NEW SOLUTIONS IN THE FIELD OF TRANSFORMERS CONTINUOUSLY ADJUSTING THE IN-LOAD VOLTAGE

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REZUMAT. În domeniul transformatoarelor destinate reglării continue a tensiunii sub sarcină o importanţă deosebită o reprezinta respectarea normelor în vigoare în ceea ce priveşte menţinerea frecvenţei şi tensiunii constante la consumator. Lucrarea de faţă prezintă două soluţii noi de transformatoare pentru reglarea continuă a tensiunii în sarcină caracterizate în primul rând prin simplitate constructivă şi siguranţă în exploatare.

Cuvinte cheie: fiabilitate, înfăşurare secundară rotitoare, sistem de actionare integrat, transformator.

ABSTRACT. În the field of transformers for continuously adjusting the in-load voltage a special importance it is respecting the existing rules regarding maintenance at consumers of the frequency and the voltage in constant parameters. The present paper presents two new solutions of transformers continuously adjusting the in-load voltage characterized primarily by simplicity and fiability.

Keywords: transformer, rotating secondary winding, integrated drive system fiability.

1. INTRODUCTION

The methods of voltage control are studied and continuously improved in order to be used in various applications such as for example in distribution networks or supply to some consumers that require fine adjustment voltage. Currently, the most common method of voltage adjustment is control with transformers with continuously adjusting the in-load voltage.

Power supply of industrial equipment or of the test installations for electric equipments is realized with the following methods: the excitation control for a synchronous generator and the adjust the turns ratio of a transformer.

Practically, in electrical systems is realized adjustment in steps of turn's ratio through switching devices in load of taps transformers.

The devices which combine the characteristics of devices with sliding current collector and characteristics of devices with relative displacement of windings are named by specialized literature the mixed devices. Although have the advantage of a very fine and precise adjustment of tension, they are described in a lesser extent in the literature.

2. CURRENT STATE OF SOLUTIONS IN THE FIELD OF TRANSFORMERS CONTINUOUSLY ADJUSTING THE IN-LOAD VOLTAGE

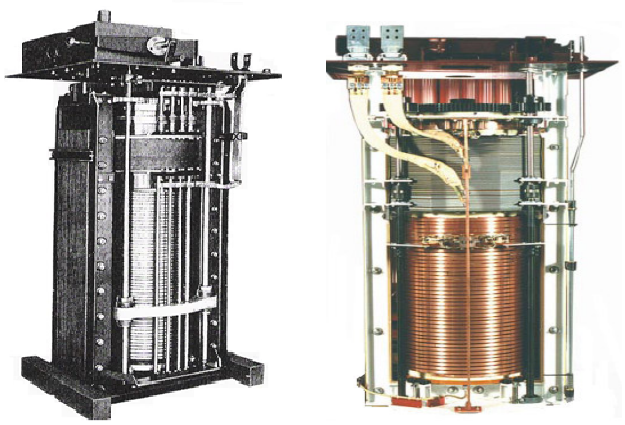
In specialized literature it is known a transformer that is part of the mixed devices and it is named regulator of type Thoma which is in fact a transformer with rotating secondary winding. The Thoma regulator is a high power single phase regulation system which is typically used for high AC dielectric test systems or as a power supply for transformer test fields or any application where a high power resistive load has to be regulated. The Thoma regulator is characterized by it rotating secondary winding and its robust oil insulated construction. The quasi step-less regulation and continuous duty rating make this regulation ideally suited for the most demanding applications. The ability of the Thoma to accept medium voltage input eliminates the need for intermediate step-down transformers.

The Thoma regulator is a two winding transformer with a gapped core. The secondary winding rotates around the primary windings, the pitch of the windings allows a sliding brush to raise and lower.

Secondary winding operation is synchronized with the operation of sliding brush so that it remains

permanently in contact with the conductor surface of the rotary secondary winding.

Variants of Thoma regulators with rotating secondary winding are made and marketed by the Haefely Test AG Company (fig.1a) [178, 200] and Phenix Technologies Company (fig.1.b) [198].



a b

Fig. 1. Regulator of type Thoma [3, 4, 5]
a) the model produced by Haefely Test AG company;
b) the model produced by Phenix Technologies company

The disadvantage of these solutions is the large number of components of the drive system of rotating secondary winding, which complicates the construction of the transformer as a whole.

3. NEW SOLUTIONS IN THE FIELD OF TRANSFORMERS CONTINUOUSLY ADJUSTING THE IN-LOAD VOLTAGE

The first solution realized by the authors relates to a transformer continuously adjusting the in-load voltage, provided with a rotary secondary winding and an integrated driving system.

The transformer consists of an "in-shell" type magnetic system (1) provided with an upper circular front yoke (1") having a cut-out (d_1) in its center to allow a cylindrical column (1') to pass there through, on said column there being concentrically located a fixed primary winding (2) and a rotary secondary winding (3), between the cylindrical column (1') and the upper front yoke (1") there being established an air gap (d_2) which is penetrated by a conductive bridge (3") connecting the upper extremity of the secondary winding (3) and a cylindrical "cup" like rotor (7) mounted in the extension of an electrically insulating cylinder (3') of the secondary winding (3); the latter being driven by means of a stator (8) of an asynchronous three-phase motor secured to the upper front yoke (1").

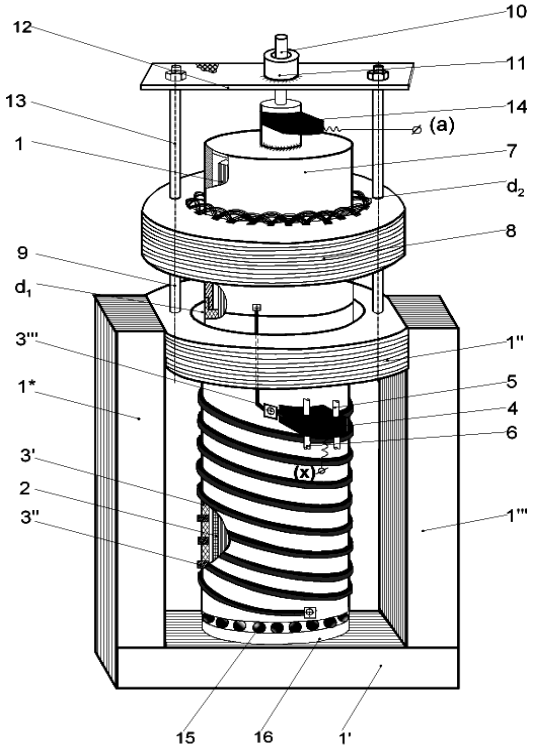


Fig. 2 Transformer continuously adjusting the in-load voltage with rotating secondary winding and integrated drive system - first variant [1]

1-"in-shell" type magnetic system; 1'- cylindrical column; 1''- upper circular front yoke; 1'''- lateral yokes; 2- fixed primary winding; 3- rotating secondary winding; 3'- electrically insulating cylinder; 3''- conductive bridge; 4- sliding brush; 5, 6 - guides; *d* - cut-out; d_1, d_2 - air gap ; 7- cylindrical "cup" like rotor; 8-stator of induction motor; 9,13 - spacers, 10-axis; 11-bearing, 12 - support, 13-spaced, 14- fixed brush; 15-insulating rolls, 16-channel circular

The cylindrical rotor rotates under the action of the rotating magnetic field produced by the stator of induction motor and in this way drives in the rotation movement the secondary winding of the transformer. The conductive bridge of the secondary winding involve in rotation movement and the sliding current collector PG As a result, between fixed brush and sliding brush obtain a continuous variation of the secondary voltage.

In another variant design, the authors have developed a transformer continuously adjusting the in-load voltage with rotating secondary winding and integrated drive system where the secondary winding is driven by a rotating stator which is consists of several single-drive modules, each with three pairs of poles apparent.

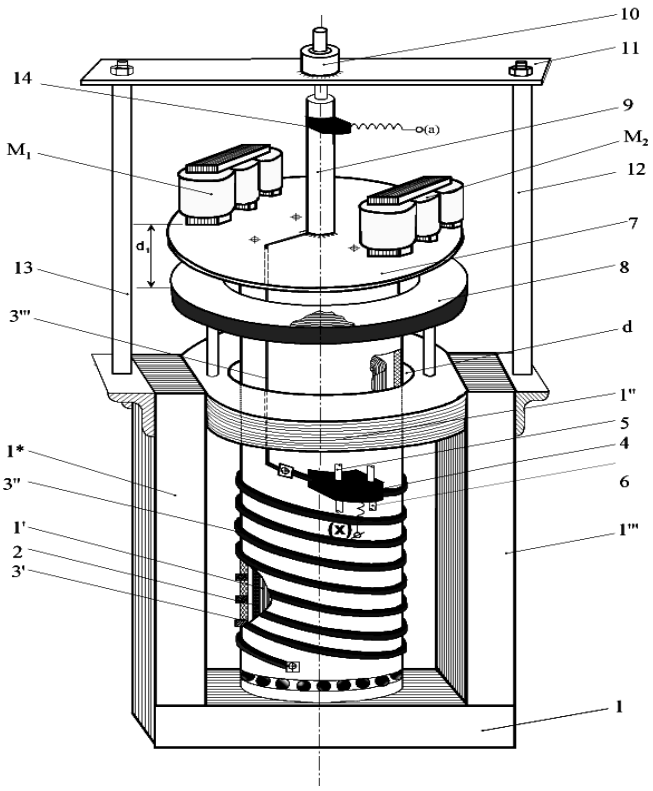


Fig. 3 Transformer continuously adjusting the in-load voltage with rotating secondary winding and integrated drive system - second variant [2]

1-"in-shell" type magnetic system; 1'- cylindrical column; 1''- upper circular front yoke; 1'''- lateral yokes; 2- fixed primary winding; 3- rotating secondary winding; 3'- electrically insulating cylinder; 3''- conductive bridge; 4- sliding brush; 5, 6 - guides; *d* - cut-out;7- rotor disk; 8-intermediate yoke; d_1- air gap, 9,- conductive axis, 10- bearing, 11- support plates, 13-spaced, 14- brush;

Rotating secondary winding drive and its electrically insulating cylinder is achieved through integrated drive system, which is consists of a rotor disk by aluminum or copper (7) attached to the upper end of the electrically insulating cylinder (3 ') which is integral with rotating secondary winding (3), thus constituting a common unit which rotates the secondary winding, under the action of magnetic field, in the air gap progressively (d1) established between intermediate yoke (8) and the stator with four inductive modules. Finally, is realized the movement of the sliding brush (4) on the two guides (5) and (6) variation of secondary voltage, respectively.

The inductive modules placed on the stator integrated in the construction transformer are located after the circular contour on the rotor disc (7) and they are formed each of one "E" type magnetic core with three identical columns and an intermediate yoke from non-ferromagnetic material (8).

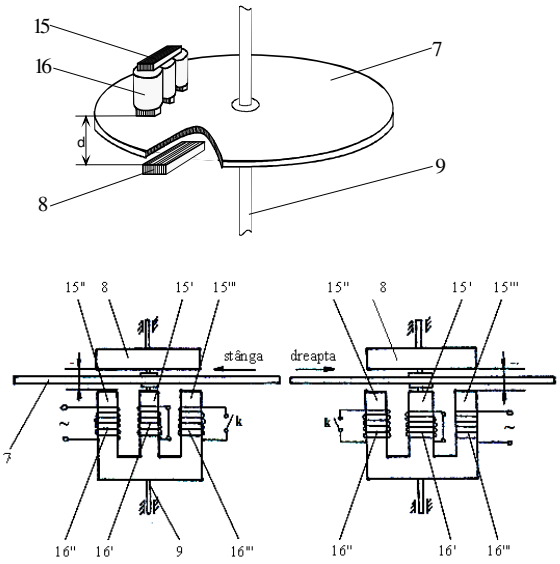


Fig. 4. Explicative at operation process of the inductive modules used in the drive system of the transformer
7 – rotor disk; d– air gap; 8 - intermediate yoke; 9 –conductive axis; 15 – magnetic system;15′- central column; 15″, 15‴- extreme columns; 16′- shielding winding, 16″- supply winding; 16‴- auxiliary short-circuited shielding winding

Three coils of winding (16) are placed on the column of magnetic system: a coil (16′) on the central column, permanently connected in short-circuit and representing the main shielding winding, and two identical coils (16″and 16‴) placed on the extreme columns of magnetic system representing the supply winding and the auxiliary short-circuited shielding winding, respectively, if the case may be, by means of a short-circuiting breaker,

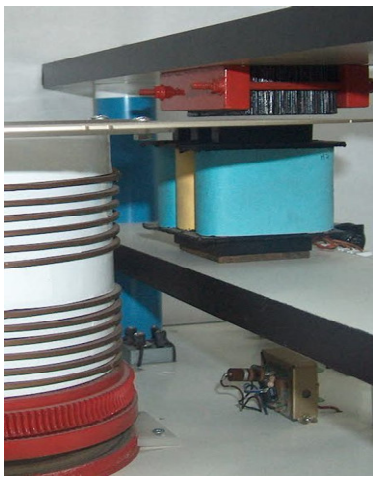


Fig. 5 Experimental model for second variant of transformer realized by authors

The transformer through the two extreme coils (18 and 19) has the possibility to reversing the rotation direction of the rotor disk (7), secondary winding respectively, by inverting the positions of the two extreme coils.

5. CONCLUSIONS

Industrial installations sensitive to voltage variations and laboratory installations there is required to maintain constant the voltage as a condition expressly required by the rules, are areas of concern which justifies the development of sources, medium and even large power, able to allow fine adjustment stepped or continuous in-load of voltage. For such sources is also require other conditions: be statics, to adapt without difficulties at control systems and automatic voltage stabilization, do not produce distortions from of sinusoidal shape variation while of voltage supplied, to have a reliability high, etc.

Some of the conditions listed above are satisfied with some precision by the autotransformers and the transformers with adjustment in steps of turns ratio. If requires continuous an continuous adjustment in load of voltage must adopt a construction involving a sliding contact on spiral route of the secondary winding and a mobile connection (conductor bridge) crossing the magnetic circuit, "last turn" linked an continuously variable number of field lines magnetic.

Besides the novelty and inventive activity the solutions proposed by authors have the following advantages:

- simplify the drive systems for rotating the secondary winding of the transformer;
- incorporate the drive systems in the transformer construction
- increasing operational safety transformer adjustable;
- requires no separate power source for drive system of the rotating secondary winding

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