DISTURBANCES CAUSED BY ELECTRICAL DOMESTIC EQUIPMENTS WITH UNIVERSAL FRACTIONAL HORSEPOWER MOTORS

Prof. Eng. **Sorin ENACHE** PhD[1], Prof. Eng. **Aurel CAMPEANU** PhD[1],
Prof. Eng. **Ion VLAD** PhD[1], Lecturer Eng. **Monica-Adela ENACHE** PhD[1].

[1]University of Craiova, Electrical Engineering Faculty, Craiova, Romania.

REZUMAT. In aceasta lucrare se analizeaza perturbatiile produse de micromotoarele universale utilizate in constructia echipamentelor electrocasnice. In acest scop se prezinta particularitatile de functionare ale acestora in curent alternativ, cu accent pe fenomenul de comutatie si masurile de imbunatatire a acesteia. Lucrarea prezinta o serie de incercari experimentale efectuate cu un motor universal pentru o rasnita de cafea, alimentat direct de la retea sau prin intermediul unor filtre special proiectate pentru imbunatatire compatibilitatii electromagnetice.

Cuvinte cheie: perturbatii, micromotoare universale, filtre, masurarea curentului

ABSTRACT. This paper analyzes the disturbances caused by universal fractional horsepower motors used in electrical domestic equipments construction. In this purpose there are presented their features for alternating current operation; the accent is laid on the commutation phenomenon and on the methods necessary for improving it. The paper presents many experimental tests performed with a universal fractional- horsepower motor for a coffee mill; the motor is directly supplied or by means of some filters especially designed for improving the electromagnetic compatibility.

Keywords: disturbances, universal fractional-horsepower motors, filters, current measuring

1. INTRODUCTION

Many electrical domestic equipments use ***universal fractional-horsepower commutator motors*** (coffee mills, vacuum cleaners, hair dryers, mixers etc.). As a consequence, it is suitable to analyze their electromagnetic compatibility, mainly owing to the great number of them [3], [4], [5] etc.

Universal fractional-horsepower motors (UFHM) utilization has got many advantages:

- very high speed can be obtained with their help (up to 20000 r.p.m or even 40000 r.p.m);
- they operates on both direct current and single-phase alternating current supply;
- the speed can be easily adjusted by varying the supply voltage or by introducing some supplementary resistances in one of the two windings circuit.

From constructive point of view, the universal fractional-horsepower commutator motors are very alike with the series-wound direct current motors.

The constructive differences occurring in comparison with series-wound direct current motors consist in:

- both the stator magnetic circuit and the rotor magnetic circuit are made of electrotechnical steel laminations;
- the number of turns supplied on d.c. is bigger than that of the turns supplied on a.c. (fig. 1).

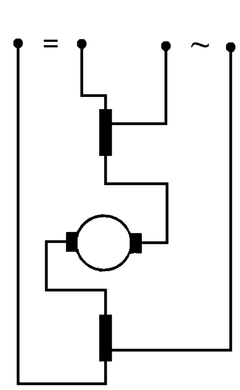

Fig. 1. Connection circuit of a universal fractional-horsepower commutator motor.

The first of the previous features is given by the necessity to decrease the iron losses that might occur because both the stator and the rotor operate in variable fields.

The second constructive feature comes from the aim to draw near the mechanical characteristics obtained on d.c. supply and the ones obtained on a.c. supply, by modifying the number of turns.

Moreover, the excitation winding is usually divided up in two half-windings, from one side and another of the armature, aiming at decreasing the radio interferences caused by the motor.

2. A.C. OPERATION FEATURES

When connected to a d.c. supply, the universal fractional-horsepower commutator motors operates in the same way as series-wound d.c. commutator motors.

However, their a.c. operation involves some features detailed below.

1) The electromagnetic torque is positive, in the most part of the time. There are intervals when it becomes negative and the rotor slows down. However, the motor operation is not affected by the instability of the motor torque, owing to the important inertia moment of the rotating parts and to the high oscillation frequency of the torque.

2) Another functional feature of the universal fractional-horsepower commutator motors regards the armature raction phenomenon in alternating current. In this case, because of $\underline{U}_{eaq}$, the power factor decreases ($\cos\varphi < \cos\varphi'$).

In order to remove this drawback, a compensation winding might be added in series with the other two windings. This winding will produce a magnetic field that will induce an e.m.f. in the rotor winding; this e.m.f. is equal and opposite to $\underline{U}_{eaq}$.

3) The third feature of the c.a. operation regards the commutation, that is worse than in d.c., because there is a supplementary non-balanced static e.m.f., dependent on the current frequency. This way, some radio interferences occur and it is imposed to use some supplementary filters.

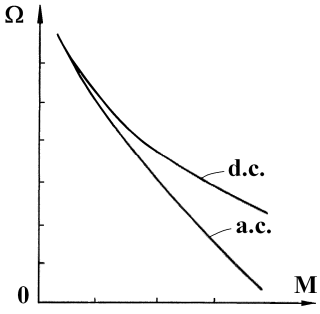

Fig. 2. Comparative mechanical characteristics of a universal fractional-horsepower commutator motor.

4) The last feature of the a.c. operation is given by the mechanical characteristics shape (fig. 2).

Thus, the characteristics obtained in this case are placed under the characteristics obtained when the motor is connected to a d.c. supply. This distortion is caused by the influences of the two windings inductivities.

As a consequence, if the same rated speed is wanted in a.c. as in d.c., the excitation winding number of turns is decreased by means of some intermediary coil taps (fig. 1). This decrease causes a decrese of the inductor flux and, this way, the speed increases.

3. UNIVERSAL FRACTIONAL-HORSEPOWER COMMUTATOR MOTORS AS DISTURBANCES SOURCES

This paper reffers to the ***commutation phenomenon*** (fig. 3) that transforms the universal fractional-horsepower motors in possible disturbances sources.

Thus, during the commutation, some fast current variations occur in the windings and in the connection conductors.

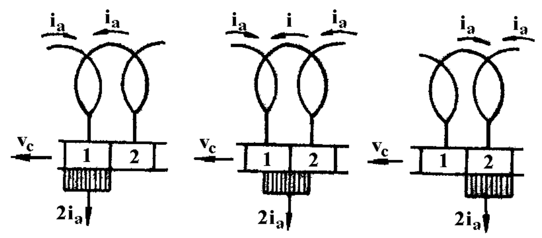

Fig. 3. Explications regarding the commutation of a universal fractional-horsepower commutator motor: i– commutation current, i_a– current in the current path, V_c- commutator speed.

If the current is not null at the separation between the brushes and the commutator segments, it will be kept by an electric arc, similar to all the contacts opening on load.

A fast current variation di(t)/dt occurs when the electric arc is interrupted. This induces some self-induction voltages in the inductivities L placed on the current path and mutual induction voltages Mdi/dt - in the adjacent current paths.

The local limitation of the disturbances is possible by connecting some concentrated inductivities (in series with the supply conductors) and a by-pass capacitor (in parallel with the brushes).

In case of the universal fractional-horsepower commutator motors rated at higher powers, auxiliary poles and compensation winding are necessary; they induce some e.m.f. in the commutating windings and these e.m.f. are opposite to the existing ones; this way, they improve the commutation.

Other methods are also available for improving the commutation [1]:
- brushshifting from the transversal axes;
- decreasing the number of turns per section;
- choosing some adequate brushes.

4. IMPROVING THE ELECTROMAGNETIC COMPATIBILITY

Some specialized circuits, called filters, might be used for improving the electromagnetic compatibility.

As known [7], the filters damp the disturbances, without influencing the useful signal.

This requirement might be fulfil by:
- adequately choosing the cutting frequencies;
- adequately choosing the transfer functions slopes.

The filters operate by the following principle: their passive components together with the sources and receivers impedances form voltage dividers; the division ratio, dependent on frequency, is the *real attenuation of the filter*. This ratio might be increased though in case of high frequency, the internal impedance of the disturbances source does not enable an efficient voltage division by connecting some series inductivities.

The basic components of the filters are the longitudinal impedances - for the work current and the transversal impedances - for the operation voltage, both of them having a preponderent reactiv character.

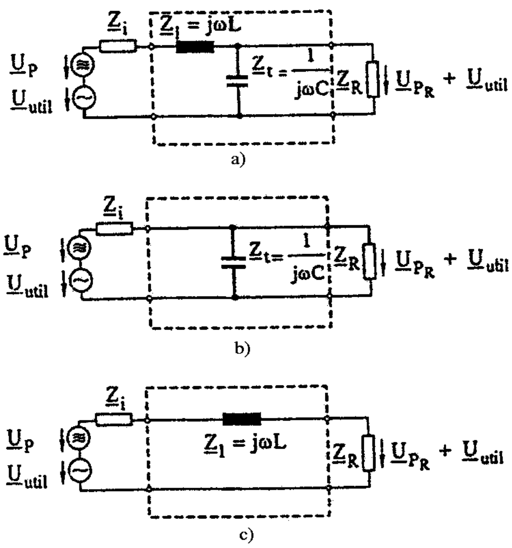

Fig. 4. a) LC filter; b) filter with transversal impedance; c) filter with longitudinal impedance [7].

The following notations have been used in the previous figure:

$\underline{U}_p$ - disturbing voltage;

$\underline{U}_{util}$ - source voltage (useful signal);

$\underline{Z}_i$ - source internal impedance;

$\underline{Z}_R$ - receiver impedance;

$\underline{U}_{pR}$ - disturbances voltage (level) at receiver;

$\underline{Z}_t$ - transversal impedance;

$\underline{Z}_l$ - longitudinal impedance.

If the source useful signal attenuation is neglected the *disturbances attenuations* are obtained for three situations [7]:

$$\alpha_F = 20\lg\frac{\left|\underline{U}_p(\omega)\right|}{\left|\underline{U}_{pR}(\omega)\right|} = 20\lg\frac{\left|\underline{Z}_i + \underline{Z}_l + \frac{\underline{Z}_R\underline{Z}_t}{\underline{Z}_R + \underline{Z}_t}\right|}{\left|\frac{\underline{Z}_R\underline{Z}_t}{\underline{Z}_R + \underline{Z}_t}\right|} \quad (1)$$

$$\alpha_F = 20\lg\frac{\left|\underline{U}_p(\omega)\right|}{\left|\underline{U}_{pR}(\omega)\right|} = 20\lg\frac{\left|\underline{Z}_i + \frac{\underline{Z}_R\underline{Z}_t}{\underline{Z}_R + \underline{Z}_t}\right|}{\left|\frac{\underline{Z}_R\underline{Z}_t}{\underline{Z}_R + \underline{Z}_t}\right|} \quad (2)$$

$$\alpha_F = 20\lg\frac{\left|\underline{U}_p(\omega)\right|}{\left|\underline{U}_{pR}(\omega)\right|} = 20\lg\frac{\left|\underline{Z}_i + \underline{Z}_l + \underline{Z}_R\right|}{\left|\underline{Z}_R\right|} \quad (3)$$

As noticed, the attenuation of the filter (of the disturbances) depends on frequency.

5. CIRCUITS

The following circuits have been used to study the disturbances caused by universal fractional-horsepower motors, with and without filters.

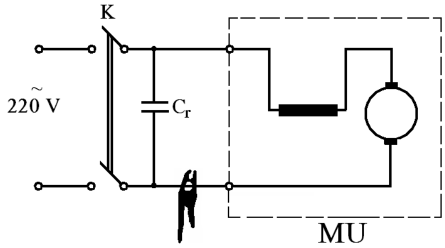

Fig. 5. Circuit with filter.

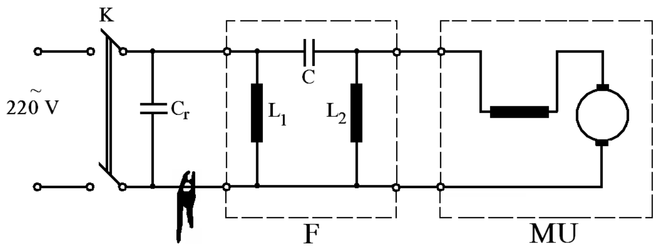

Fig. 6. Circuit with “ Π ” filter.

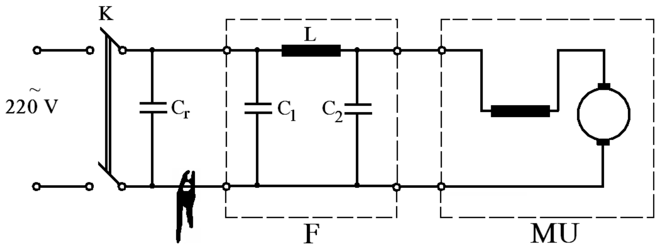

Fig. 7. Circuit with “T” filter.

The following notations have been used in the the previous figures:

F – filter;

MU – universal fractional-horsepower commutator motor.

As noticed, two types of filters have been used - “ Π ” type and “T” type.

The capacitor C_r provides a path of low impedance for the disturbances coming from the supply network. This way, the current test probe of the measuring device is only crossed by the distorted current caused by the universal fractional-horsepower commutator motor [2], [6].

The measurements have been performed by a harmonics analyzer, Fluke 41B [8].

In order to follow the system operation there has been used a specialized program; its interface is depicted in the following figure [9].

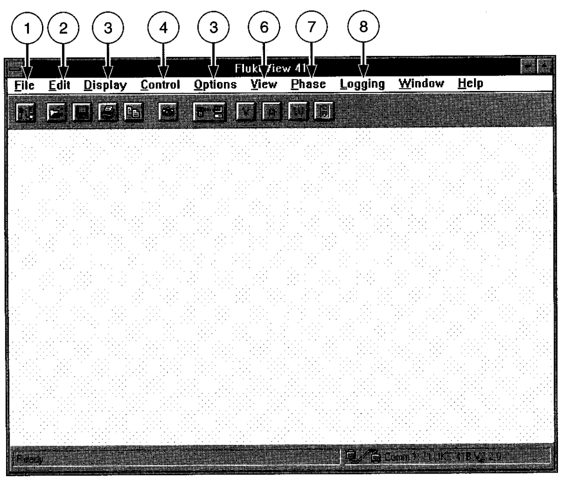

Fig. 8. Work menu.

The main options of this menu carry out the functions filled in the following table.

Table 1

No.	Option	Desccription
1.	File	Open, save and print files.
2.	Edit	Copy data in clipboard.
3.	Display	Display data, catch characteristics.
4.	Control	Form and test communication, fix tester.
5.	Options	Change type, labelling and scaling options.
6.	View	View data in Volt, Ampere or Watt.
7.	Phase	Select way for reading data at multi-meter.
8.	Logging	Log data for multi-meter Fluke 41B.

6. EXPERIMENTAL RESULTS

The following experimental results have been obtained by performing experimental tests with a motor for a coffee mill (figs. 9, 10 and 11).

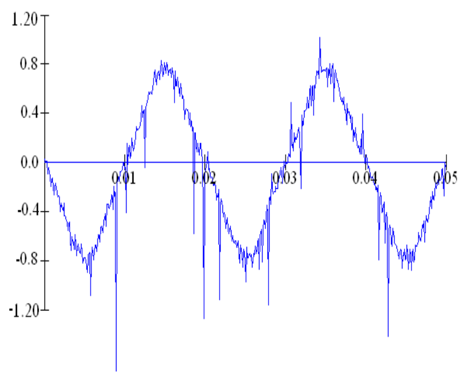

Fig. 9. Dependence $i = f(t)$ witout filter in the supply circuit.

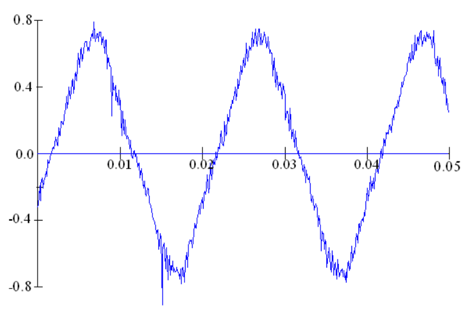

Fig. 10. Characteristic $i = f(t)$ when „ Π ” filter is used.

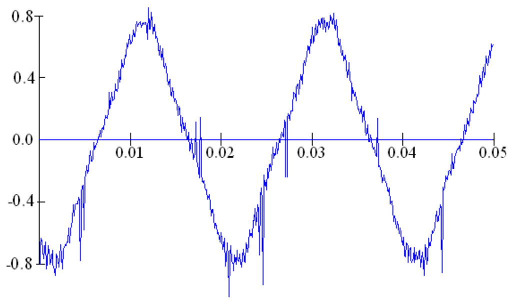

Fig. 11. Dependence $i = f(t)$ when „T" filter is used.

7. CONCLUSIONS

1. As noticed in figure 9, the distubances caused by commutation are important. When the motor is directly supplied, the content of the superior harmonics reaches 27 %.

2. As noticed in figures 10 and 11, the filters lead to a decrease of the superior harmonics in the current curve.

3. The most favourable operation is obtained for the case when a „Π" filter is used. In this case, the distorting residuum has got a value of 11 %.

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About the authors

Prof. Eng. **Sorin ENACHE,** PhD.
University of Craiova, Electrical Engineering Faculty, Craiova, Romania
email:senache@em.ucv.ro

Sorin Enache was born in Filiasi, Romania, in 1966. He received the Engineering degree and the Ph.D. degree in Electrical Engineering from the University of Craiova, Romania, in 1990 and 2001, respectively.
At present he is a Professor in the Electrical Engineering Faculty, University of Craiova; he was the Dean of the Faculty of Electromechanical, Environmental and Industrial Informatics (2008-2012). He authored over 130 papers and 12 books.
His current research interests include electrical machines and power quality. He is a Member of IEEE and AGIR.

Prof. Eng. **Aurel CAMPEANU,** PhD.
University of Craiova, Electrical Engineering Faculty, Craiova, Romania
email:acampeanu@em.ucv.ro

Aurel Campeanu – received the Dipl. Eng. degree in Electrical Engineering from the Polytechnic Institute of Bucharest in 1958 and Ph. D. degree from Polytechnic Institute of Timisoara in 1969. From 1958 to 1963 he worked at the Electric Research Laboratory of Electroputere Craiova. From 1962 to 1972 he was an assistant professor at the Polytechnic Institute of Timisoara. He has been a full professor at University of Craiova since 1972. He authored over 160 papers and 17 books. Fields of interest are theory, design and dynamical processes of electrical machines. In 1992 he received the Award of Romanian Academy. He is member of the Academy of Technical Sciences of Romania and also member of IEC.

Prof. Eng. **Ion VLAD,** PhD.
University of Craiova, Electrical Engineering Faculty, Craiova, Romania
email:ivlad@em.ucv.ro

Ion Vlad was born in Calinesti, Romania, in 1953. He received the Engineering degree and the Ph.D. degree in Electrical Engineering from the University of Craiova, Romania, in 1977 and 1995, respectively. At present he is a Professor in the Department of Electromechanical, Environmental and Industrial Informatics, University of Craiova; he was the Head of the Department of Electrical Machines and Environmental Engineering. His current research interests include design and test of electrical machines. He is a Member of the IEEE and AGIR.

Prof. Eng. **Monica-Adela ENACHE,** PhD.
University of Craiova, Electrical Engineering Faculty, Craiova, Romania
email:menache@em.ucv.ro

Monica-Adela Enache was born in Craiova, Romania, in 1971. She received the Engineering degree and the Ph.D. degree in Electrical Engineering from the University of Craiova, Romania, in 1995 and 2010, respectively. She has been a Lecturer in the Department of Electromechanical, Environmental and Industrial Informatics, University of Craiova, since 2007. Her main areas of research interest are reluctance machines, permanent magnet synchronous machines and renewable energies. She is a Member of SRAIT.