HEALTH DIAGNOSTIC FOR COMPLEX ACTING MECHANISM

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Keywords : condition based maintenance, maintenance strategy, gearbox

Abstract : The objective of maintenance is to reduce the number of unexpected breakdowns due to failures, which may be catastrophic and may occur huge loss. Many industrial companies have shifted their maintenance programs to condition-based maintenance (CBM), which, if correctly and effectively implemented, can significantly reduce the maintenance cost.CBM made a continuous health diagnostic of equipment components.

1. INTRODUCTION

The objective of maintenance is to preserve the condition of products and to fulfill their required functions throughout their life cycle.

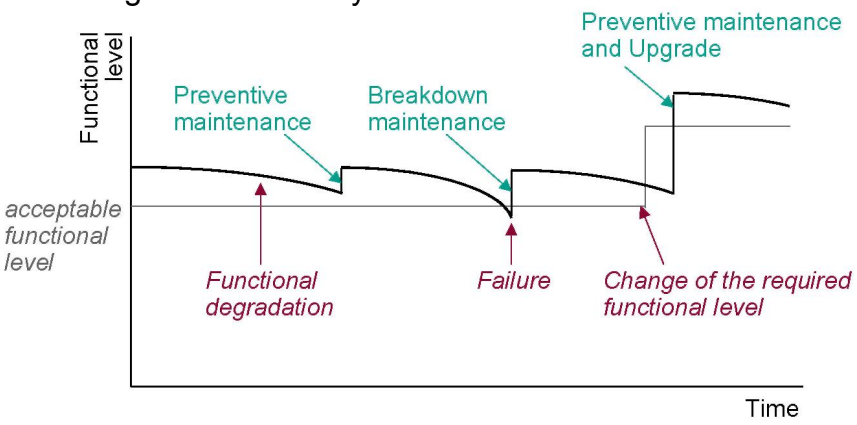

Figure 1. Maintenance activities [1]

There are two reasons why it is necessary to control the conditions of products: the change in product conditions due to deterioration, and the changing needs of customers or of society. These changes generate gaps between the required function and the realized function. Maintenance is executed to compensate these gaps by means of treatment or upgrading, as shown in figure 1. For this purpose, maintenance should involve the following activities:

1. Maintainability design;
2. Maintenance strategy planning;
3. Maintenance task control;
4. Evaluation of maintenance results;
5. Improvement of maintenance and products;
6. Dismantling planning and execution.

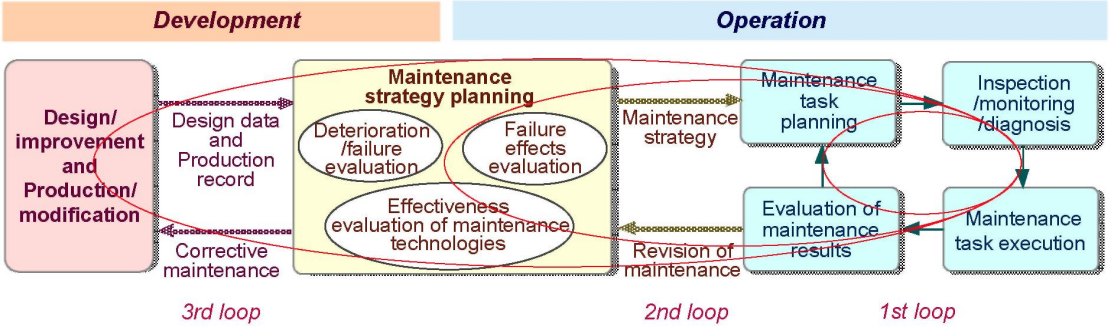

Figure 2. Framework for life cycle maintenance [2]

For fulfilling the requirements of life cycle maintenance described above, effective execution of a P-D-C-A (plan-do-check-action) cycle is essential. For this purpose, the framework for life cycle maintenance shown in figure 2 has been proposed.

2. HEALTH DIAGNOSTIC

This study concerns the maintenance diagnostic of a complex acting mechanism which acting elements tower diffusion. Tower diffusion (extraction) is equipment mainly in the output of beet sugar in it taking place diffusion sugar beet in solution technology for obtaining the sugar.

The tower diffusion actuation scheme is presented in figure 3.

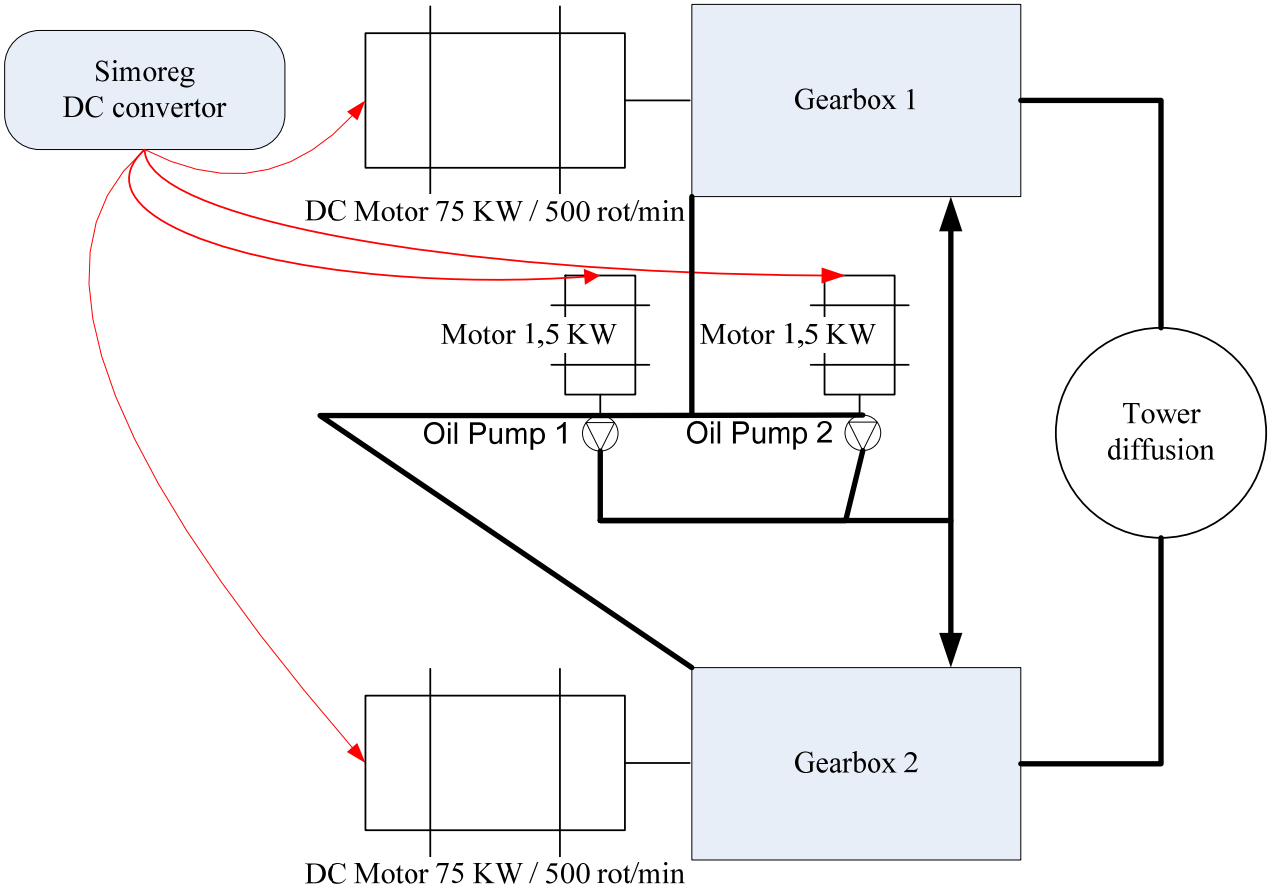

Figure 3. Equipment and acting mechanism

The main features of the diffusion equipment are diameter = 5800 mm, height = 16450 mm, capacity = 3600 to/day. The height of the ground level at which this mechanism operates is 22 m.

The equipment is driven through very big wheels (4 m diameter) by two groups of gearbox powered by a DC converter. Each gearbox (figure 4) contains the following wheels, on orders from engine they are: z_1 = 40 (V), z_2 = 226, z_3 = 37 (V), z_4 = 162, z_5 = 14, z_6 = 43, z_7 = 21, z_8 = 144, final z_9 = 21 (located outside of gearbox), z_{10} = 157 (Φ_{ext} = 4000 mm).

In figure 4 there are used the following notation: PT.1 - PT.8 - points of vibration measuring; V, O, A - the direction of measurement: V-vertically, O-horizontally, A-axial.

In figure 5 is presented the current electrical acting scheme.

DC motors are HINZ type GS 315 Mb-41 (P = 75 kw, I_{max} = 245 A, n_{max} = 500 rot/min, U = 120 - 380 V c.c.), connected in series and supplied by Siemens DC converter Simoreg type 6RA7078-6DS22-0.

Measurements of vibrations were made with mobile device Impaq produced by Benstone

Instruments Inc. USA, and thermal images with an infrared camera Flir i50 produced by Flir Systems USA.

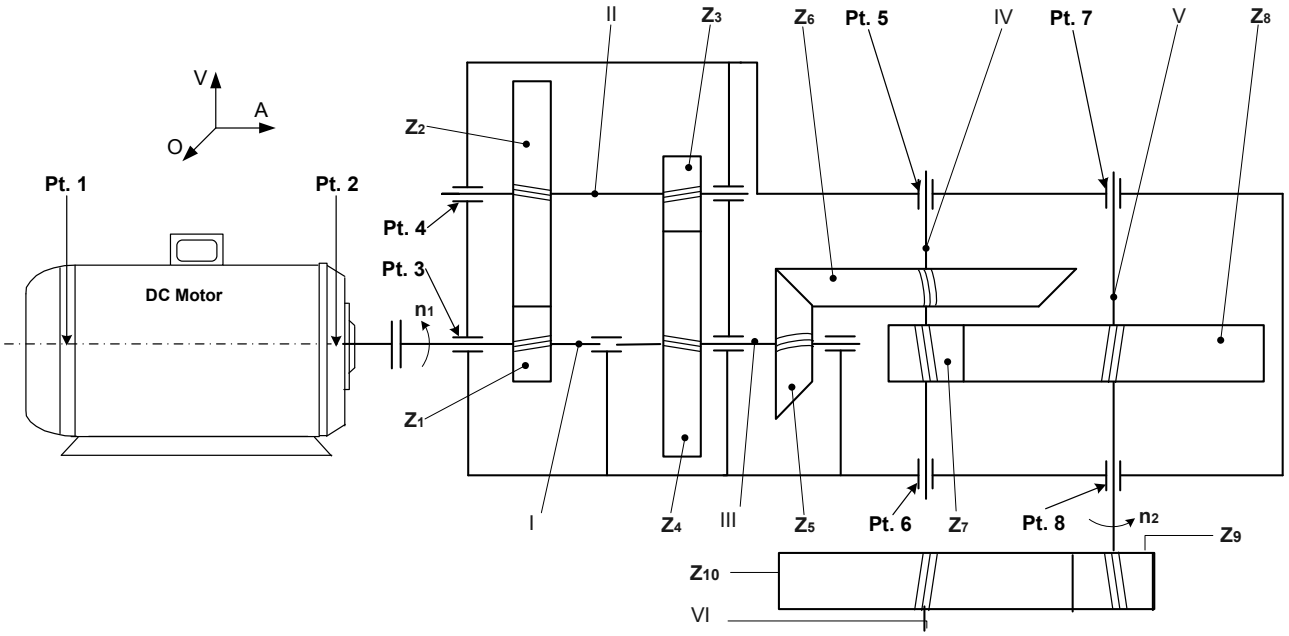

Figure 4. DC motor and the gearbox

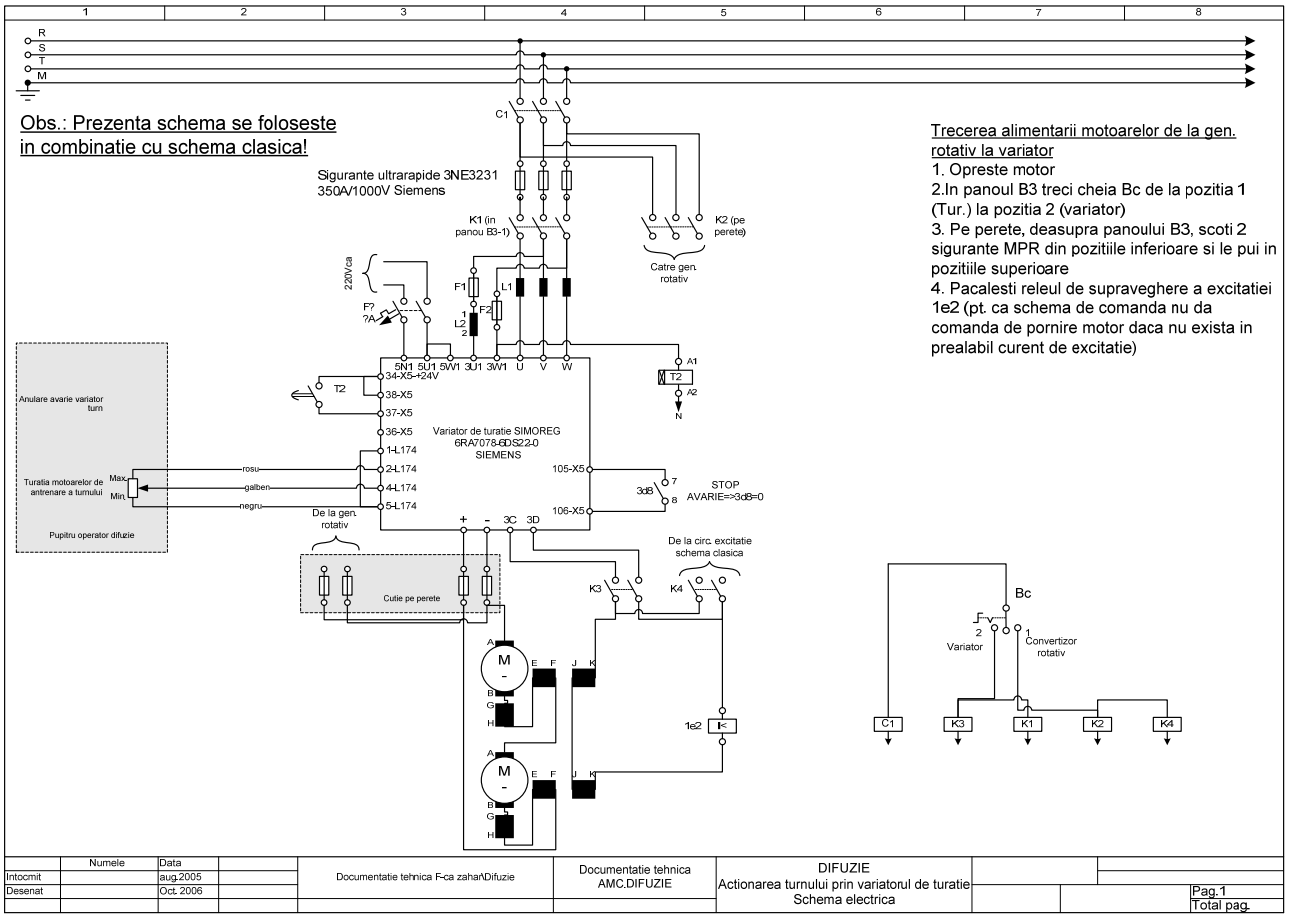

Figure 5. Current electrical scheme

After the measurements of temperature and vibration, there were prepared two measuring reports according with standard ISO 10816/3-2009, which are listed in table 1 and table 2. The result of measurements confirmed that the method of driving the tower is not the

optimum for one of the groups (who actually played the role of master), being in the minimum level of functioning.

Table 1. Bulletin to measure the overall level of vibration no. 1

<table>
<tr><td colspan="8">1. Effective values measured.
Measurements of vibrations were made with the machine loaded. The parameters of measurement are speed and movement of vibration in the field of frequency 10-1000 Hz, 2-1000 Hz.</td></tr>
<tr><td colspan="2" rowspan="3">Points of measuring</td><td colspan="6">Direction of measurement</td></tr>
<tr><td colspan="2">Vertical</td><td colspan="2">Horizontal</td><td colspan="2">Axial</td></tr>
<tr><td>[mm/s]</td><td>[µm]</td><td>mm/s]</td><td>[µm]</td><td>[mm/s]</td><td>[µm]</td></tr>
<tr><td colspan="2">Pt. 1</td><td>1</td><td>15</td><td>1,2</td><td>13</td><td>1,4</td><td>5</td></tr>
<tr><td colspan="2">Pt. 2</td><td>1,6</td><td>23</td><td>1,3</td><td>26</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Pt. 3</td><td>0,5</td><td>6</td><td>0,6</td><td>9</td><td>0,5</td><td>11</td></tr>
<tr><td colspan="2">Pt. 4</td><td>0,4</td><td>7</td><td>0,6</td><td>11</td><td>0,4</td><td>10</td></tr>
<tr><td colspan="2">Pt. 5</td><td>0,2</td><td>4</td><td>0,4</td><td>11</td><td>0,4</td><td>7</td></tr>
<tr><td colspan="2">Pt. 6</td><td>0,2</td><td>5</td><td>0,4</td><td>8</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Pt. 7</td><td>0,2</td><td>6</td><td>0,3</td><td>9</td><td>0,3</td><td>9</td></tr>
<tr><td colspan="2">Pt. 8</td><td>0,3</td><td>9</td><td>0,3</td><td>9</td><td>0,2</td><td>6</td></tr>
<tr><td colspan="8">2. Grade operating under ISO 10816/3-2009</td></tr>
<tr><td colspan="2">Machine type</td><td colspan="3">Average machine 15<P<300 [kW]</td><td colspan="3">Average machine 15<P<300 [kW]</td></tr>
<tr><td colspan="2">Foundation</td><td colspan="3">Rigid</td><td colspan="3">Rigid</td></tr>
<tr><td colspan="2">Measurement Unit</td><td colspan="3">[mm/s]</td><td colspan="3">[µm]</td></tr>
<tr><td rowspan="4">Grade operating</td><td>Good</td><td colspan="3"><1.4</td><td colspan="3"><22</td></tr>
<tr><td>Utilizable</td><td colspan="3">1.4 – 2.8</td><td colspan="3">22-45</td></tr>
<tr><td>Placed under surveillance</td><td colspan="3">2.8 – 4.5</td><td colspan="3">45-71</td></tr>
<tr><td>Forbidden</td><td colspan="3">>4.5</td><td colspan="3">>71</td></tr>
<tr><td colspan="8">3. The technical state of the equipment</td></tr>
<tr><td>Machine type</td><td>P [kW]</td><td>n [rpm]</td><td colspan="2">U [V]</td><td colspan="3">Grade operating</td></tr>
<tr><td>Acting mechanism</td><td>75</td><td>400</td><td colspan="2">380</td><td colspan="3">Good</td></tr>
<tr><td colspan="8">4. Diagnosis of vibration</td></tr>
<tr><td colspan="8">Grade functioning of the group is: usable. Operation of bearings is good.</td></tr>
</table>

Radial deviation is not allowed to exceed 0.11 mm, and the angular deviation is not to allow to exceed 0.13 under recommendations of Hamer USA and Pruftechnik Germany.
In figure 6 are presented for comparison, the spectrum at the point 5 from both groups.
The main problems are as follows:

- stopping machinery lead to big financial losses,
- equipment is not at today technology,
- maintenance operations do not improve the operation in long term,
- it is not possible to cut the maintenance costs.

The only possibility is to upgrade the mechanism with new technology.
The economic solution, shown in figure 7, it is the of one more Siemens Simoreg DC converter to ensure the synchronization of the two engines in regime master slave.
The ideal solution is replacement of DC motors and converter with AC motors and AC converter. This solution – the best for long term – is presented in figure 8.

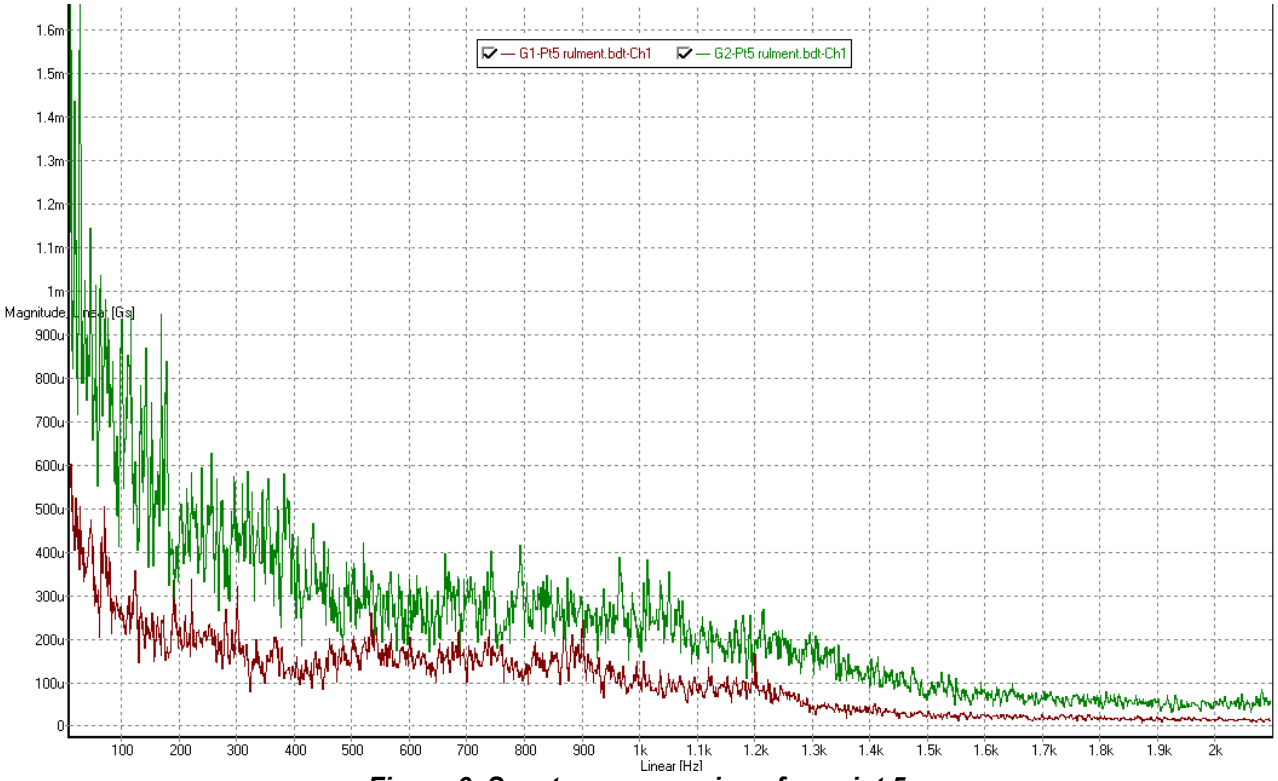

Figure 6. Spectrum comparison for point 5

Table 2. Bulletin to measure the overall level of vibration no. 2

1. Effective values measured. Measurements of vibrations were made with the machine loaded. The parameters of measurement are speed and movement of vibration in the field of frequency 10-1000 Hz, 2-1000 Hz.							
Points of measuring		Direction of measurement					
		Vertical		Horizontal		Axial	
		mm/s	µm	mm/s]	µm	mm/s	[µm]
Pt. 1		3.2	48	0.9	15	1.4	5
Pt. 2		1.6	27	1.8	40	2.1	33
Pt. 3		0.5	9	0.6	13	0.7	12
Pt. 4		0.5	12	0.6	10	0.6	12
Pt. 5		0.3	6	0.5	11	0.4	13
Pt. 6		0.3	8	0.4	6	-	-
Pt. 7		0.2	4	0.4	8	0.3	12
Pt. 8		0.4	6	0.3	8	0.4	6
2. Grade operating under ISO 10816/3-2009							
Machine type		Average machine 15<P<300 [kW]				Average machine 15<P<300 [kW]	
Foundation		Rigid				Rigid	
Measurement Unit		[mm/s]				[µm]	
Grade operating	Good	<1.4				<22	
	Utilizable	1.4 – 2.8				22-45	
	Placed under surveillance	2.8 – 4.5				45-71	
	forbidden	>4.5				>71	
3. The technical state of the equipment							
Machine type	P [kW]	n [rpm]		U [V]		Grade operating	
Acting mechanism	75	400		380		Good	
4. Diagnosis of vibration							
Grade functioning of the group is: admitted under supervision. Operation of bearings is good.							

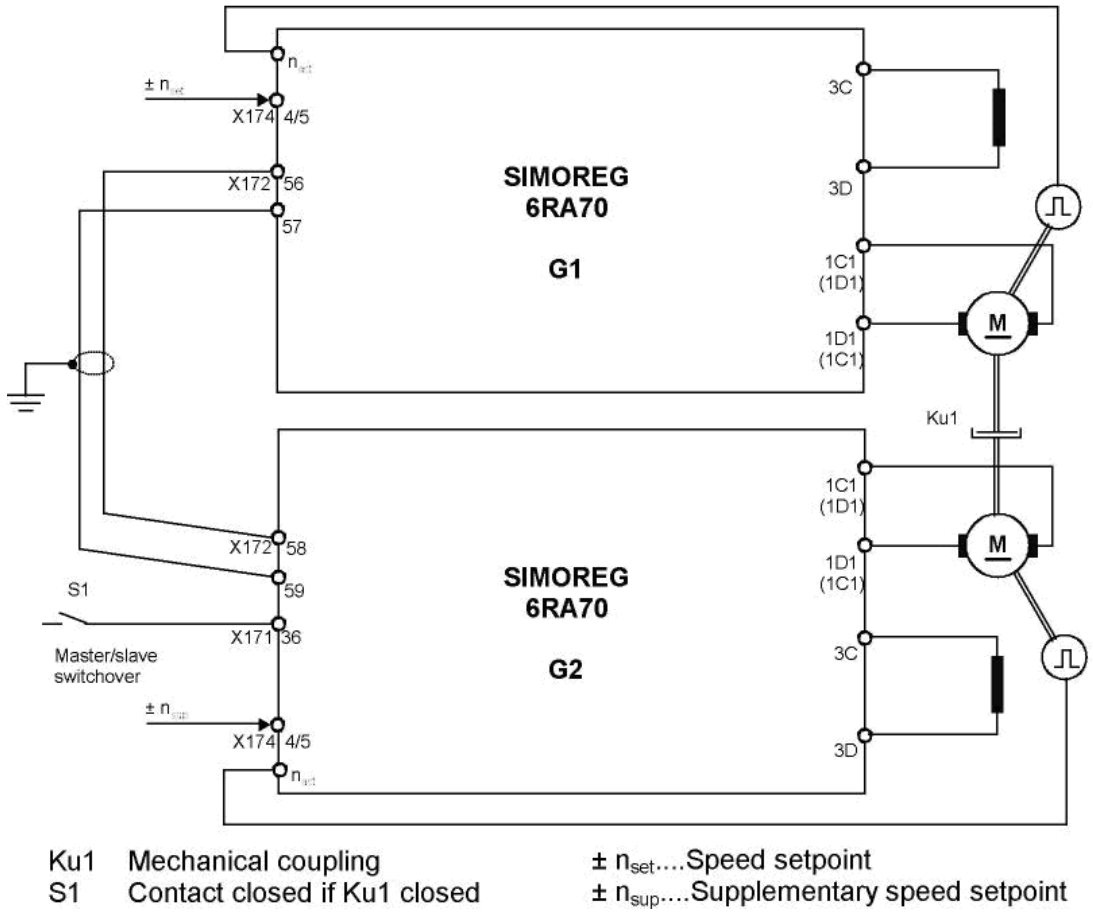

Figure 7. Recommended electrical scheme for economic solution [11]

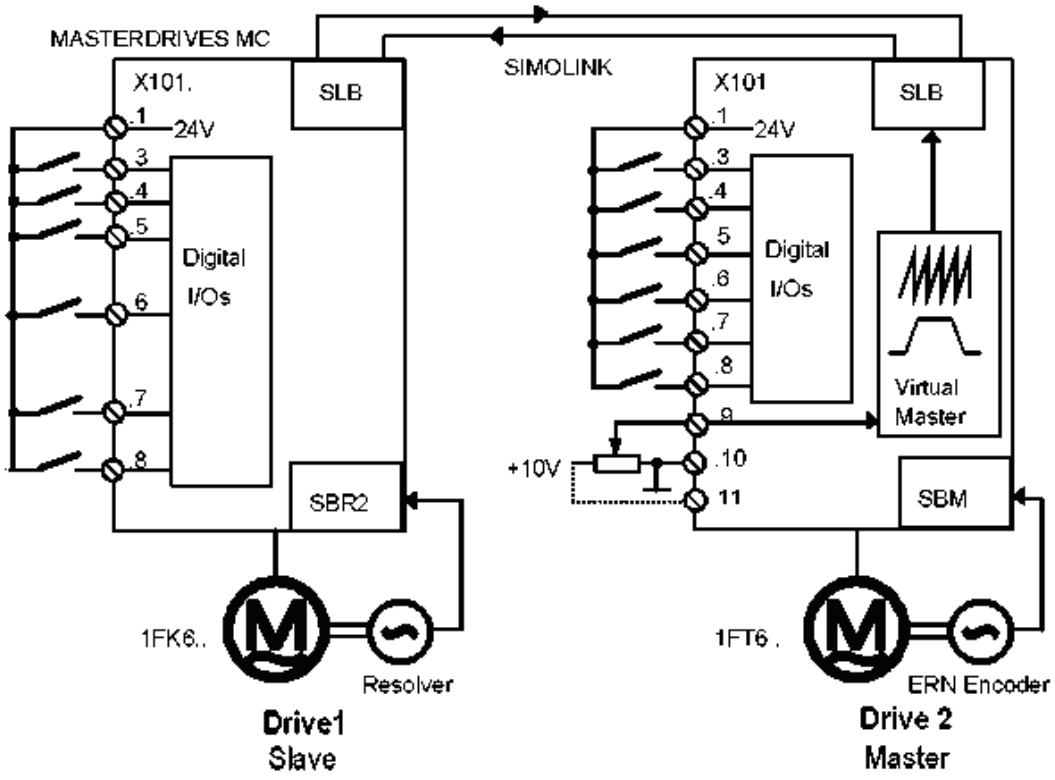

Figure 8. Recommended electrical scheme for long term [12]

3. CONCLUSIONS

Health diagnostic of equipments is a complicate task, where ISO 10816/3-2009 standard is the main support for the right decision in diagnostic.
Because investments in new machines are pretty small in Romania, it is a major consideration in the operations of maintenance to upgrading machinery and equipment.
An investment that is recommended, are pays off in two years of operation, leading to reduction the costs and risks of accidental failure.

REFERENCES

1. Donca G., Mihăilă I., Ganea M., Hirţe D., Nica M., *Maintenance role in life cycle management*, în Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XVI, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 2158-2163, 2007
2. Donca G., Mihăilă I., Ganea M., Hirţe D., Nica M., *Aspecte ale mentenanţei bazate pe stare*, în Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XV, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 973-978, 2006
3. Donca G., Mihăilă I. M., *Aspects of maintenance strategy selection process*, în Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XVIII, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 1654-1659, 2009
4. Ganea M., I. Mihăilă, G. Donca, D. Hirţe, M. Nica, *Cu privire la soluţiile mecanismelor de avans paralele pentru curse lungi şi viteze mari la roboţii monorail*, în Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XV, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 895-898, 2006
5. Ganea O., Horge I., Ganea M., Mihăila I., *About the feed mechanism for rotary movements as cnc axes at machine tools*, Inter-Ing 2007, Editura Universităţii ,,Petru Maior" Tîrgu Mureş, 2007
6. Hirţe D., Mihăilă I., Ganea M., Donca G., M. Nica, *Mecanisme de avans paralel implementate în sisteme flexibile de fabricaţie,* în Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XV, ISSN 1583 – 0691, pp. 889-894, 2006
7. Hirţe D., Ganea M., Donca G., Nica M., *Problematica constructivă a mecanismelor de avans paralelele pentru curse lungi şi viteze mari la roboţi monorail*, în Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XV, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 895-898, 2006
8. Hirţe D., Ganea M., Donca G., Nica M.,, *Specifyc methods for synchronize the parallel feed mechanisms*, Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XVI, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 1326-1331, 2007
9. Hirţe D., Ganea M., Donca G., Nica M., *The classification of paralel feed mechanisms at monorail robots weight velocity and long tacks,* Analele Universităţii din Oradea, Fascicola Management şi Inginerie Tehnologică, volumul XVI, Editura Universităţii din Oradea, ISSN 1583 – 0691, pp. 1320-1325, 2007
10. Takata S., Kimura F., Van Houten F.J.A.M., Westkamper E., Shpitalni M., Ceglarek D., Lee J., *Maintenance: Changing Role in Life Cycle Management*, Annals of the CIRP, Vol. 53/2, pp. 643-655, 2004
11. http://www.automation.siemens.com/ld/dc-stromrichter/html_76/dc-master/dc-master.html
12. http://www.automation.siemens.com/mcms/mc/de/umrichter/niederspannungsumrichter/ simovert-masterdrives/Seiten/frequenzumrichter-simovert-masterdrives.aspx