3-8 Ratio of Starting To Rated Torque:-

$$T = \frac{3}{\omega 1}\ I2e^2 \frac{R2e}{s} \text{ in general}$$

$$\text{at starting} \quad Ts = \frac{3}{\omega 1} I2s^2 R2e = \frac{Pcu2}{\omega 1} \ldots\ldots\ldots (1)$$

$$\text{at rated condition} \quad Tr = \frac{3}{\omega 1}\ I2r^2 \frac{R2e}{sr}$$

$$\text{then } \mu s \text{ or } Ksr = \frac{Ts}{Tr} = Sr\ \left(\frac{I2s}{I2r}\right)^2$$

3-9 Ratio of Starting To Maxi Torque:-

$$Tm = \frac{3}{\omega 1} \cdot \frac{V1^2 sm\ R2e}{R2e^2 + (sm\ X2e)^2} \quad \text{assuming that } Z1 = \quad \text{also } R2e = Sm\ X2e$$

$$\text{then} \quad Tm = \frac{3V1^2}{\omega 1} \cdot \frac{sm(sm\ X2e)}{2(sm\ X2e)^2} = \frac{3V1^2}{2\omega 1 X2e}$$

$$\text{similarly} \quad Ts = \frac{3}{\omega 1} \cdot \frac{V1^2\ R2e}{R2e^2 + (\ X2e)^2} \quad ,\text{since} \quad s = 1$$

$$\text{then} \quad \mu sm \quad \text{or } Ksm = \frac{Ts}{Tm} = \frac{2R2e\ X2e}{R2e^2 + X2e^2} = \frac{2R2e \frac{X2e}{X2e^2}}{\frac{R2e^2 + X2e^2}{X2e^2}}$$

$$\mu sm = \frac{2sm}{1 + sm^2} \qquad (\ 0.3 - 0.7)$$

Ex 1) A 3-phase ,5.5kw,4-pole,50HZ,1455 rpm IM. its stand still rotor impedance is Z2=0.8+j4 and rotor short circuit current is 60A.neglect the friction and winding losses and find 1)Ts/Tr ,2)Ts/Tm

Sol:-

$$n1 = \frac{60F}{P} = 1500rpm \quad , \quad Sr = \frac{no - n}{no}, sr = \frac{1500 - 1455}{1500} = 0.03$$

$$sm = \frac{R2}{X2} = \frac{0.8}{4} = 0.2 \quad Pcu2 = Pm \ \frac{sr}{1 - sr} = 5500 \, . \frac{0.03}{1 - 0.03} = 170w$$

$$Pcu2 = 3I2r \ R2 \quad or \ \ I2r = \sqrt{\frac{Pcu2}{3R2}} = \sqrt{\frac{170}{3 \times 0.8}} = 8.4A$$

$$\mu s = \frac{Ts}{Tr} = \left(\frac{Isc}{I2r}\right)^2 Sr = \left(\frac{60}{8.4}\right)^2 0.03 = 1.2$$

$$\mu m = \frac{Tm}{Tr} = \frac{sm^2 + sr^2}{2sr\ sm} = \frac{0.2^2 + 0.03^2}{2*0.2*0.03} = 3.4$$

$$\frac{T_S}{T_M} = \frac{T_S}{T_r} X \frac{T_r}{T_M} = 0.35$$

Or $\mu sm = \frac{2S_m}{1 + {S_m}^2}$

Ex2) The synchronous speed of 4-pole,50HZ,3-phase IM drops by 4% at full load ,its rotor standstill impedance is 0.2+j0.8 .find the full load output power and Ts if Tm=100 N-M

Sol:-

$$n1 = \frac{60f1}{p} = 1500\text{rpm} \quad \text{Sr} = 0.04 \qquad N\text{r} = 1440\text{rpm}$$

$$Sm = \frac{R2}{X2} = \frac{0.2}{0.8} = 0.25$$

$$\mu m = \frac{Tm}{Tr} = \frac{Sm^2 + Sr^2}{2Sm\ Sr} = \frac{0.25^2 + 0.04^2}{2 \times 0.25 \times 0.04} = 3.205$$

$$Tr = \frac{Tm}{\mu m} = \frac{100}{3.205} = 31.2 \ \ N.M$$

$$P2 = \frac{2\pi n}{60} Tr = 2\pi\ \frac{1440}{60}\ .31.2 = 4700\omega$$

$$\mu sm = \frac{Ts}{Tm} = \frac{2\ sm}{1 + sm^2} = \frac{2 \times\ 0.25}{1 + 0.25^2} = 0.47$$

$$Ts = \mu sm\, Tm = 0.47 \times 100 = 47\ N.M$$

Ex3) A 3-phase , 4-pole,1 5kw ,50HZ,1455 rpm Im.its rated slip is 3%and stand still rotor impedance is (0.2+j0.8) find the max. torque and the speed at which occurs.

Sol:-

$$n1 = \frac{60F1}{P} = 1500\text{rpm}, n = (1 - 0.03)1500 = 1455rpm$$

$$Sm = \frac{R2}{X2} = \frac{0.2}{0.8} = 0.25$$

$$Tr = \frac{P2}{\omega} = \frac{60 \times 15000}{2\pi \times 1455} = 98.5\ N.M$$

$$\mu m = \frac{Tm}{Tr} = \frac{Sm^2 + Sr^2}{2Sm\ Sr} = \frac{0.25^2 + 0.03^2}{2 \times 0.25 \times 0.03} = 4.77$$

$$Tm = Tr \times \mu m = 98.5 \times 4.77 = 470\ N.M$$

The speed at which the max. Torque occurs

$$nm = (1 - sm)n1 = (1 - 0.25)1500 = 1125rpm$$

Ex4) A 3-phase ,SRIM having stand still rotor impedance is (0.2 +j0.6) Ω/phase . find the value of the additional resistance to be added to the rotor winding in order to increase the starting torque to ↑75% of the max. torque.

Sol:-

$$\frac{Ts}{Tm} = \frac{2sm}{1 + sm^2} = 0.75$$

$$0.75sm^2 - 2sm + 0.75 = 0$$

$$sm = \frac{2 \pm\ \sqrt{2^2 - 4 \times 0.75 \times 0.75}}{2 \times 0.75} = 0.45$$

$$sm = \frac{Rt}{X2} = \frac{R2 + R_{add}}{X2} = 0.45$$

$$R_{add} = 0.6 \times 0.45 - 0.2 = 0.07\Omega$$