3-Motor Circle Diagram

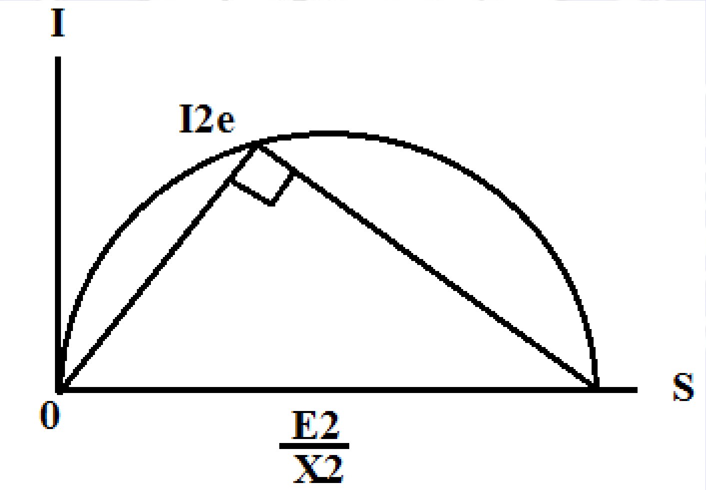
3-1 Rotor Circle Diagram: -

$$I2e = \frac{E2e}{\sqrt{\left(\frac{R2e}{s}\right)^2 + X2e^2}} \quad \ldots\ldots\ldots\ldots\ldots eq(1)$$

$$I2e, E2e, \cos\varphi 2 = function\ to\ S\ \ F(s)$$

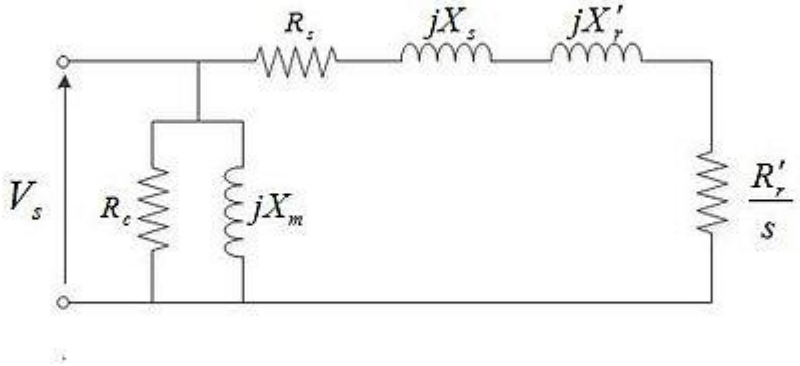
$$OD = \frac{OA}{\sin\varphi 2} = \frac{I2e}{\frac{X2e}{Z2s}} = \frac{E2S}{Z2S} \times \frac{Z2S}{X2S} = \frac{E2S}{X2S} = \frac{SE2}{SX2} = \frac{E2}{X2} = CONSTANT$$

S=0 ,I2s=0



Circle Diagram for the approximate equivalent cct.

It is clear that the circuit to the right of points ab is similar to a series circuit ,having a constant voltage and reactance (X1+X2e)but variable resistance (corresponding to different values of slip s)

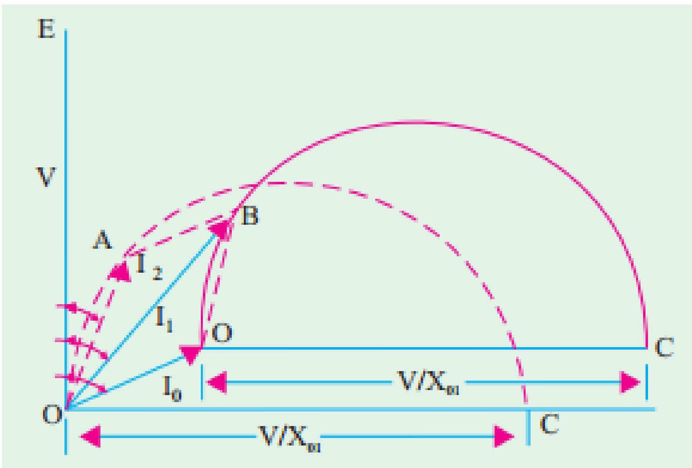


Hence, the end of current vector for I2e will line On a circle with a diameter of $V/(x_1+x_{2e})$.In fig.(2) I_{2e} is the rotor current referred to stator, $I_e=I_o$= no load current or exciting current and I1 is the total stator current and is the

When I_{2e} is lagging and $\varphi_2=90^\circ$, then the position of vector for I_{2e} will be along OC, right angles to the voltage vector OE, for any other value of φ_2, point A will be move along the circle shown dotted.

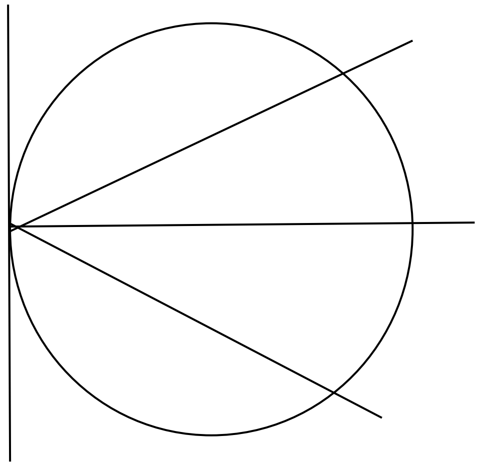
The exciting current I_e is drawn lagging V by an angle φ_e if conductance Gi and saucepans BM of the exciting circuit are assumed constant, then I_e and φ_e are also constant.

The end of current vector for I_1 is also seen to lie on another circle which is displaced from the dotted circle by an amount Ie. its diameter is still V/X_1+X_{2e} and is parallel to the horizontal axis OC. hence, we find that if an induction motor is tested at various loads, the locus of the end of the vector for the current (drawn by it) is a circle.



Fig(2)

Complete Circle :-



Motoring s=0 →+1

Braking s=1 →+∞

Generating s=0 → -∞

3-2 Motor Mechanical Characteristics

-Torque from electromagnetic forces:-

$Pem = m1\ E2e\ I2e\ \cos\varphi 2 \ldots\ldots\ldots (1)$

$E2e = enduce\ emf\ in\ rotor\ coils$

$E2e = 4.44\ F1\ T1\ K\omega 1\emptyset \ldots\ldots\ldots (2)$

$\cos\varphi = Power\ Factor$

$$\cos\varphi = \frac{\mathrm{R2e}}{\mathrm{Z2e}} = \frac{\mathrm{R2e}}{\sqrt{\mathrm{R2e}^2 + (\mathrm{SX2e})^2}} \ldots\ldots\ldots (3)$$

We will have torque equ.

$$Tem = \frac{Pem}{\omega 1} = \frac{p}{2\pi f1} . Pem \ldots\ldots\ldots (4)$$

$$= \frac{m1\ p}{2\pi f1}(4.44\ f1\ T1\ K\omega 1) I2e\ \Phi\ \cos\varphi 2$$

$$= \frac{1}{\sqrt{2}}(m1\ K\omega 1\ T1\ I2e \cos\varphi 2) P\emptyset$$

$$Tem = KT\ \emptyset m\ I2e\ \cos\varphi 2 \ldots\ldots\ldots (*)$$

$$* \, kT = \frac{1}{\sqrt{2}} p \, m1 \, k\omega1 \, T1$$

المعادلة(*)تعبر عن عزم الدوران في جميع المكائن الكهربائية وهي تعني بأن مقدار العزم يتناسب طرديا مع الفيض المغناطيسي($\emptyset$)ومع المكونة الفعالة لتيار الدوار.

وان مكونه التيار تعتمد على مقدار وزاوية الطور لهذا التيار,وتعتمد زاوية الطور على طبيعة ممانعة لفيفه الدوار

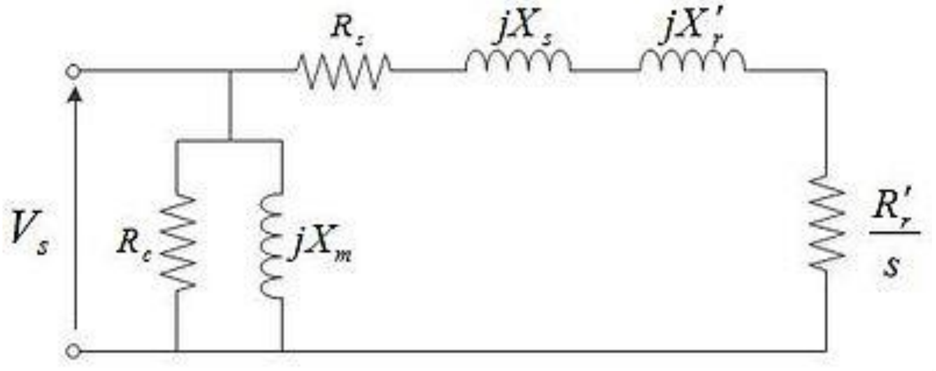
$$Tem \propto \emptyset, I2e, \cos\varphi$$

إن المشكلة في هذه المعادلة هي أن العزم فيها هو داله لثلاث مقادير هي($\emptyset$)و($I2e$)و($cos\varphi2$) وكلها مقادير متغيره لها علاقة بمقدار الانزلاق وحمل المحرك لهذا يفضل عمليا الاستعانة بمعادله الدائرة المكافئة للتعبير عن عزم الدوران.

$$Tem = \frac{Pem}{\omega1} = \frac{m1}{\omega1} I2e^2 \frac{R2e}{S}$$

3-3 Torque From Electromagnetic Power

-For Approximate Equivalent cct.



$$Z2t = \left(R1 + \frac{R2e}{s}\right) + j(X1 + X2e),\ \ V1 = E1$$

$$I2e = \frac{V1}{Z2t} = \frac{V1}{\sqrt{\left(R1 + \frac{R2e}{s}\right)^2 + (X1 + X2e)^2}}.$$

$$Pem = \frac{m\ I2e^2\ R2e}{s}$$

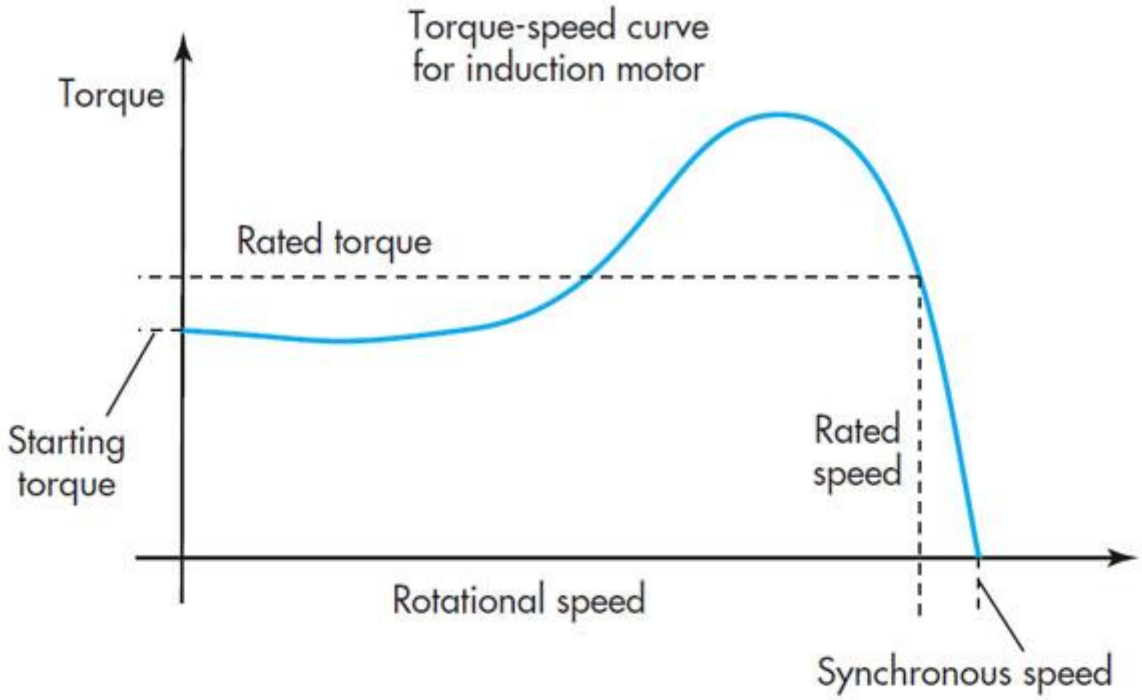
$$Tem = \frac{m1\ Pem}{\omega 1} = \frac{m1}{\omega 1}\left[\frac{v1^2.\frac{R2e}{s}}{\left(R1 + \frac{R2e}{s}\right)^2 + (X1 + X2e)^2}\right]$$

T_{em} will variable with (V1,R2e,S)

At S=1 and V1=const.→Tα R2e

عند ثبوت مقدار الجهد المسلط فأن العزم يتناسب طرديا مع مقدار مقاومه لفيض الدوار عند بدء الحركة(s=1).ولزيادة العزم ينبغي زيادة مقدار المقاومة.

في الحالات الاعتيادية يكون مقدار الجهد المسلط ومقدار المقاومة في الدوار ثابتين فأن العزم يتغير بتغير الانزلاق(s)ويعطي منحني(Torque slip curve)



$$Tem = \frac{Pem}{\omega 1} = \frac{m1}{\omega 1}\left(\frac{V1^2 \frac{R2e}{s}}{\left(R1 + \frac{R2e}{s}\right)^2 +}\right)$$

Multiply by s^2/s^2 for 3phase motor

$$Tem = \frac{3}{\omega 1}\left(\frac{V1^2 \;\; R2e\, S}{(SR1 + R2e)^2 \;\; + S^2(X1 + X2e)^2}\right)$$

If ,s=0 then Tem=0

For s↓↓ ($s<s_m$) then SR1 and $S^2(X_1+X_{2e})^2$ are neglected then we will have

$$Tem = \left(\frac{3\,V1^2}{\omega 1\; R2e}\right)s$$

The torque is directly proportional to the slip and the torque/slip curve is a straight line.

For S↑↑($S>S_m$) neglect $SR_1=0$ then

$$Tem = \left(\frac{3\,V1^2 R2e}{\omega 1\;(\mathrm{X1} + \mathrm{X2e})^2}\right).\frac{1}{s}$$

Then the torque is inversely proportional to the slip and the torque is continuously droping starting from critical slip at S=∞ then the $Tem = 0$