Design And Performance Analysis Of Permanent Magnet DC Motor

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Abstract

Permanent magnet dc motors are very much popular in modern world because of the fact that it is free from consuming electrical energy in exciting the magnetic field within the motor and there by contributing towards the conservation of conventional energy sources which are alarmingly decrease day by day by using less Electrical energy. Using of permanent magnet in the electrical machine leads to burning of less conventional fossil fuel and there by contribute indirectly in preventing environmental air pollution. With permanent magnet dc motor, the efficiency of the machines also rise up considerably. This paper is an effort to give a computer aided design algorithm of permanent magnet dc motor.

Keywords: permanent magnet, dc motor, performance, efficiency

1.Introduction:

The electrical energy conversion device containing permanent magnet as exciter can be termed as permanent magnet machine. (PM Machine). In earlier days, low energy density prevented the designer to go for permanent magnet electrical machine. With advent of Alnico (Aluminium,nickel and cobalt alloy)PM dc motor with high efficiency could be designed. Low coercive force was still a disadvantage before ceramic permanent magnet with high coercive force came into the picture .Samarium cobalt made it possible to construct small sized, light weight and high efficiency PM dc motor. Now a days PM dc motor, Synchronous motor with permanent magnet ,Brushless dc motor with PM are available in the field. PM Electrical motors are better in field of Control, cost, volume& weight, size& shape in comparison to its counterpart. Economic consideration can be discussed from another point also. PM motors may be i) High volume mass production ii)Low volume specialized design. The first category includes PM dc commutator motor and PM Synchronous motor The cost of production of such kind motors depends on i)Material cost, ii)Machine assembly cost ii)Machine controller cost iv)Operating cost(v)Heat transfer cost(vi)Routine and emergency maintenance cost. Low volume Specialized permanent magnet machines include dc brushless P M Machine.

An attempt is made to formulate a computer aided design of permanent magnet dc motor keeping in view the electro- magnet dc motor . The programming language used is Q-BASIC in a pc. Mathematical Expression used in computer programme for design:

Machine's Specification:

1. Output Voltage=u volt
2. Out put power=w watt
3. Speed of rotation= N rpm
4. Type of duty=continuous
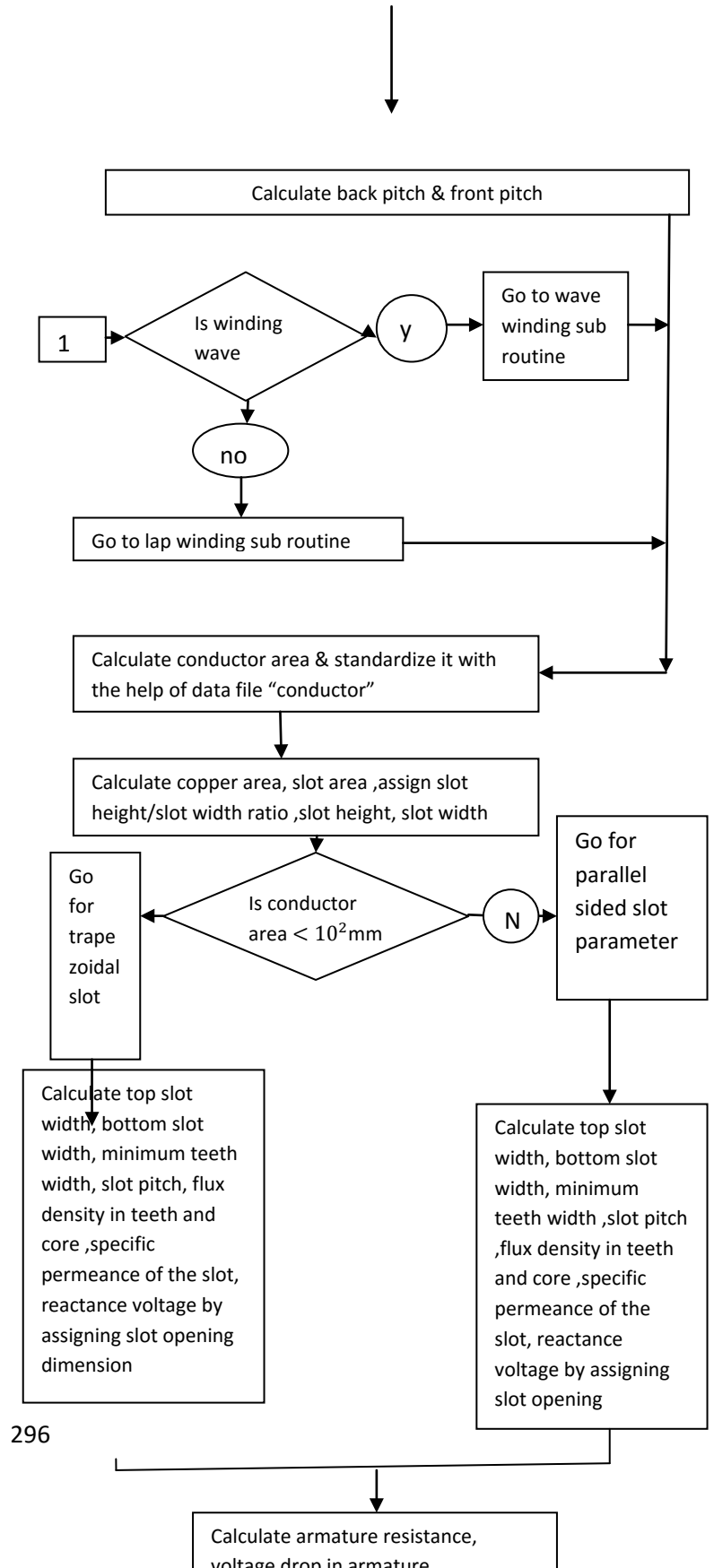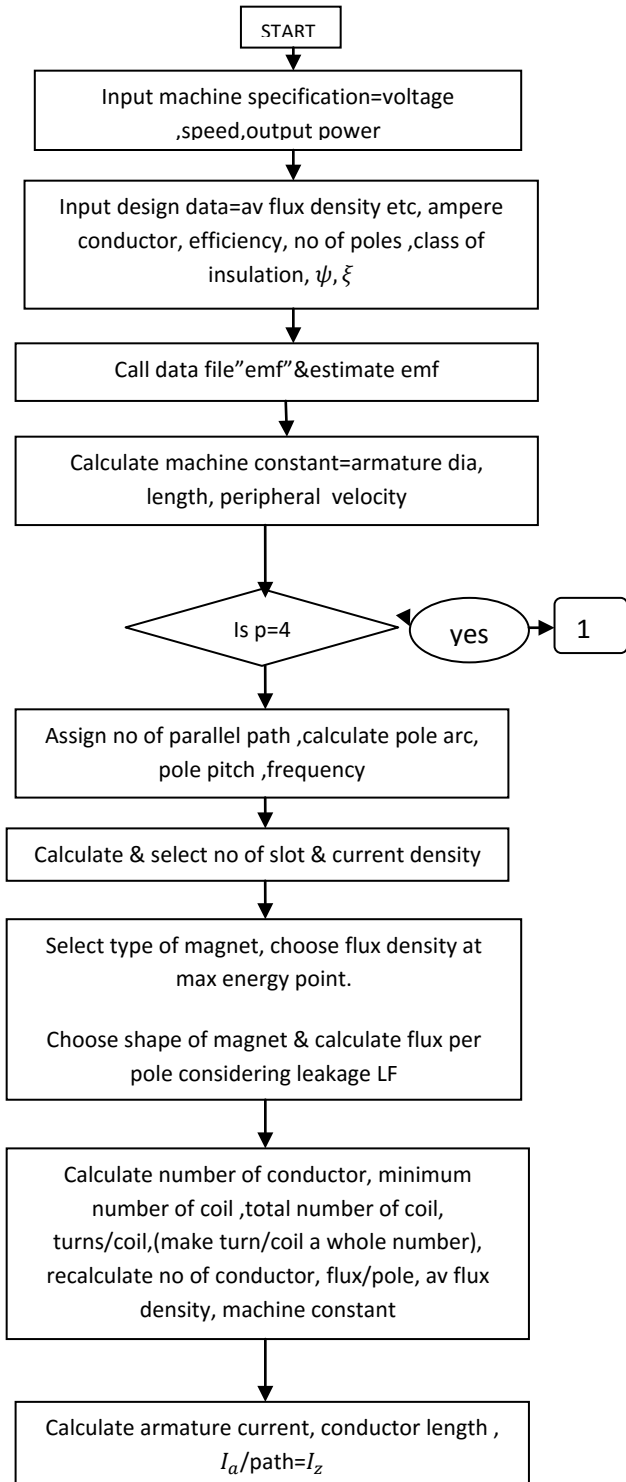5. Type of construction=totally enclosed

2.Design data:

1. Required efficiency=η
2. Number of pole=p
3. Av. Air gap flux density=$B_{av} \leq 0.2$ wb/m^2
4. Ampere conductor=A$\leq$5000amp/mtr
5. Pole arc/pole pitch=0.67to 0.7
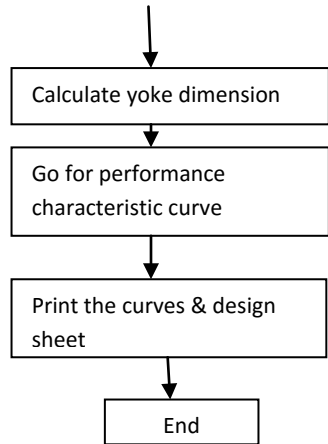6. Armature length/diameter=ξ
7. Current density=$\alpha\ amp/mm^2$

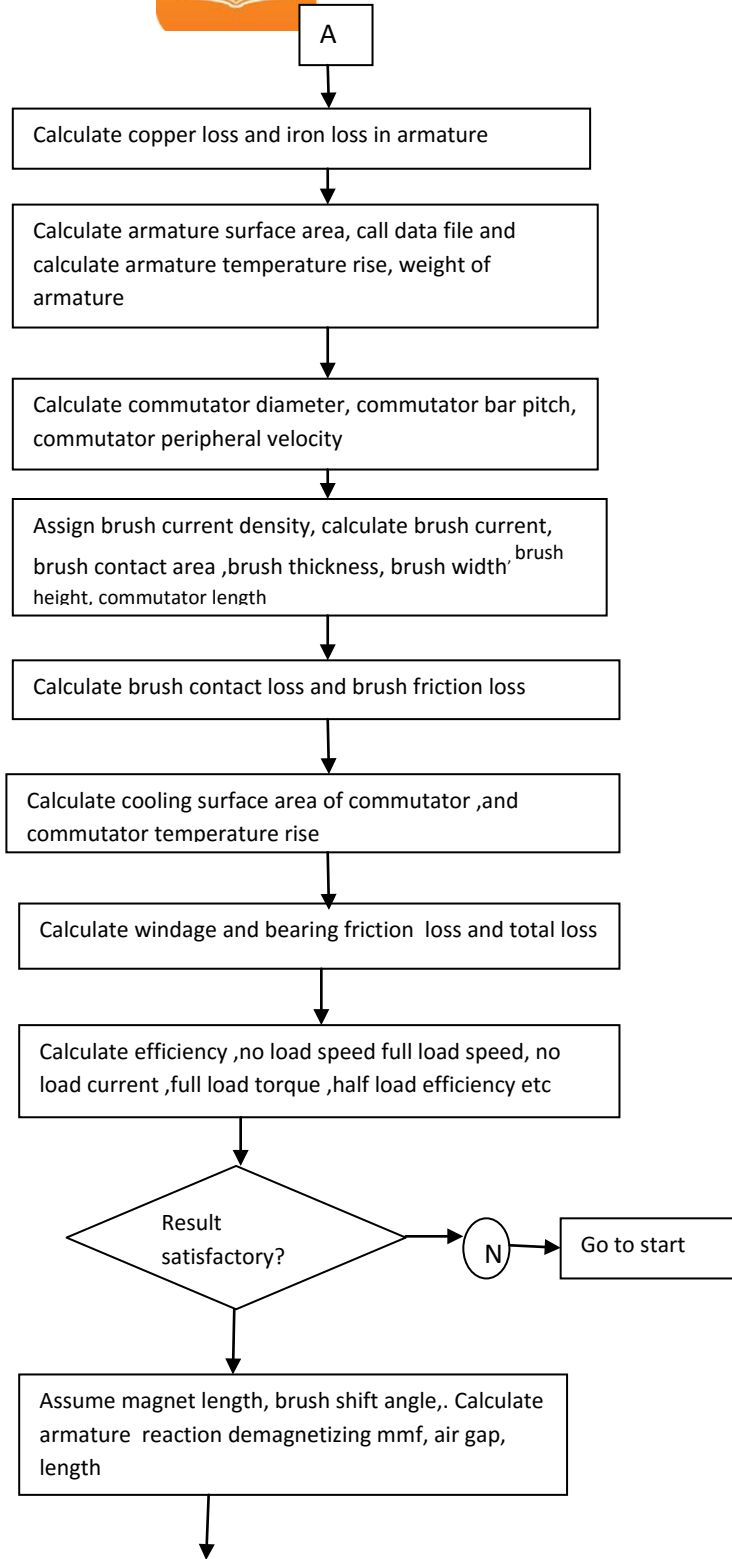**3.Calculation:**

1. Input power to Armature=W2
2. RPS=N1=N/60
3. Machine constant=C=3.1416*3.1416*B_{av}*A*.001
4. Diameter=$D_a=(W2/(C.N1.\xi))^{.333}$
5. Armature length=Lc=$(D_a.\xi)$mtr

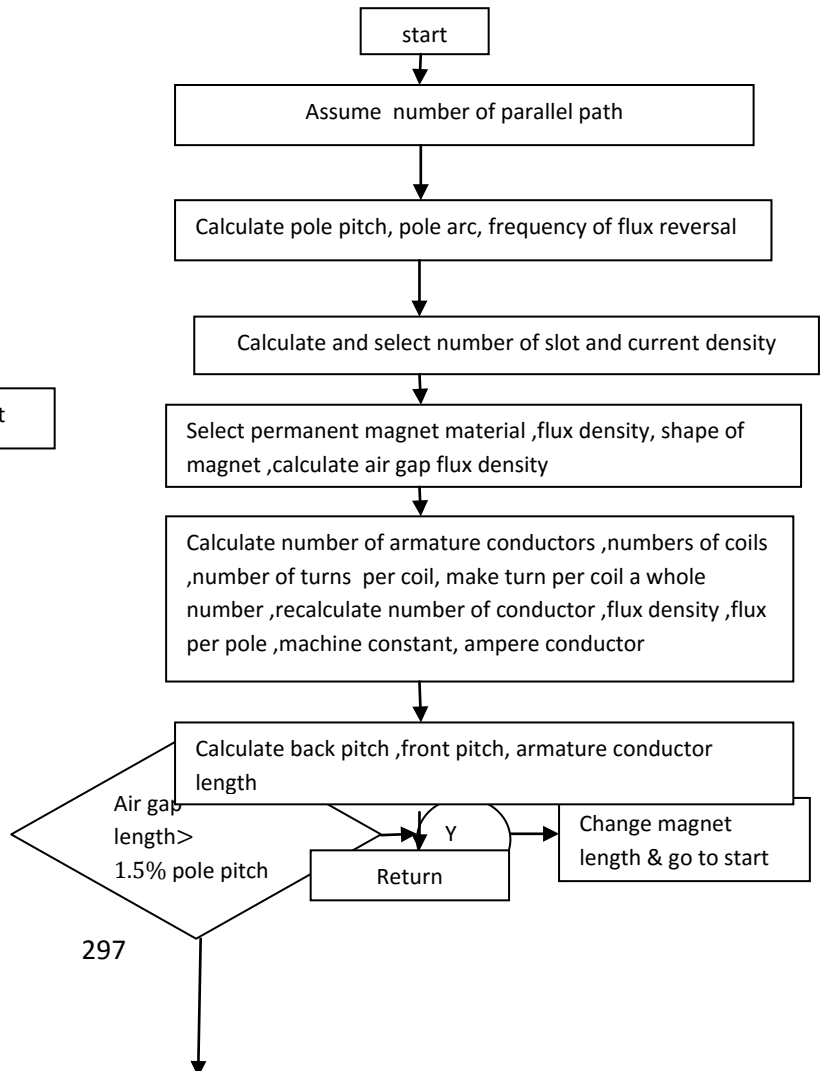6. Peripheral velocity=$V_a=\pi.D_a.N1$ mtr/sec
7. Pole pitch=$\tau=\pi D_a/p$ mtr
8. Pole arc=$b_0=\tau.\psi$ mtr
9. Pole face area=$A_m=b_o.L_c$ sq mtr
10. operating flux density=$B_d=B_\tau/2$
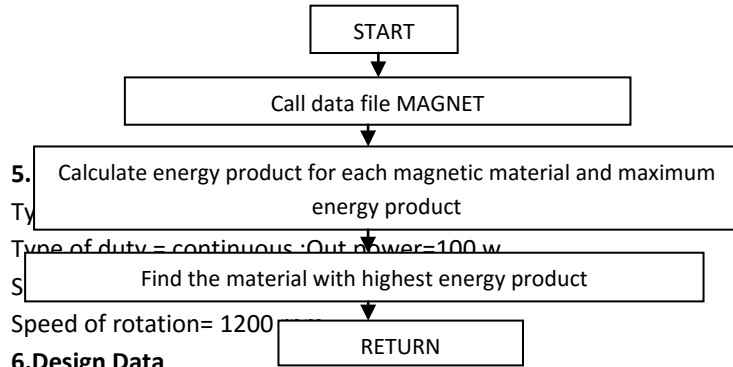11. Operating field=$H_d=$H amp-/mtr

4.FLOW CHART

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A

Calculate copper loss and iron loss in armature

Calculate armature surface area, call data file and calculate armature temperature rise, weight of armature

Calculate commutator diameter, commutator bar pitch, commutator peripheral velocity

Assign brush current density, calculate brush current, brush contact area ,brush thickness, brush width, brush height, commutator length

Calculate brush contact loss and brush friction loss

Calculate cooling surface area of commutator ,and commutator temperature rise

Calculate windage and bearing friction loss and total loss

Calculate efficiency ,no load speed full load speed, no load current ,full load torque ,half load efficiency etc

Result satisfactory? → N → Go to start

Assume magnet length, brush shift angle,. Calculate armature reaction demagnetizing mmf, air gap, length

Calculate yoke dimension

Go for performance characteristic curve

Print the curves & design sheet

End

SUB ROUTINE for Wave Winding

start

Assume number of parallel path

Calculate pole pitch, pole arc, frequency of flux reversal

Calculate and select number of slot and current density

Select permanent magnet material ,flux density, shape of magnet ,calculate air gap flux density

Calculate number of armature conductors ,numbers of coils ,number of turns per coil, make turn per coil a whole number ,recalculate number of conductor ,flux density ,flux per pole ,machine constant, ampere conductor

Calculate back pitch ,front pitch, armature conductor length

Air gap length> 1.5% pole pitch

Y → Change magnet length & go to start

Return

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Sub routine for Magnet Selection

START

Call data file MAGNET

Calculate energy product for each magnetic material and maximum energy product

Find the material with highest energy product

RETURN

5.
Ty
Type of duty = continuous ;Out power=100 w
S
Speed of rotation= 1200

6.Design Data
Required efficiency=0.7
Regulation=5%
Ampere conductor=2100 Amp/mtr
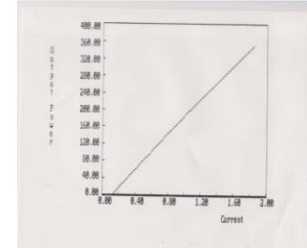Number of pole=4
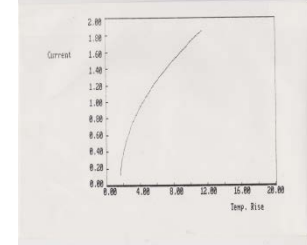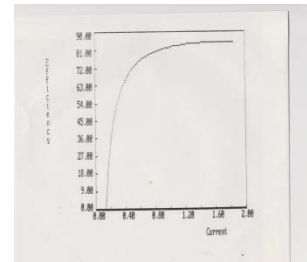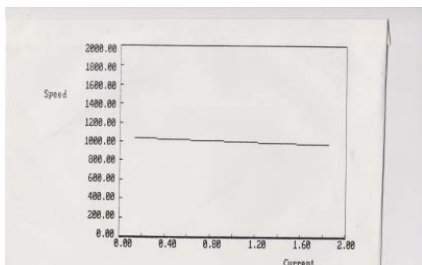Pole arc/pole pitch=0.7
Diameter/Length=2
Current density=5 amp/sq mm
Type of Magnet=Ceramic
Shape of Magnet=Rectangular
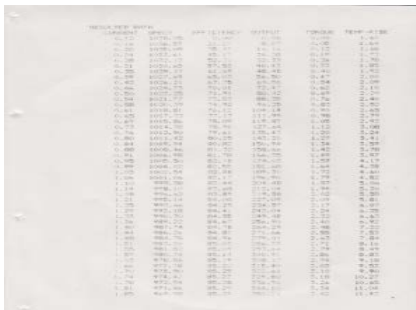
7.Performance/Results :
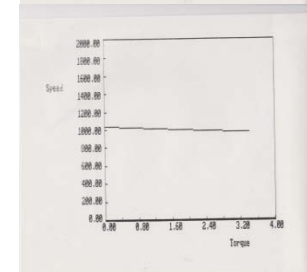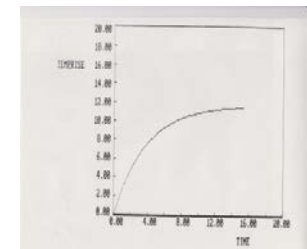
8.Conclusion :

 PM dc motor is excitation loss free and hence some amount of contribution is given to the conservation of energy as well as air pollution control by this kind of machine .The out put power /volume is high and better dynamic performance is available with this motor .Construction and maintenance is also simple.

The majority of PM dc motor with slotted rotor use Ferrite PM. Barium and strontium Ferrite PM dc motor are going to be used extensively in Auto mobile sector .With the advent of rare earth PM material like Samarium cobalt ,Nedium iron Boron, the brushless PM motor become more efficient than Induction motor. In servo mechanism also maintenance free brush-less PM dc motor replace the conventional servo motor. In Germany PM Brushless motor up to 1KW is already designed .The design will more cost effective if optimization aspect is brought into consideration.

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