EQUIVALENT CIRCUIT OF AN INDUCTION MOTOR

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The equivalent circuit of most practical use is shown in Figure 1 for one star connected winding, where: Vs is supply voltage per phase; I_1 is supply and stator current per phase; I_2 is rotor current per phase; X_m is magnetising reactance of the complete iron core, which represents the flux that passes across the air gap between the stator and the rotor; Rc is resistance representing the iron core eddy current loss. In some situations the manufacturer may add to this a component to represent friction and windage so that the calculated efficiency and power factor more closely match their measured values when the motor is tested in the factory; R_1 is stator winding resistance: X_1 is stator winding reactance; R_2 is rotor winding resistance; X_2 is rotor winding reactance; R_{out} is rotor resistance that represents the power delivered to the shaft.

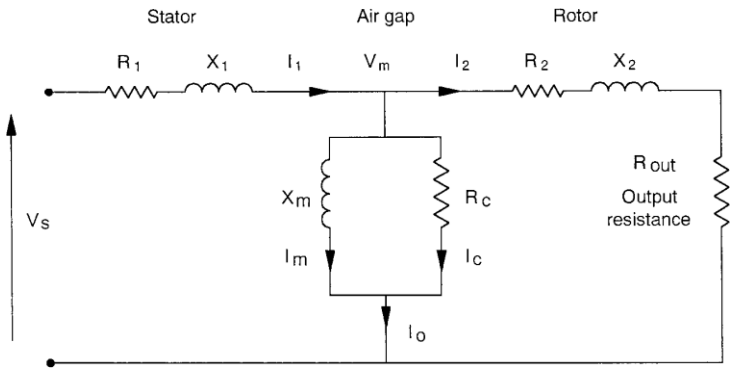

Figure 1

This equivalent circuit takes account of the turns ratio between the stator and the rotor if all the rotor resistances and reactance are given in the data as 'referred to the stator' values. The circuit can be used with actual quantities such as ohms, amps and volts, or in their 'per-unit' equivalent values which is often more convenient. This approach is customary since it easily corresponds to measurements that can be made in practice when tests are carried out in the factory. The resistance R_2 and reactance X_2 are designed by the manufacturer to be functions of slip, so that they take advantage of what is called the 'deep-bar' effect. If the rotor bars are set deep into the surface of the rotor then the rotor resistance R_2 is not so influenced by surface eddy currents, and the rotor leakage reactance X_2 is relatively high due to the depth of the slot which gives a low reluctance path across the slot sides for the flux produced by the bars. Conversely if the conductors are set near to the surface then R_2 becomes high and X_2 becomes low for a given slip. Some special motors actually have two separate cages in their rotors. These are called 'double-cage' motors and are used for driving loads that have high and almost constant torques, such as conveyor belts and cranes. Modern motors utilise the principle of deep bars by designing bars that are shaped rather than simple round bars. The shapes, or cross-sectional areas, are arranged to be narrower at the surface than at their bases. Manufacturers tend to have their own preferences for the shapes and geometries of the rotor bars.

References: 1. Handbook of Electrical Engineering: For Practitioners in the Oil, Gas and Petrochemical Industry. Alan L. Sheldrake, 2003 John Wiley & Sons, Ltd.