9	0,123	0,256
6	13	L10	0,066	0,13
7	8	T1	0	0,0176
7	9	T1	0	0,11
9	10	L11	0,032	0,085
9	14	L12	0,127	0,27
10	11	L13	0,082	0,192
12	13	L14	0,221	0,2
13	14	L15	0,171	0,348

Tab.6. Generators and compensators parameters

No	Name	X'_d , p.u.	X_d , p.u.	T_{d0} , s	T'_d , s	T_J , s
2	G	0,275	1,915	8,85	1,09	8,68
3	C1	0,238	2,458	10,4	1,01	10,43
6	C2	0,171	1,651	7,45	0,77	5,36
8	C3	0,186	2,007	9,16	1,12	7,4

Parameters of induction motors M1 and M2 are represented in Tab.7.

Tab.7. Induction motors parameters

No	Name	P_N , kW	U_N , kV	n_N , r.p.m.	T_J , s	Insulation system
12	M1	1000	6	2970	1,1	B
14	M2	1000	6	2979	1,2	B

The periodic inspection of motors M1 and M2 (without switching-off from grid) have been identified next values of diagnostically parameters (Tab.8).

Tab.8. Diagnostically parameters of induction motors M1 and M2

№	Name	Moto-hours	θ_{stator} , °C	$\theta_{bearing}$, °C	I_1 , A	I_2 , A
12	M1	10800	128	99	104,5	3,2
14	M2	13550	129	101	103,3	4,2

Worked resource of stator winding insulation and worked resource of bearings are determined by $\Delta\theta$ -degree rule ($\Delta\theta = 15,385^\circ$ for the insulation system “B”):

$$R_{ISO-M1} = \frac{T_{M-H}}{T_{M-H}^N} e^{\frac{\theta_{stator} - \theta_{stator}^N}{\Delta\theta}} = \frac{10800}{20000} e^{\frac{128-130}{15,385}} = 0,474, \quad (13)$$

$$R_{ISO-M2} = \frac{T_{M-H}}{T_{M-H}^N} e^{\frac{\theta_{stator} - \theta_{stator}^N}{\Delta\theta}} = \frac{13500}{20000} e^{\frac{129-130}{15,385}} = 0,633, \quad (14)$$

$$R_{POD-M1} = \frac{T_{M-H}}{T_{M-H}^N} e^{\frac{\theta_{bearing} - \theta_{bearing}^N}{\Delta\theta}} = \frac{10800}{20000} e^{\frac{99-100}{15,385}} = 0,506, \quad (15)$$

$$R_{POD-M2} = \frac{T_{M-H}}{T_{M-H}^N} e^{\frac{\theta_{bearing} - \theta_{bearing}^N}{\Delta\theta}} = \frac{13500}{20000} e^{\frac{101-100}{15,385}} = 0,72. \quad (16)$$

Negative sequence of phase stator currents in percents:

$$I_{2-M1}^{\%} = \frac{I_2}{I_1} \cdot 100 = \frac{3,2}{104,5} \cdot 100 = 3,06 \%, \quad (17)$$

$$I_{2-M2}^{\%} = \frac{I_2}{I_1} \cdot 100 = \frac{4,2}{103,3} \cdot 100 = 4,07 \%. \quad (18)$$

Total worked resources of induction motors M1 and M2 are determined by fuzzy model:

$$S_{M1} = \phi(R_{ISO-M1}, R_{POD-M1}, I_{2-M1}^{\%}) = \phi(0,474; 0,506; 3,06) = 0,532, \quad (19)$$

$$S_{M2} = \phi(R_{ISO-M2}, R_{POD-M2}, I_{2-M2}^{\%}) = \phi(0,633; 0,72; 4,07) = 0,659. \quad (20)$$

Mamdani type output algorithm for induction motors M1 and M2 are represented at the Fig.5 and Fig.6 respectively.

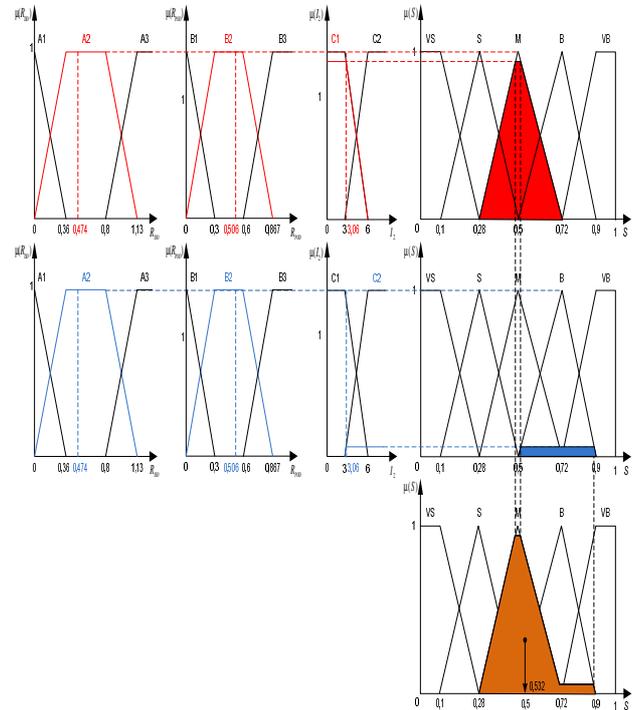


Fig.5. Mamdani type output algorithm for induction motor M1

M1 has been in the exploitation 15 months and M2 –19 months. According to the statistical function of induction motors faults distribution are determined the values of $F(t_1)$ and $F(t_2)$ for both motors ($t_2 = t_1 + \Delta t = t_1 + 3$):

$$F(t_1)_{M1} = F(15) = 0,48, \quad (21)$$

$$F(t_2)_{M1} = F(18) = 0,563, \quad (22)$$

$$F(t_1)_{M2} = F(19) = 0,603, \quad (23)$$

$$F(t_2)_{M2} = F(22) = 0,749. \quad (24)$$

Probabilities $p(H_1)$ and $p(H_2)$ are defined according to (4), (5):

$$p(H_1)_{M1} = \frac{0,563 - 0,48}{1 - 0,48} = 0,16, \quad (25)$$

$$p(H_2)_{M1} = 1 - p(H_1)_{M1} = 1 - 0,16 = 0,84, \quad (26)$$

$$p(H_1)_{M2} = \frac{0,749 - 0,603}{1 - 0,603} = 0,368, \quad (27)$$

$$p(H_2)_{M2} = 1 - p(H_1)_{M2} = 1 - 0,368 = 0,632, \quad (28)$$

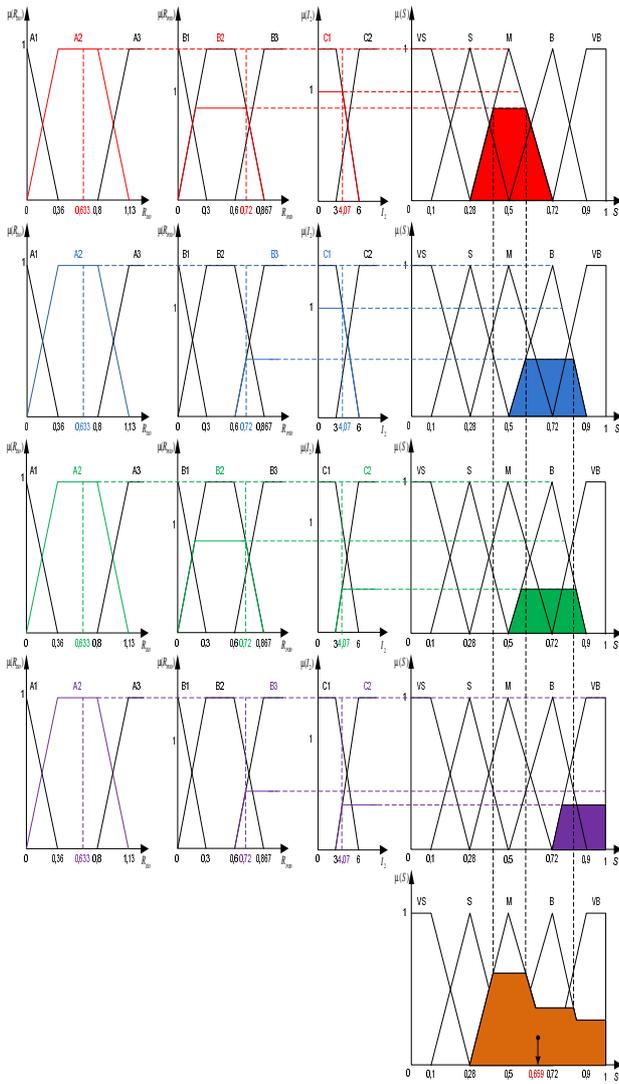


Fig.6. Mamdani type output algorithm for induction motor M2

Conditional probabilities $p(B/H_1)$ and $p(B/H_2)$ are defined at the Harrington scale intervals with using the Zadeh compositional rule (6):

$$P_{P-M1} = R_P \circ S_{M1} = \begin{bmatrix} 0,85 & 0,093 & 0,004 & 0,004 & 0,005 \\ 0,082 & 0,837 & 0,064 & 0,036 & 0,018 \\ 0,04 & 0,05 & 0,815 & 0,078 & 0,044 \\ 0,022 & 0,014 & 0,105 & 0,802 & 0,109 \\ 0,006 & 0,007 & 0,012 & 0,08 & 0,825 \end{bmatrix} \circ \begin{bmatrix} 0 \\ 0 \\ 0,855 \\ 0,145 \\ 0 \end{bmatrix} = \begin{bmatrix} 0,004 \\ 0,064 \\ 0,815 \\ 0,145 \\ 0,08 \end{bmatrix} \quad (29)$$

$$p(B/H_1)_{M1} = \frac{\sum_{i=1}^5 P_{P-M1i} \cdot y_{Pi}}{\sum_{i=1}^5 P_{P-M1i}} = 0,543. \quad (30)$$

$$P_{Q-M1} = R_Q \circ S_{M1} = \begin{bmatrix} 0,005 & 0,004 & 0,004 & 0,116 & 0,835 \\ 0,02 & 0,031 & 0,07 & 0,811 & 0,103 \\ 0,048 & 0,091 & 0,817 & 0,054 & 0,037 \\ 0,106 & 0,808 & 0,096 & 0,014 & 0,02 \\ 0,82 & 0,076 & 0,013 & 0,005 & 0,005 \end{bmatrix} \circ \begin{bmatrix} 0 \\ 0 \\ 0,855 \\ 0,145 \\ 0 \end{bmatrix} = \begin{bmatrix} 0,116 \\ 0,145 \\ 0,817 \\ 0,096 \\ 0,013 \end{bmatrix} \quad (31)$$

$$p(B/H_2)_{M1} = \frac{\sum_{i=1}^5 P_{Q-M1i} \cdot y_{Qi}}{\sum_{i=1}^5 P_{Q-M1i}} = 0,456. \quad (32)$$

$$P_{P-M2} = R_P \circ S_{M2} = \begin{bmatrix} 0,85 & 0,093 & 0,004 & 0,004 & 0,005 \\ 0,082 & 0,837 & 0,064 & 0,036 & 0,018 \\ 0,04 & 0,05 & 0,815 & 0,078 & 0,044 \\ 0,022 & 0,014 & 0,105 & 0,802 & 0,109 \\ 0,006 & 0,007 & 0,012 & 0,08 & 0,825 \end{bmatrix} \circ \begin{bmatrix} 0 \\ 0 \\ 0,277 \\ 0,723 \\ 0 \end{bmatrix} = \begin{bmatrix} 0,004 \\ 0,064 \\ 0,277 \\ 0,723 \\ 0,08 \end{bmatrix} \quad (33)$$

$$p(B/H_1)_{M2} = \frac{\sum_{i=1}^5 P_{P-M2i} \cdot y_{Pi}}{\sum_{i=1}^5 P_{P-M2i}} = 0,653. \quad (34)$$

$$P_{Q-M2} = R_Q \circ S_{M2} = \begin{bmatrix} 0,005 & 0,004 & 0,004 & 0,116 & 0,835 \\ 0,02 & 0,031 & 0,07 & 0,811 & 0,103 \\ 0,048 & 0,091 & 0,817 & 0,054 & 0,037 \\ 0,106 & 0,808 & 0,096 & 0,014 & 0,02 \\ 0,82 & 0,076 & 0,013 & 0,005 & 0,005 \end{bmatrix} \circ \begin{bmatrix} 0 \\ 0 \\ 0,277 \\ 0,723 \\ 0 \end{bmatrix} = \begin{bmatrix} 0,116 \\ 0,723 \\ 0,277 \\ 0,096 \\ 0,013 \end{bmatrix} \quad (35)$$

$$p(B/H_2)_{M2} = \frac{\sum_{i=1}^5 P_{Q-M2i} \cdot y_{Qi}}{\sum_{i=1}^5 P_{Q-M2i}} = 0,354. \quad (36)$$

According to the Bayes theorem (3) probabilities of induction motors M1 and M2 at the time interval $\Delta t = 3$ month are determined:

$$p(H_1/B)_{M1} = \frac{0,16 \cdot 0,543}{0,16 \cdot 0,543 + 0,84 \cdot 0,456} = 0,185, \quad (37)$$

$$p(H_1/B)_{M2} = \frac{0,368 \cdot 0,653}{0,368 \cdot 0,653 + 0,632 \cdot 0,354} = 0,517. \quad (38)$$

For the determination of induction motors M1 and M2 fault probabilities $p(H_1/D)$ are simulated 100 regimes of test scheme with using the probabilistic statistical approach. Value of voltage in the bundle №1 (bundle of connection subsystem to EPS) is determined by random number generator (RNG) in diapason [0,95; 1,05] according to the Gauss distribution law. Set of the elements, which failure will lead to the accidents in EPS subsystem, includes:

- circuit breakers B1...B50;
- lines L1...L15;
- transformers T1, T2, T3.

Element, which failure the first at the time interval $\Delta t = 3$ months is determined by RNG with the account of its technical condition.

In the case of these elements failure, the next scenarios of accident development are possible:

- static stability loss of M1, M2;
- dynamic stability loss of M1, M2;
- M1, M2 switching off from grid.

At each regime of test scheme the simulation of steady state and transient condition are made for the induction motors M1, M2 static and dynamic stability appreciation. Simulation results are presented in the Tab.9.

Tab.9. Simulation results

№	Voltage in bundle №1 p.u.	Failure element	Accident with M1 or M2
1	1,02	-	nothing
2	1	L15	M2 dynamic stability loss
3	0,99	L14	M1 dynamic stability loss
4	1,01	-	nothing
5	1,03	B32	nothing
6	1,02	-	nothing
7	1,02	-	nothing
8	0,97	B6	nothing
9	1	-	nothing
10	1,01	-	nothing
11	1,03	-	nothing
12	1,02	L12	nothing
13	1,05	-	nothing
14	0,98	L9	M1 dynamic stability loss
15	1,02	T1	nothing
16	1,01	-	nothing
17	1,04	-	nothing
18	1,02	-	nothing
...
100	1,06	-	nothing

In result of simulation are obtained 7 regimes with induction motor M1 fault and 8 regimes with induction motor M2 fault. So, the probabilities $p(H_1/D)$ at the time interval $\Delta t = 3$ months make up:

$$p(H_1/D)_{M1} = \frac{7}{100} = 0,07; \quad (39)$$

$$p(H_1/D)_{M2} = \frac{8}{100} = 0,08. \quad (40)$$

Probabilities of motors M1, M2 fault at the time interval $\Delta t = 3$ months with the account of them technical condition and EPS subsystem regime are defined by (12):

$$p(H_1 / B, D)_{M1} = p(H_1 / B)_{M1} + p(H_1 / D)_{M1} - p(H_1 / B)_{M1} \cdot p(H_1 / D)_{M1} = 0,185 + 0,07 - 0,185 \cdot 0,07 = 0,242$$

$$p(H_1 / B, D)_{M2} = p(H_1 / B)_{M2} + p(H_1 / D)_{M2} - p(H_1 / B)_{M2} \cdot p(H_1 / D)_{M2} = 0,517 + 0,08 - 0,517 \cdot 0,08 = 0,556$$

Damage costs in the case of motors M1 and M2 fault make up $V_{M1} = 100000$ \$ and $V_{M2} = 80000$ \$ respectively. Risk, according to (2), is equal to:

$$Z = \sum_{i=1}^2 p(H_1 / B, D)_{Mi} \cdot V_{Mi} = 0,242 \cdot 100000 + 0,556 \cdot 80000 = 68680 \text{ \$}$$

6 Conclusions

Using the risk as reliability indicator allows take into account causes and consequences of accidents in EPS subsystem that gives an opportunity to organization the effective risk-oriented management of EPS subsystem for providing its reliable operation. In article is proposed the method of the risk estimation of induction motor fault in EPS subsystem in fuzzy-information conditions. Next results are obtained:

- 1) Fuzzy-statistical method of induction motor fault probability determination with the account of its technical conditions and EPS subsystem regime is developed. This method allows appreciating the induction motor fault probability in uncertainly conditions, such as the probabilistic character of equipment fault, stochastically character of EPS regime, scenario of accident development, input information restrictions and etc.
- 2) Fuzzy model for the induction motor technical condition appreciation is developed. This model allows appreciating the technical condition of induction motor without its switching off from grid in the absence of

adequate mathematical model of induction motor condition.

- 3) The simulation at the test scheme of EPS subsystem is held. Obtained result is the technical risk of important induction motors faults in the case of accidents in EPS subsystem. This value is input information for the risk-based management of EPS subsystem.
- 4) For the obtaining the more complete estimation of the induction motors regime fault probability, it is expedient to expand the set of accident scenarios which lead to the induction motors fault. Expand of this set is possible by including the cable faults, relay protection action, motors overload and etc.
- 5) Further development of this work lies in the elaboration of methods and means of EPS subsystem risk-oriented management for the induction motors faults risk decreasing.

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