PM EXCITED POLYPHASE SYNCHRONOUS MACHINES WITH SINGLE-PHASE SEGMENTS FEATURING SIMPLE TOOTH COILS

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The paper deals with a family of PM excited electrical machines characterized by simple tooth coils. By arranging the common elementary structure, comprising just one pair of slots, in appropriate groups it is possible to build poly-phase machines open to standard VVVF inverters and control units. It can be conceived of single-sided as well as double-sided machines (**Figs. 1, 2**).

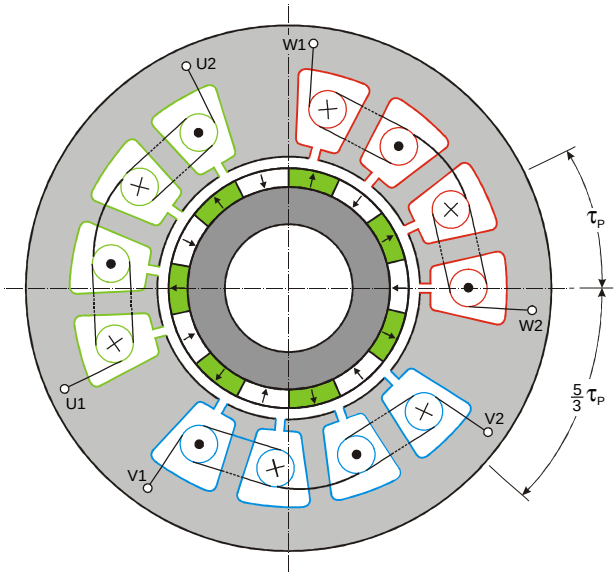

Fig. 1: Single-sided segmented three-phase machine

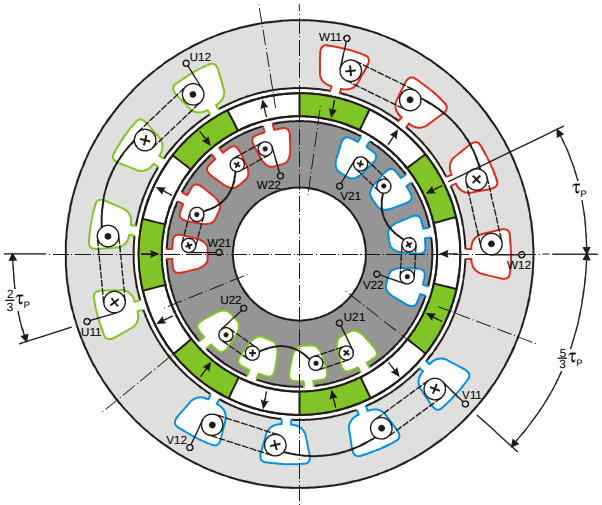

Fig. 2: Double-sided segmented three-phase machine

For the classification, the number of phases m, the number of pairs of slots per segment k, and the repetition factor r are relevant. In **Figs. 1, 2** we have $m = 3$, $k = 2$, $r = 1$. Certain periodicity conditions require the distance between the segments to be either

$$d = \tau\left(1+\frac{2}{m}\right) \qquad \text{or} \qquad d = \tau\left(1+\frac{1}{m}\right) \quad , \tag{1}$$

depending on the intended winding interconnection, while the appropriate number of pairs of PM poles is

$$p_{pm} = r\,(mk+1) \quad \text{or} \quad p_{pm} = r\left(mk+\frac{1}{2}\right) \quad . \tag{2}$$

For the investigation and a reliable prediction of the machine behaviour, first a two-dimensional analytical model in polar coordinates has been developed and discussed in the paper. It is based on the vector potential method and a wave approach. The investigations were then extended and supplemented by detailed FE calculations to include iron saturation and cogging torque effects.

As an example, a machine intended for high torque servo motor applications has been studied. The geometry may be visualized by means of a field plot obtained from the FE calculation (**Fig. 3**). The situation refers to the right hand side formula of (1) and (2) and is for $m = 3$, $k = 2$, $r = 2$.

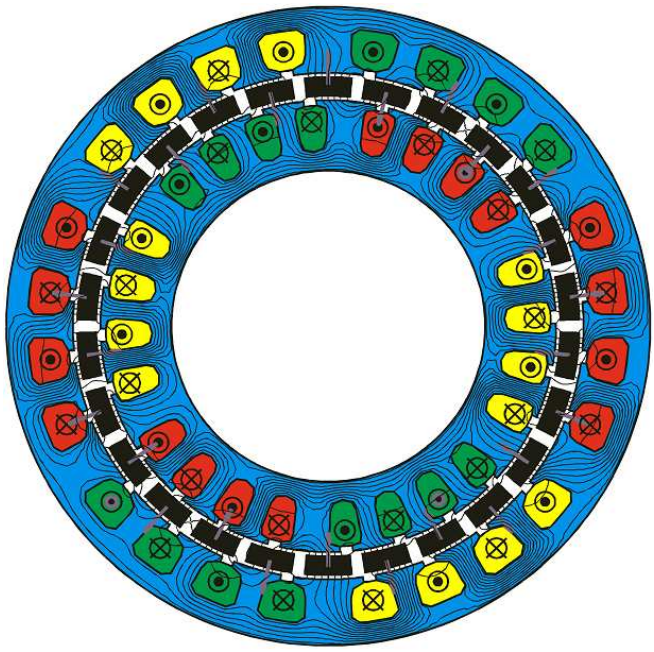

Fig. 3: Field plot of exemplary high torque machine

The concept of permanent magnet excited synchronous machines based on simple tooth coils represents a versatile means to design high torque polyphase machines with high overload capability, excellent dynamic performance, and small moment of inertia.