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Multispeed Operation of Dual Stator Winding Induction Motor

Rucha Sardar, Prof. A. R. Soman

Electrical Power System, Bharati Vidhyapeeth College of Engineering, Pune, Maharashtra, India

ABSTRACT

Obtaining multispeed operation is a major concern in most of the industry .The possibility of obtaining more than one speed by providing the stator with the winding so arranged that by suitable switching the number of poles & hence the speed can be changed. Means by constructing a dual stator winding. This paper deals with design consideration & different technological methods used for obtaining multispeed operation.

Keywords: Dual stator winding Induction Machine, Dahlender, Tapped, Alexandersen

I. INTRODUCTION

Dual stator winding is constructed by splitting the stator or main winding or single winding into two seprate winding .These type of single winding giving two speed is also called as Dahlender or Alexandersen winding or Tapped winding. To reduce the magnetic coupling between two stator winding & to decouple the torque, stator winding have a two different number of poles say 2/6 poles. Power is supplied to one winding at one time and getting the required speed.

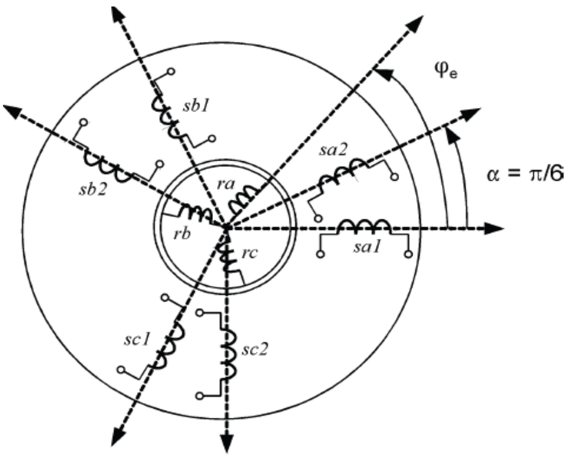

Figure 1. Schematic Representation of motor winding dual stator winding induction motor (DSIM)

Two speed motors with single winding is used where the speed ratio is 2:1 i.e all the polarities having a combination of 1:2 e.g 2/4p,4/8p,6/12p,8/16p.Two separate winding are used where any combination of speed other than 1:2 is required.

Two independent stator winding one wound for 4 poles & other wound for 12 poles can be placed in 210/48 slots. Such that synchronous speed of 150 rpm & 500 rpm can be obtained for a 50 HZ supply system.

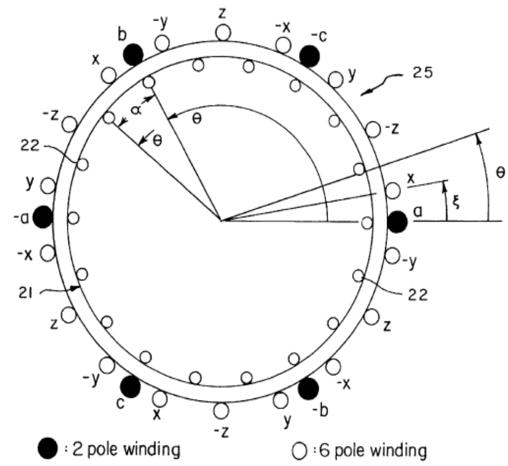

Figure 2. Illustrative view of an 2 pole-6 pole dual stator winding induction machine .

Normally the rotor of a multispeed motor is of squirrel cage type. The reason is that it adjusts itself easily to any number of poles.However ,rotor wound with same number of poles as that of stator winding can also be used .But each rotor winding requires its own set of

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carbon brush ,own set of sliprings & the mechanical construction remains no more simple one.

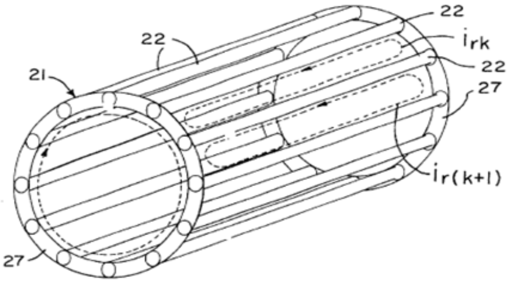


Figure 3. Squirrel Cage Induction Machine

II. METHODS AND MATERIAL

✓ **Design Consideration**

1. When a multispeed motor is using two or more winding, each winding is to be designed for a star connection & winding is to be a series connection winding .Parallel paths are not to be used in any winding.The reason is that with parallel connection or mesh connection in one winding .It acts as a shorted secondary of a transformer drawing high current & resulting in burning of winding.
2. When series star connection is not possible & a delta connection is to be issued ,it is to be a open delta with 4 terminals only.This connection is to be specified when delta winding is not connected to the lines.
3. Multispeed motors are suitable for DOL/AUTO transfer starting .In case a star delta winding starting is required on either winding ,six terminals of each winding are required to be brought out,resulting in increased dimensions of terminal box. Also, it is to be ensured that the starter returns the connection to star in the off position or completely open circuit the winding.
4. when two winding are used then with the greatest number of poles is put near the core.The reason for this choice is that
   - The extra reactance of the high speed, due to it being in the bottom of slot causes a drop in the power factor .The high speed winding has a better power factor as compared to low speed winding. Hence, it can withstand the slight drop in the power factor without affecting full load current appreciably.
   - The low speed winding has a lower overload capacity .By putting the low speed winding to near to the airgap, overload capacity sacrification will be avoided.
   - When two winding are used , a reasonable balance between copper crosssection is to be carried out.Generally ,the distribution of copper area will be 40:60 for high /low speed.This is because ,a higher value of current density is permissible on high speed .Also,if ratios are exceeded,it is possible than winding with cross section becomes to weak for handling.

A. Connection Diagram According To Application

1. Variable Torque Applicaton [E.G PUMPS,FAN] ƛ ƛ/ƛ

Here winding connection is star on both speeds. This connection gives minimum flux for low speed relative to the high speed flux stamping to be used. High speed stampings to be used.

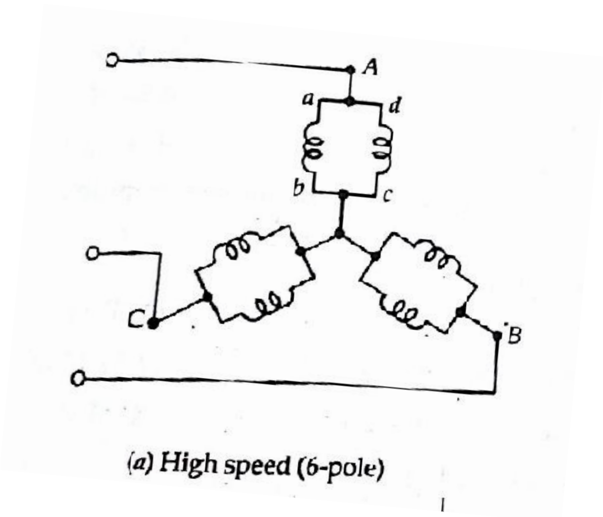


Figure 4

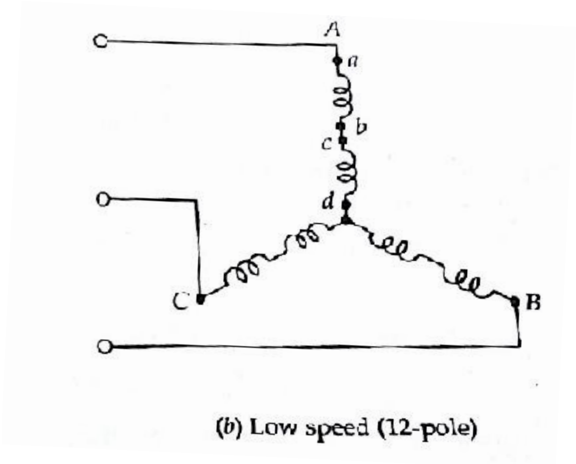


Figure 5

2. CONSTANT TORQUE APPLICATION [CONVEYORS] ƛ ƛ/Δ

Here normally parallel star connection is used on higher speed &series delta on lower speed.

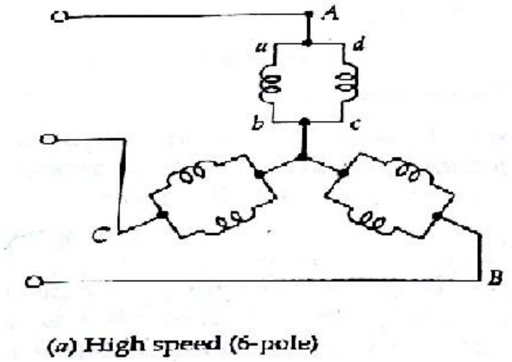


Figure 6

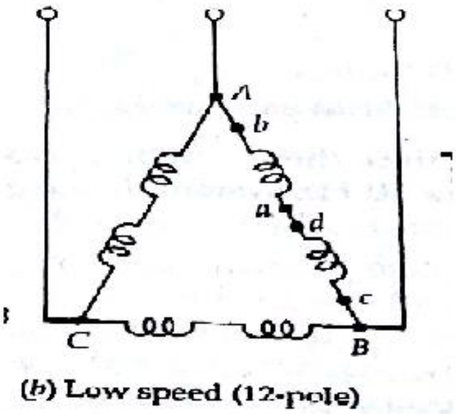


Figure 7

3. CONSTANT HORSEPOWER APPLICATION ƛ ƛ/Δ

Here parallel star/delta is to be used because low speed is electrically more loaded & hence should have higher flux .Hence low stampings are to be used since flux level at higher speed is low.

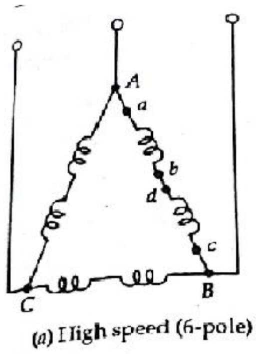


Figure 7

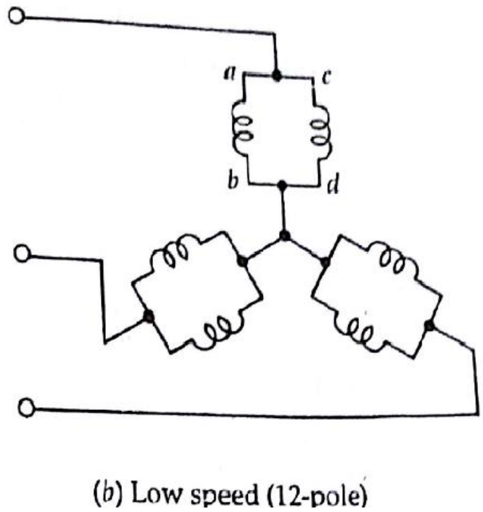


Figure 8

B. Application

1. MACHINE TOOLS
   A number of gears,that are used to get different speeds can be reduced by using double/tripple/four speed squirrel cage induction motor,as drive for machine tool.
2. CHEMICAL INDUSTRY
   In chemical plants ,liquid are to be pumped at different rates to suit the different requirement.Double speed Induction machine can be used for having two different speeds.
3. RUBBER &PLASTIC INDUSTRY
   For different quality of ingredient, the mixing cycle is to be different in the mixers employed in rubber & plastic industries.

4. FAN DRIVES
   At lower speeds, where torque requirement is low,fan can be run at two different speeds for every conservation.
5. TEXTILE RING FRAMES
   During starting motor is run at low speed to minimum yarn breakage. During running, a higher speed is used for economic production.
6. CENTRIFUGES
   For stirring the paste, low speed is used at start & for finishing operation higher speed is used.
7. LIFTS & ELEVATORS
   Here wide ratio pole changing motors are used e.g.4/12p,4/16p,6/18p,6/24p.
8. CRANES
   For smaller capacity cranes dual speed single winding motors are used instead of having two different motors of different speed.

✓ **Speed Control Of Induction Motors**

The rotor speed of induction machine is given by

Nr=(1-s)Ns

Ns=120f/p

Nr=120f/p*(1-s)

Where

Nr-Rotating speed

Ns-Synchronous speed

s-slip

f-frequency

p-pole

Changing in frequency number of poles, or slip, the motor speed can be changed.

✓ **Methods For Speed Control Pole Changing**

Changing the number of stator poles is done by

A) MULTIPLE STATOR WINDINGS
B) METHOD OF CONSEQUENT POLES
C) POLE AMPLITUDE MODULATION (PAM)

Pole changing method is most suited for cage motors only because cage rotor automatically develops number of poles is equal to poles of stator windings.

A) Multiple Stator Windings

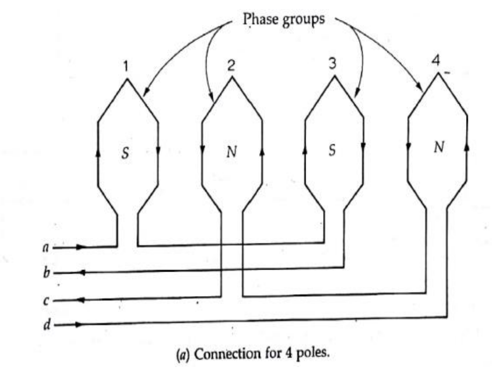
Two separate windings are wound for two different pole numbers for stator .One winding is energised at one time .If motor has wound for 4&12 poles. For 50HZ supply will be 1500 & 500 rpm. For full load slip of 5%, the operating is reduced to 1425 & 475 rpm resp. Disadvantage of this is less efficient & more costly used as per required application.

B) Methods Of Consequent Poles

Developed in 1897, consequent poles method single stator winding is divided into few coils groups.The terminals of all groups are brought out.By simple changes in coil connections, the number of poles can be changed .In practice, in 2 coil groups the stator winding is divided.In the ratio of 2:1 the number of poles is changed.

Fig.10. shows Stator winding consist of 4 coils divided in two group in one phase say a-b & c-d.Group a-b consist of odd number coils(1,3) & connected in series.Group c-d has even numbered coils(2,4) connected in series.The coil group are connecting in series & parallel to carry the current in given direction.

Total of 4 poles gives a speed of 1500 rpm for 50hz system with this connection.All the coils will produce north (N) poles ,if the current is reversed through the coil of group a-b. The flux of the pole groups must go through the spaces between the groups in order to complete the magnetic path, thus inducing magnetic poles of opposite polarity(S poles) in the inter pole spaces.These induced poles is known as consequent poles. Hence, the machine has twice as many poles as earlier (i.e 8p) & the Ns is half the previous speed i.e 750 rpm. The two set of coil groups a-b & c-d can be connected either in series for one speed or in parallel for other speed.



(a) Connection for 4 poles.

Figure 10

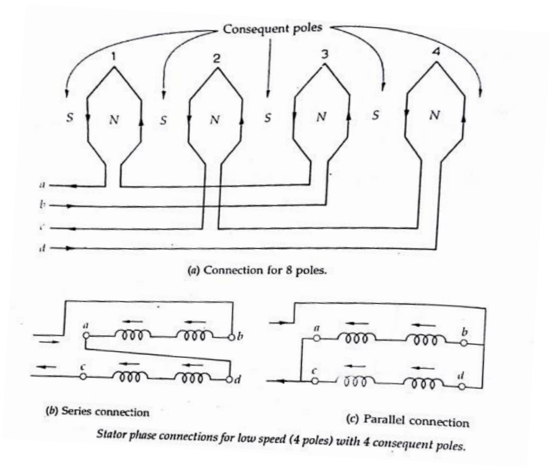


Figure 11

C) Pole Amplitude Modulation (PAM)

In application where speed ratios other than 2:1 are required pole amplitude modulation technique is used. It is flexible method. The motor designed of speed changing based on poled amplitude modulation scheme are known as PAM MOTOR.

Assume the mmf distribution due to the stator winding in the air gap of a three phase Induction motor carrying three phase balanced current is given by

$F_{A=}F_{mA}\,\text{sinp}\,\theta$ -1A

$F_{B=}\ F_{mB}\sin(p\,\theta - 2\pi/3)$ -1B

$F_{C=}F_{mC}\ \sin\left(p\theta - \frac{4\pi}{3}\right)$ -1C

P=No of poles pair
Ɵ=Mechanical angle in radians

As in each phase winding, number of turns are equal in a three phase induction machine & if the motor is supplied by balanced three phase current, the maximum values of mmf in all the three phases is the same. To modulate the mmf waves three modulating mmf waves of amplitude F are displayed from each other by 2π/3 radians of equation 1 than the equation can be written as

$$F_{mA,}F_{mB,}F_{mC}$$

$F_{A=}F_{mA}\,\text{sinp}\,\theta$- - 2A

$F_{B=}F_{mA}\sin(\text{k}\,\theta - \alpha)$ - 2B

$F_{C=}F_{mA}\sin(\text{k}\,\theta - 2\alpha)$ -2C

Where

F=constant
K=no. of modulating in one complete perimeter of the moto

$$\alpha = \pm 2\pi/3$$

Substitution Equation 2 in 1

$F_{A=}F\sin\text{p}\theta\,\text{sinp}\,k\theta$ -3A
$F_{B=}F\sin(\text{p}\Theta - 2\pi/3)\sin(k\theta - \alpha)$ -3B
$F_{C=}F\sin(\text{p}\Theta - 4\pi/3)\sin(k\theta - 2\alpha)$ -3C

Equation 3A & 3 C can be written as

$$F_{A=\frac{F}{2}}[\cos(p-k)\theta - \cos(p+k)\theta]\ \text{-4A}$$

$F_{B=}\frac{F}{2}\{\cos[(p-k)\,\theta - \frac{2\pi}{3} + \alpha] - \cos[(p+k)\theta - \frac{2\pi}{3} - \alpha]\}$-4B

$F_{C=}\frac{F}{2}\{\cos[(p-k)\,\theta - \frac{4\pi}{3} + 2\alpha] - \cos[(p+k)\theta - \frac{4\pi}{3} - \alpha]\}$-4C

Two sets of three phase mmf with (p+k) & (p-k) poles having p pair of poles is produced by modulating the amplitudes of the mmf in three phase machine.

III. CONCLUSION

Study of dual stator winding suggested that we can use single induction machine for multiple operation. By obtaining different speed as per application by splitting the stator single winding into two winding. Due to its high reliability, maintenance free & economic operation dual stator winding induction machine has many applications for industry use like lift, cranes, chemical industry etc. In this paper, overall the dual stator winding is constructed, various methods applied and how pole changing and multiple stator winding is beneficial as per application is described in detail.

IV. REFERENCES

[1] T A. Lipo,"Dual Stattor Winding Induction Machine Drive",Usa 6, 242,884 B1,June .5,2001.

[2] A. Husain,"Electric Machines"Second Edition, Dhanpat Rai Publication, New Delhi, 2005.

[3] S.E.M. de Oliveira, "Operation of three-phase induction motors connected to one-phase supply" Energy Conversion, IEEE Transactions on, Volume: 5 Issue: 4 , December 1990, pp: 713 –718.

[4] T. A. Lettenmaier, D.W. Novotny, and T. A. Lipo, "Single-phase induction motor with an electronically controlled capacitor," IEEE Trans. on Ind. Applicat., vol. 27, no. 1, pp. 38–43, Jan/Feb. 1995.

[5] C. G. Veinott, Theory and Design of Small Induction Motors, McGraw-Hill Book Company, Inc, New York, 1959.

[6] R. W. Fei and J. D. Lloyd, "Design and test analysis of single-phase induction motors with 4-8 pole common winding," IEEE Trans. on Ind.Applicat., vol. 31, no. 6, pp. 1437–1440, Nov/Dec. 1995.