Comparison and Inspection of Harmonic Effects in PMSM and Induction Motors

Seyed Zeinolabedin Moussavi, Aliakbar Rahmani

*Abstract— **Regarding to different kinds of load, domestic electrical appliances, increasing application of further electrical equipment's which leads to consumption of electric energy, destructive electromagnetic sources EMI added. Recognizing this source and it's side effects on performance of electronic and electrical equipment that could be in form of conductive, inductive and radiated is outstanding. An ideal electric machine is a system that electric energy is applied in pure sinusoid waveform flow has no loss in the heat form. However in practice, elements and equipment's with nonlinear characteristic, specially power electronic equipment's and storage elements of energy could arise higher frequency harmonics causing losses in the form of heat. Numerous electrical motors used in industrial manufacturing companies cause notably heat losses especially then induction motors. The fact that complexity of interconnection between stator and rotor can consider as source of higher harmonics and energy losses, attention is paying from induction motors into Permanent Magnet Synchronous Motors (PMSM). The paper, make a comparison between PMSM and widely used induction motors from the view point of higher frequency harmonics and shows the advantage of PMSM in this regards.***

Keywords: Torque Control, Induction Motors, Energy Consumption, Harmonic Sources, Permanent Magnet Synchronous Motors (PMSM), Ripple.

I. INTRODUCTION

In this paper, we are going to planning(coding) and simulating one permanent magnetic synchronous motor, and comparing these two motors with each other, permanent magnet synchronous motor is equipped with one exciting coil and one or several damping coil, and ever rotor coil has it's specific- electric feature. In addition to, rotor of outstanding polarity synchronous machine is asymmetrical and because of this asymmetrically of motor ,changing variables in rotor variables isn't useful.in most cases ,stator variables are transferred to reference set in rotor ,however it is possible that stator variables be shown in reference set, that is suitable for some computerized simulations.[1] In many cases, best and most efficient method for improving system is changing the system, I mean system change would result in system behavior, sometimes it is possible that this process wouldn't be changeable, or it's behavior couldn't be acceptable, in these cases adding compensatory network wouldn't be useful.

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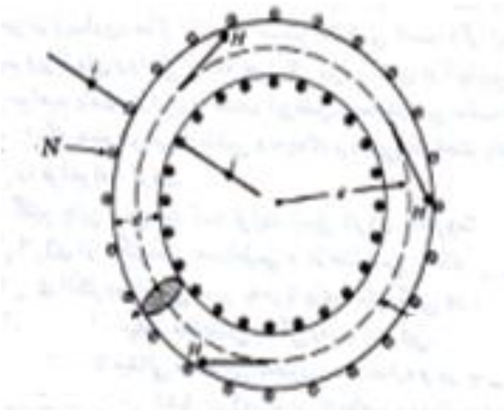
II. DYNAMIC ANALSISOF MOTORS

For knowing that alternative current flow motors has dynamic, we should consider coil in figure (1),that flow (i) is current in that ,in this case, intensity of magnetic field would be current inside core because of magnetic reluctance of iron core is minimum, and by considering figure (1),(1-1) relation would be resulted, that this kind of flux outside of magnetic core could be neglected ,that this kind of flux is leakage flux. We can define leakage magnetic eruption that block its route through air, is called leakage flux.

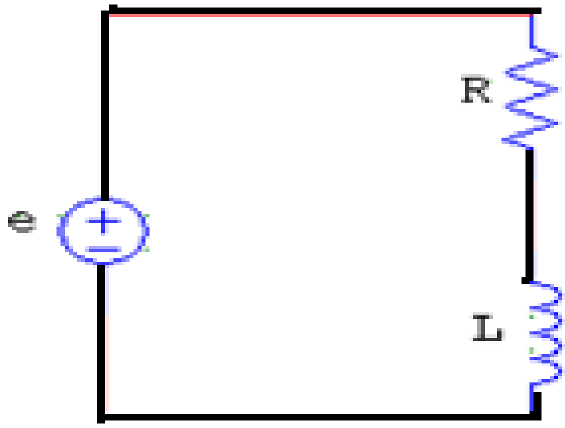


Fig(1):coil tassel

$$\oint H.dl = Ni$$

$$H(2\pi r)=Ni \longrightarrow H=\frac{N.i}{2\pi r} \quad (1\text{-}1)$$

When current flow (i) changes in coil , flux would change so and according to Faraday's Law, electromotive force would induce in coil, that is basic law for transformer performance. In designing of rotating electric machines specially permanent magnetic electric motor, this phenomena results in making inductive voltage in armature, which making deviant neutral axis and increasing sparkle between brushes and commutators ,that some methods should be considered for eliminating it. Value of this electric power could be attained from (2-1) relation.



Fig(2):circuit electric

$$e=\frac{d\lambda}{dt} \qquad (2\text{-}1)$$

$$e=R.i+P\lambda \qquad (3\text{-}1)$$

Equivalent magnetic circuit of figure (1) can be considered as figure (2), and relation (3-1) could be attained from figure (2), that this relation is applicable for modeling of electrical machines. Regarding to circuit of figure (2) that constitute serious RL circuit, we can recognize dynamic model of all machines and fixed period . These parameters are main factors for considering synchronous and asynchronous motors as components of dynamic loads.[2-3] permanent magnetic Synchronous motors have high efficiency because of rotor structure thus with deletion of motivator coil ,copper wasting reduce, that resulted in efficiency increase and also make more resistance and less maintenance, and it's high price is main problem for using this kind of motor. In addition to this matter, permanent magnetic motor has main problem in relation to line frequency, it is braking torque. in recent years, for electric economizing in industrial motors, motors with high efficiency are considered. permanent magnetic motors in small sizes, has more applications. in figure (3), rotor for one permanent magnetic motor is shown, that magnet is located inside of that, that squirrel cage is used for that.[4-5-6-7]

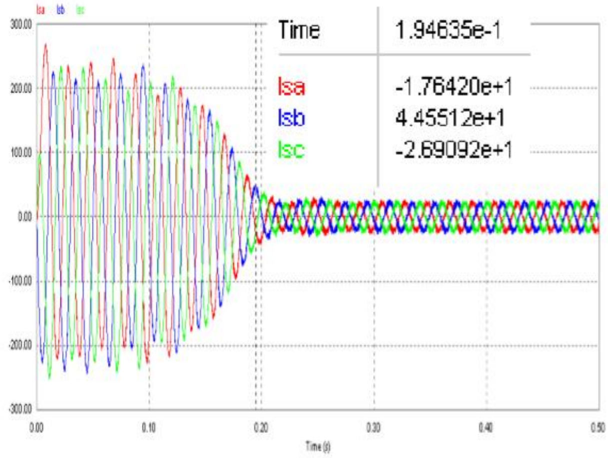
Fig(3):rotor of the permanent magnetic motor

In permanent magnetic Synchronous motor, for dc source deletion, one permanent magnet is used. main part of produced torque in this motor is interactional kind that is produced by effect of rotating field of stator and produced field of permanent magnet in rotor. Progress of technical knowledge in making permanent magnets with high energy density was main reason for using this material in direct current machine, and synchronous. because of difficulty of magnetic ability feature using permanent magnets are dangerous.[8-9-10]

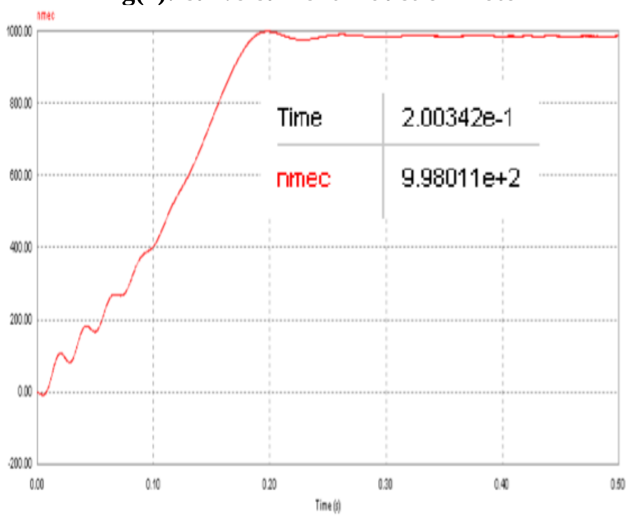
III. SIMULATION OF SYNCHRONOUS MOTOR WITH INVERTER VOLTAGE(VSI)

In this step, for simulating inductive motor, one motor with below specifications should be selected in order to obtain behavior of this motor with using inverter circuits and modeling pulse width I shape of open loop, and obtaining this ability with comparing output features. We can explain, first, which method better estimate optimal purposes of control ,second, which motor better estimate predictions for future.
R_s=0.294Ω , L_s=1.39mH , R_r=0.156Ω , L_r=0.00074H , 2P=6 , T_L=40N.M, F=50HZ

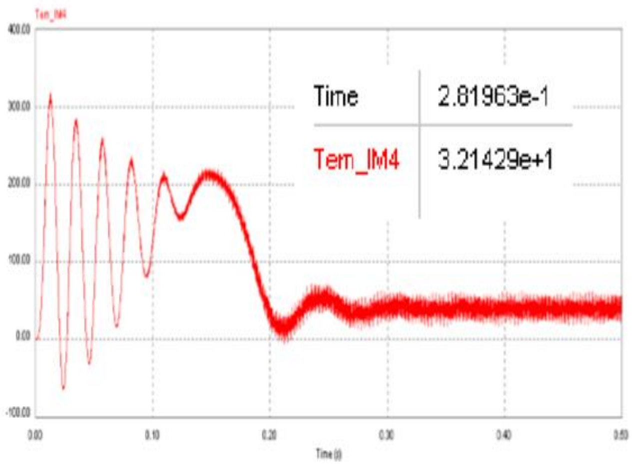
In stimulating of inductive motor with above suppose, curve of current to motor, motor speed, torque, harmonic spectrum of motor, are indicated in (4),(5),(6),(7),and results are inspected with Synchronous motor.



Fig(4): curve current induction motor



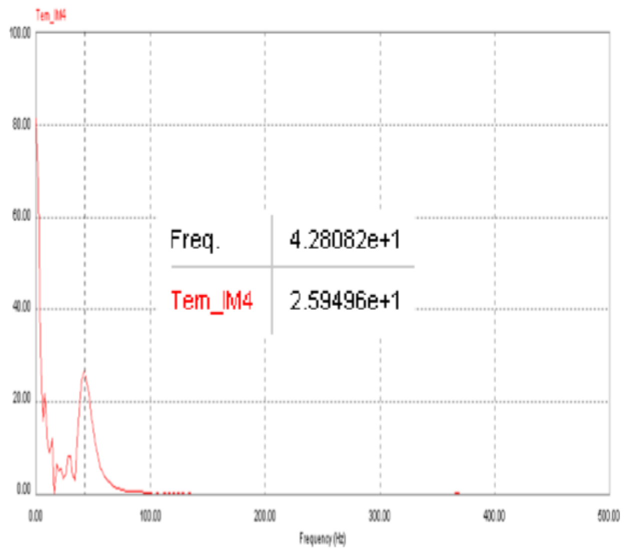
Fig(5):curve speed induction motor



Fig(6):curve torque induction motor

According to figure (6),it is evident that moment fluctuations in moment of load in inductive motor is very high and reason for this matter is complexity of stator coils and rotor and fixed periods in transient modes and magnetic flux with each other. As shown in figure (6), torque would attain final value of 32NM with passing approximate period of 282 ms.

After torque curve of inductive motor, we pointed out harmonic behavior of this motor. Figure (7), is indicating load moment. For reducing harmonic effects with high frequency that is obtained in switching of IGBT with control PWM filters can be used.



Fig(7): curve harmonic induction motor

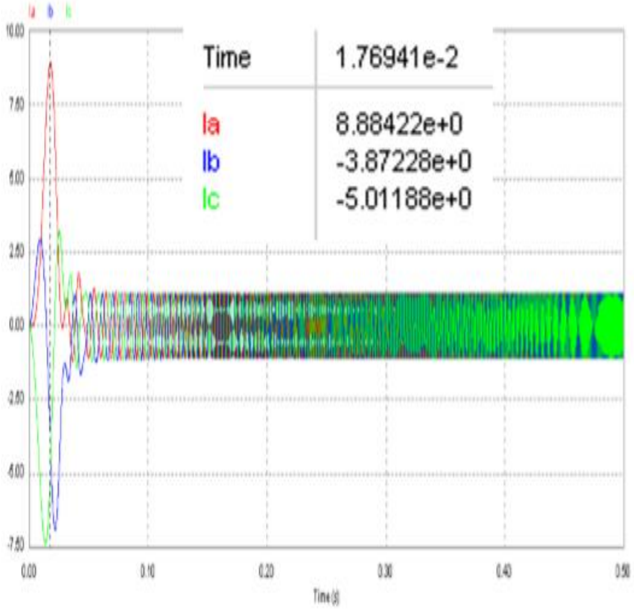
According to figure(7),it is indicated that most harmony in inductive motor is caused near to major frequency and this phenomenon making some bad effects that including :additional wasting ,making more heath in motors. Interference with control system of sinuosity and smart relay ,mechanical fluctuations in motors ,inconsistent performance offering circuit for switching , destructing of capacitor bank , because of insulation break or increase more than reactive capacity. These factors are important for using permanent magnetic synchronous and DC motors without sweeper in order to decreasing these destrutive effects on transformation and distribution line and decreasing voltage drop in transformation line .

IV. SIMULATION OF SYNCHRONOUS PERMANENT MAGNETIC MOTOR

In this phase, we pointed out simulation of permanent magnetic motor, thus a motor with following specifications is selected in order to attain behavior of this motor by using inverter circuits and modulation of pulse width in open loop. We attain ability for recognizing that which motor showing desirable behavior in front of transitive fluctuations, we do this by comparing output specifications of motor and making destructive harmonic.

R_s=4Ω , L_d=0.5H , L_q=0.03H, 2P=6 , T=40N.m, F=50HZ

In simulating of Permanent Magnet Synchronous Motor with above mentioned specifications, motor characteristic, speed of motor, torque harmonic spectrum of moment of motor are indicated in figures (8),(9),(10),(11) respectively and results are assessed in inductive motor in order to most suitable one be selected for reducing wasting aspect.



Fig(8): curve current Synchronous motor

As it is obvious from (4) and (8) ,performing current to Synchronous permanent magnetic motor in less time IS in proportion to performing current of induction motor, would be in fixed value.

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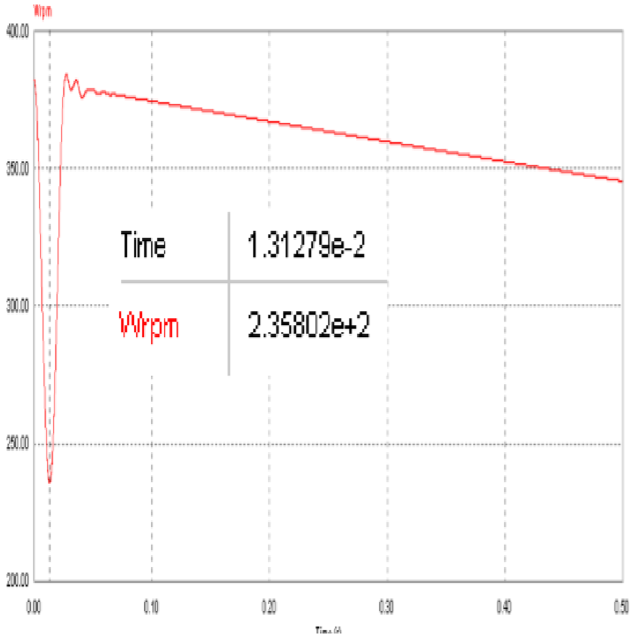
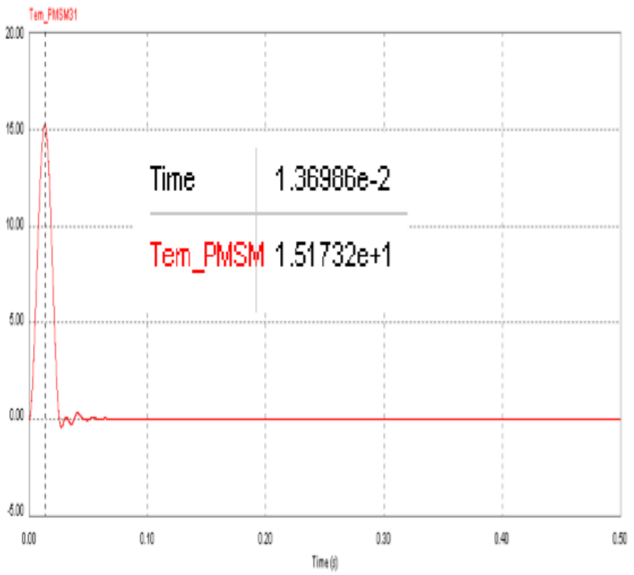
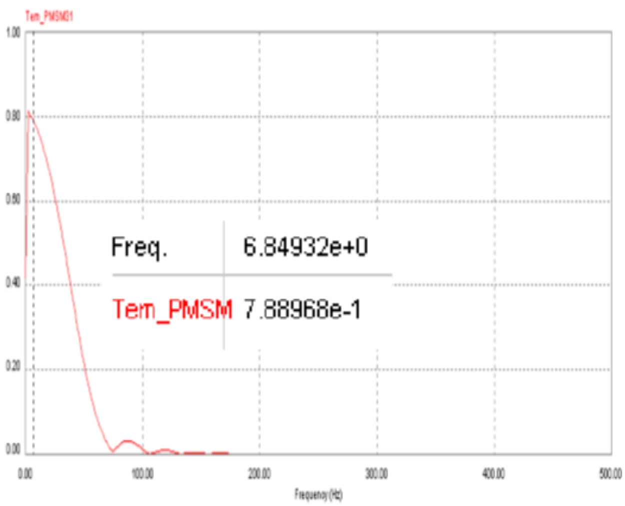


Fig(9): curve speed Synchronous motor



Fig(10): curve torque Synchronous motor



Fig(11): curve harmonic Synchronous motor

By comparing two figure (7) and (11) ,it is obvious that harmony in permanent magnetic motor in proportion of inductive motor is little .wasting resulted from temperature that has bad effects on insulation of motor coil, wires and cables thus this reduction in synchronous permanent magnetic motor is very low.

V. CONCLUSION

In this paper, two inductive motor and synchronous permanent magnetic are investigated in respect of harmonic spectrum, and we can analyze which motor is most suitable in relation to load type. Today with various type of load, we should use energy transformers that has minimum wasting and fluctuation and maximum durable performance thus with performed simulation about these two motors, it is obvious that using permanent magnet in rotor section would result in reduction of moment fluctuations and harmonics. this one reduces motivating current reduction that this benefit would resulted in reduction of efficient life time in proportion to inductive motor.

FUTURE WORKS

In future paper, we are going to compare suggestive 4 axial-model that it resulted in 3-axial,2-axial and 1-axial model with 2-axial model. we are going to inspect results of these two models with each other so.

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