# Title of invention:
# Hybrid Reluctance Induction Motor

## FIELD OF INVENTION AND USE OF INVENTION

The present invention relates generally to electric motors specially a 3-phase induction motor for industrial, hybrid and electric vehicle.

The advantages of the invention are increase in the 3-phase induction motor total performance with same amount of power input. More advantages are energy recovery and increased cooling efficiency.

## PRIOR ART

The three-phase induction motor market is changing fast towards higher efficiency classes, Nowadays the global market is dominated by higher efficiency (IE2-class) motors. The fast motor market transformation is a result of minimum energy performance standards (MEPS) being adopted all over the World. To reduce carbon emission, rely on hybrid/electric vehicles in India, picking up space very fast. So, need of inexpensive high efficiency MEPS type induction motor raised.

- IN332228A1 titled "Squirrel-cage induction motor for hybrid and electric vehicle" discloses a type of induction motor for application in electric and hybrid vehicles. The specialty of the motor of the present invention is that it takes less voltage and produces higher torque and speed. It uses a low-cost technology but on the other hand highly reliable and maintenance free. This motor works along with engine and helps to minimize fuel consumption by maintaining optimum load on engine. During heavy load and in the regions where Engine is not efficient, motor will assist engine and improve the engine performance. During braking, idle running or under-loading this machine acts as generator and recover power.

- US5254894A titled "Dual-stator induction synchronous motor" discloses An induction synchronous motor with two rotor cores and two stator cores includes a rotor having two mutually connected first rotor windings (31,31) of a predetermined number of poles and two mutually connected second rotor windings (33,34) connected of a different number of poles with respect to the number of poles of the first rotor windings; and two stators having two stator windings (21,22) of the number of poles identical with the number of poles of the first rotor windings (31,32) and two excitation windings (41,42) of the number of poles identical with the number of poles of the second rotor windings (33,34).

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The motor further includes a rectifier circuit (35) for rectifying outputs from the second rotor windings (33,34) and supplying the rectified voltages to the first rotor windings (31,32) at a synchronous operation. A phase shifter (SW1) associated with the first stator windings (21,22) produces a phase difference of 180° between a rotating magnetic field around one of the rotor cores and that around the other one of the rotor cores. The motor starts based on a theory of an ordinary induction motor under a phase difference of 0° and can operate as a synchronous motor after the rotating speed has reached its synchronous speed under the phase difference of 180° produced by the phase shifter.

## PROBLEM TO BE SOLVED

Till now include prior arts all induction motor uses the half magnetic flux (Ø/2) resides inside cavity of stator. However, the other half of magnetic flux (Ø/2), which ship through the stator core is not been used. This unused magnetic flux is also one of the responsible factors of motor heat. Use of this unused magnetic flux will further optimize the induction motor performance.

Note: let Ø = the magnetic flux through the coil.

## OBJECTS OF INVENTION

With the existing technology total flux(Ø) created by an induction motor is not used. So, the principal object of this invention is increasing motor performance (speed and torque) by using this unused magnetic flux(Ø/2) which ship through the stator core. Another object of this invention is to produce continuous power as motor run. A further object of this invention is to remove induction fan by increasing cooling efficiency.

Note: let Ø = the magnetic flux through the coil.

## SUMMARY OF INVENTION

- The present invention discloses a type of hybrid reluctance induction motor for industrial, electric vehicle. The specialty of the motor of the present invention is that it uses the unused magnetic flux (Ø/2) with the help of reluctance between permanent magnet and rotating magnetic field(rmf).

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- The novel and key features of the proposed motor is as follows. The motor has an arrangement by which it can use maximum magnetic flux [half flux(Ø/2) = flux resides in cavity of stator + other half flux(Ø/2) = flux that ship through the stator core]. By which it produces extra torque & speed and continuous recover energy till motor start to stop.

- The advantages of the disclosed motor are as follows:
  - Cooling efficiency: The special design of motor provides direct cooling to the stator of motor so Cooling efficiency is greater than induction motor fan
  - Energy recovery: Said motor can generate continuous power by rotor permanent magnets and system of coils.
  - Mechanical Advantage (MA): The MA is higher as MA = input arm/output arm and said Motor's rotor has larger length of rotor (input arm) from the shaft where it attached.

    Note: let Ø = the magnetic flux through the coil.

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## BRIEF DESCRIPTION OF DRAWINGS

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The foregoing and further objects, features and advantages of the invention will become apparent from the following description of embodiments as illustrated in the accompanying drawings. The following drawings are only examples and it may be noted that it is possible to apply the same principle and construct other types of motors.

**Figure 1** illustrates a complete pictorial view of the induction motor HRIM1 of the present invention.

**Figure 2** illustrates a pictorial view of the stator part and rotor part separately of induction motor HRIM1 of the present invention.

**Figure 3** illustrates a pictorial view of the stator part and rotor part separately in face-to-face position of induction motor HRIM1 of the present invention.

**Figure 4** illustrates a pictorial view of the stator part of induction motor HRIM1 of the present invention.

**Figure 5** illustrates a pictorial view of the power generating assembly i.e., system of coils with a smaller laminated core part of induction motor HRIM1 of the present invention

**Figure 6** illustrates a pictorial view of the rotor part of induction motor HRIM1 of the present invention.

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## DETAIL DESCRIPTION OF THE PREFERRED EMBODIMENTS

**Figure 1** illustrates a pictorial view of 3 phase AC hybrid reluctance induction motor HRIM1 disclosed. The induction motor consists of Points **1,6,12** is referring the outer most system of coils attached where each coil **20** has a laminated core **19** inside. Points **2,15** is referring the outer permanent magnet attach rotor stationed over the stator on a bearing **24,25**. The bearings attached with shaft **5**. Points **3,11,14,22** are referring squirrel cage induction rotor inside the stator **7** cavity. Points **4,17** are referring the bearing and **5,10,16** are shaft on which the rotor is situated.

Here points **7,13,18** are referring the stator **7** with a system of coils. Points **9,23** are permanent magnets distributed over the rotor in teethes.

**Figure 6** Here one part **22** is like induction rotor resides inside the cavity of stator **7** another part **2** with permanent magnets **9** are mounts over it, this part one end stationed just over the stator other end attached with the shaft by bearing.

The said motor has 3 main parts:

I. Stator: Here in **Figure 4**, A rotating magnetic field (*rmf*) is the resultant magnetic field produced by a system of coils symmetrically placed and supplied with polyphase currents.

II. Rotor consist of two parts **Figure 2,3** one is induction squirrel cage type rotor used the inside magnetic flux resides in cavity of stator(Ø/2) and another part situated on the outer side of stator as shown in **Figure 6** it is also have attached permanent magnets (PMs) **9**. The PMs are distributed at 90° angle with respect to the outside rmf field to get the maximum flux cut. Now, the outer side rmf is distributed all over the stator body the permanent magnet is able to gather and concentrate this rmf thus while the rmf rotate also rotate the PMs rotor **Figure 6** due to reluctant force between them. Thus, another half of magnetic flux(Ø/2) is been used.

II.I This PMs rotor part is designed like an impeller of a blower as shown in **Figure 6**. It covers the whole stator body and it stationed just over the stator.  So, while it rotating, it also cuts the air i.e., working as a fan as well. Thus, it produced much cooling effect then induction fan attached with induction motor.

III. Another system of coils (design like alternator stator coils) is introduced in outermost side of PMs rotor to act as a generator as shown in **Figure 5** to generate electricity. It generates electricity as the PMs rotor interact with system of coils while rotating. But as we can see here, the PMs rotor will rotate as the motor start and only stop when motor stop So, throughout this it will able to generate power.

Note: let Ø = the magnetic flux through the coil.

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## SEQUENTIAL FLOW OF INVENTION

- As we are still not able to use the maximum magnetic flux (Ø/2 = flux resides in cavity of stator + Ø/2 = flux that ship through the stator core) produced by the Current 3 phase AC motor.
- So, Can Current 3 phase AC motor be more efficient? (By means of using the unused magnetic flux)

↓

Understanding the existence of unused magnetic flux (Ø/2 = flux that ship through the stator core)

↓

**Create a new type of motor to use the maximum magnetic flux (Ø/2 = cavity of stator + Ø/2 = ship through the stator core)**

Inventive Step

↓

An example Experiment done with the prototype motor to generate data for the following points

- *Energy consumption should remain same at all time(experiment)*
- *Extra torque should generate (Due to unused flux)*
- *Checks the more advantages of the new design*
  - *Increase in motor cooling efficiency (Fan can be remove)*
  - *continuous Recovery of energy (It can work as an alternator all the time from motor start to stop)*

**An example Experiment with a prototype HRIM1 motor (2 pole, 0.5 HP, 220volt)**

Definition:

Arrangement: One Extra Rotor has been introduced outside of the stator **Figure 6**

Normal Condition: Condition when the outside rotor is stopped by manual intervention.

Energy generating module: outermost system of coil as shown in **Figure 5**

Mechanical advantage = input arm distance/output arm distance

| Experiments | Observation | Conclusion |
|---|---|---|
| Now let start the motor from VFD | Motor has been started | The total system is working fine |

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<table>
<tr><th>Experiments</th><th>Observation</th><th>Conclusion</th></tr>
<tr><td>a. Temperature<br>/Heat control</td><td><table><tr><td>With arrangement<br>at 10 hz</td><td>In Normal condition<br>at 10 hz</td></tr><tr><td>After 1 min –34.6°C<br>After 2 min –34.9°C<br>After 3 min –35.0°C<br>After 4 min –35.4°C<br>After 5 min –35.7°C<br>After 15 min –36.2°C<br>After 40 min –41.9°C</td><td>After 1 min –35.1°C<br>After 2 min –35.5°C<br>After 3 min –36.8°C<br>After 4 min –37.7°C<br>After 5 min –40.3°C<br>After 6 min –42.7°C</td></tr></table></td><td>The unused magnetic field is act upon the stator body and coil so it gets heated up.<br>As the unused magnetic field is been used by the arrangement and the air flow makes the whole motor cool so there is no extra fan is required at the end of the motor</td></tr>
<tr><td>b. Check the input current by clamp meter (Ampere)</td><td><table><tr><td colspan="3">In Normal condition<br>at 10 hz</td><td colspan="2">With arrangement<br>at 10 hz</td></tr><tr><td>reading</td><td>1st</td><td>2nd</td><td>1st</td><td>2nd</td></tr><tr><td>Phase 1</td><td>0.133</td><td>0.135</td><td>0.133</td><td>0.139</td></tr><tr><td>Phase 2</td><td>0.139</td><td>0.136</td><td>0.136</td><td>0.135</td></tr><tr><td>Phase 3</td><td>0.132</td><td>0.133</td><td>0.139</td><td>0.132</td></tr></table></td><td>The both range difference is very minimum, so the arrangement is not taking extra load/current to perform its work.<br>Although the both rotors are rotating from the same source of input current it should take more current, but it taking almost same amount of current, which proves that the unused flux is the force responsible for moving the outside rotor</td></tr>
<tr><td>c. Output/Work done</td><td><table><tr><td colspan="4">Energy generated by the energy generating module is ~12V. The current consumption is</td></tr><tr><td>reading</td><td>1st</td><td>2nd</td><td>3rd</td></tr><tr><td>Phase 1</td><td>0.136</td><td>0.139</td><td>0.136</td></tr><tr><td>Phase 2</td><td>0.145</td><td>0.142</td><td>0.135</td></tr><tr><td>Phase 3</td><td>0.136</td><td>0.136</td><td>0.139</td></tr></table></td><td>The Phase current is remained almost same while generating power.<br>The current can be generated throughout the life cycle, form motor start to stop.<br>The power generated by it can be used as per requirement.</td></tr>
<tr><td>d. Measurement of Unused magnetic flux (in term of torque)</td><td>The weight displayed is 0.095kg at 25Hz</td><td>So, mass(m) = 0.095kg<br>Torque = Force(F) X Distance(d)<br>Force = mass x acceleration<br>Value of acceleration (As per earth gravitation force) = 9.81<br>= 0.095 x 9.81 Newton<br>=0.93195 Newton<br>Rope radius = 3 cm<br>Shaft radius = 6 cm<br>So, Effective radius = 3+6<br>=0.09 m<br>Extra Torque = 0.93195 x 0.09<br>= 0.0838755 Nm at 25 Hz<br>= (0.0838755x2) 0.167751 Nm at 50 Hz<br>With Mechanical advantage<br>6/3= 2<br>Total Extra = 0.167751x2 =0.335502 Nm</td></tr>
<tr><td>Measurement of Speed</td><td>Speed Displayed is 4000 rpm at 50 Hz</td><td></td></tr>
<tr><td>Measurement of torque in normal condition</td><td>The weight displayed is 0.230kg at 10Hz</td><td>Radial Torque = 0.235 x 9.81 x 0.06 = 0.157941 Newton at 10 Hz<br>= 0.789705 Nm<br>Distance = 6 cm = 0.06 m</td></tr>
</table>

**Conclusion:**

❖ From the above experiment results the following points are concluded
- Current consumption is remained approx. same as initial motor start throughout the experiment.
- Extra torque is found and measured also speed is measured
  Main torque = **0.789705 Nm** Extra torque = **0.335502 Nm**
  Speed **= 4000 rpm at 50 Hz**
- Advantage we get, the motor is cooled even after a long run
  - So, the induction motor fan can be removed as we are getting sufficient cooling.
  - Motor is continuously generating power while running

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## CLAIMS

**I CLAIM**,

1. A 3-Phase AC reluctance induction motor for industrial, hybrid and electric vehicles with increased performance where the said motor uses the maximum flux (Ø/2 = flux resides in cavity of stator + Ø/2 = flux that ship through the stator core) and produces maximum torque with same current as induction motor use, the design optimizes the cooling efficiency by impeller like design of rotor. Motor comprising a stator **Figure 4** attached from one side of cavity into a plate. Two rotors **Figure 6** mounted on a shaft **5**,**10** one rotor **22** is directly attach to shaft, other rotor (outer rotor) **2** is attach with a bearing **25** and the bearing attach with shaft **5.** Outer rotor **2** one end attach with shaft **25** by bearing and other end **2** cover the whole stator body **18** with its teethes **21**. All being housed in a body **Figure 1**. Permanent magnets **9,23** are attached to the outer rotor teethes **21** with 90° angle with respect to the stator outside rmf field to get the maximum flux cut. The outer most stator **Figure 5** attach with plate **27** placed above the outer rotor. It has a system of coils **20** each coil encircles a laminated core **19** forming power generating assembly. In between two rotors **2, 22** the stator **18** is situated in horizontal position. Let Ø = the magnetic flux through the coil.

2. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the Stator **Figure 4** is attached to a plate **27** with bolts **26** from one side of cavity.

3. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the rotors **2**,**22** are attached to a common shaft **5** and the shaft is attached with plates **27** with two normal bearings **4**,**17**.

4. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the outer most stator **Figure 5** with a system of coils **20** with inside laminated core **Figure 5** attached with plate **27** mounted over the outer rotor **2**.

5. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the maximum flux cut at angle 90° mean reluctance force between permanent magnet and rmf is maximum at said angle.

6. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the outer rotor **2** attached to shaft **5** with bearing or it can directly attach to shaft.

7. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the Ø mean the magnetic flux through the coil and maximum flux mean the sum of Ø/2 (flux resides in cavity of stator) and Ø/2 (flux that ship through the stator core)

8. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the outer rotor **2** consist teethes with permanent magnets **9** interact with flux Ø/2 (flux ship through the stator core) mean the reluctance force between permanent magnets and stator outside rmf field.

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9. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the PMs rotor part is designed like an impeller **Figure 6** mean the rotor teethes each have air gap between them.

10. The 3-Phase AC reluctance induction motor as claimed in claim 1, wherein the motor produces maximum torque means torque produce by rotor **22** in stator cavity and rotor **2** outside stator **18** body.

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## ABSTRACT

The present invention relates to a 3-Phase AC Hybrid reluctance induction motor for industries, hybrid and electric vehicles. Induction motor only use half of its magnetic flux(Ø/2) as other half(Ø/2) of it ship through the stator so, it is not efficient, to improves the motor performance. This flux needs to be used. The motor has been designed such that it able to use this flux as well as retaining all its previous advantages as induction motor. Now the motor is produces higher torque & speed & cooling efficiency and motor acts as generator and continuously recover power from motor start to stop.

Note: let Ø = the magnetic flux through the coil.