Model Design Document – AC Motor (Electrical)

Note: For other organizations, use the appropriate title and address.

Technical Memo

Model Design Document
AC Motor (Electrical)

4/21/2016

Prepared by
Thomas Stubbs

Verified by
Rod Leonard

REVISION HISTORY

Version Number	Date	Comments
1.0.0	4/21/2016	Initial documentation for AC motor model in Electrical discipline

Table of Contents

1 Functionality

1.1 Model Capabilities

1.1.1 Functional description

The AC Motor is used in the electrical discipline to simulate the amount of power consumed to produce the torque requested from the motor in the mechanical discipline. In the mechanical discipline, the motor acts as a source. In the electrical discipline, the motor acts similarly to an electrical load.

This device is capable of requesting power from electrical sources. The equipment has an attribute, "Rated Electrical Power", that specifies the maximum power the motor should draw. This attribute should be set to the value appropriate for the actual equipment that it represents. During simulation, the user will be warned if the electrical power to the motor exceeds the "Rated Electrical Power." The port attributes specify the voltage, current type, and frequency. These attributes will need to match the port attributes of all the equipment that it is connected.

The "Actual Electrical Power" attribute defines how much electrical power the motor requests when driving a load. The actual electrical power is determined from the motor's efficiency and the "Mechanical Power Supplied" (Actual Mechanical Power).

$$P_{Electrical} = \frac{P_{Mechanical}}{\varepsilon}$$

The general power-flow system of equations used is of the form shown in *Eq. 1.1*. The solver can use a variety of methods to solve this system, such as Gauss-Seidel or Newton-Raphson to solve for the *V* vector.

$$S = V \cdot \sum_{k=1}^{n} Y_k^* \cdot V_k^* \qquad \textit{Eq. 1.1}$$

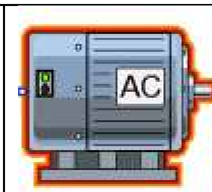
The length of *S* and *V* vectors is equal to the total number of nodes *n*, and the *Y* matrix is of size *n* x *n*. From the individual model's perspective, *n* represents the total number of ports in the model, under the assumption that they may each be connected to a different node. If multiple ports are shorted into the same node, the solver is responsible for combining the equations into one node equation.

Load models are responsible for supplying the value of *S*. The model is therefore represented by *Eq. 1.2*.

$$S = -ActualElectricalPower \qquad \textit{Eq. 1.2}$$

1.1.2 Control Modes

Notional	State	Non-notional
	Offline	

	Online	

1.1.3 Special Actions

Double Clicking

Double clicking the motor icon causes the motor to cycle between the online and offline states. For instance, if the motor is double clicked while the "Online" attribute is set to true, then the attribute will become false (taking the motor offline) and vice versa.

1.1.4 Cross-Discipline Effects

The AC Motor in the electrical discipline is used to model the amount of electrical power required to supply the amount of power being requested in the mechanical discipline. If a load that the motor is providing power to in the mechanical discipline changes, then the amount of power that the motor needs to provide will likewise change. In essence, this means that the amount of power that the motor needs in the electrical discipline will also change.

Due to the inefficiencies of the motor there will be losses in the form of heat. Therefore, an equivalent motor model exists in the thermal disciplines in order to model the cooling requirements of the motor. The amount of power needed to cool the motor is the difference between the "Actual Electrical Power" and the "Actual Mechanical Power".

1.1.5 Operating range limitations

This model produces results even when it is being operated out of the bounds set by the "Rated Electrical Power" attribute. The user will need to pay attention to warnings in order to determine if the motor is being properly used.

1.2 Fault Modeling

1.2.1 Simulation Events

Electrical Power Greater Than Rating

This event is raised by the simulation model whenever the "Actual Electrical Power" produced by the motor is greater than the setting for the "Rated Electrical Power" attribute. An example is shown in Figure 1.

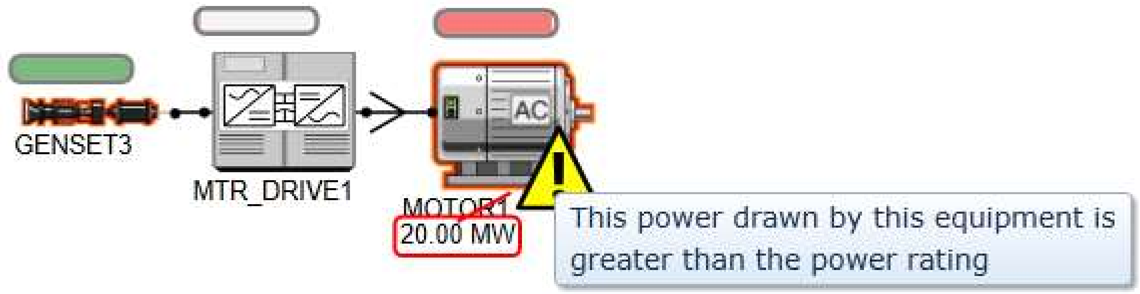


Figure 1. An example of the "Electrical Power Greater than Rating" simulation event. The amount of power being drawn by the motor is greater than the "Rated Electrical Power" attribute value.

2 Analytical Methods

2.1 General Algorithms

This equipment is modeled as a ZIP load-flow model. This model provides a negative constant power injection.

The solver uses the constant power injection provided to solve for system steady-state voltages at every node as well as currents and power flow through every branch using known algorithms such as Gauss-Seidel and Newton-Raphson methods.

2.2 Analytical Capabilities

Steady-State, load-flow analysis.

3 Data

3.1 Attributes

3.1.1 Equipment Attributes

Actual Electrical Power

Defines how much power the motor is requesting from the system in the current context. This value is calculated from the analysis results of the Machinery Designer. The Actual Mechanical Power and the Efficiency are used to calculate this value.

Efficiency

Defines the percentage of power that will be successfully converted from electrical energy to mechanical energy. The losses are modeled as heat. The heat will need to be transferred from the equipment using the motor model in the Thermal Designer.

Electrical Percent Power Efficiency Curve

The result of this curve yields the efficiency value. The values used to calculate percent of power is the Actual Electrical Power and Rated Electrical Power.

$$\varepsilon\left(\frac{P_{Actual}}{P_{Rated}}\right)$$

For example, as shown by the figure below, if the actual power is 60% of the rated power, the resulting efficiency of the motor will be 96%.

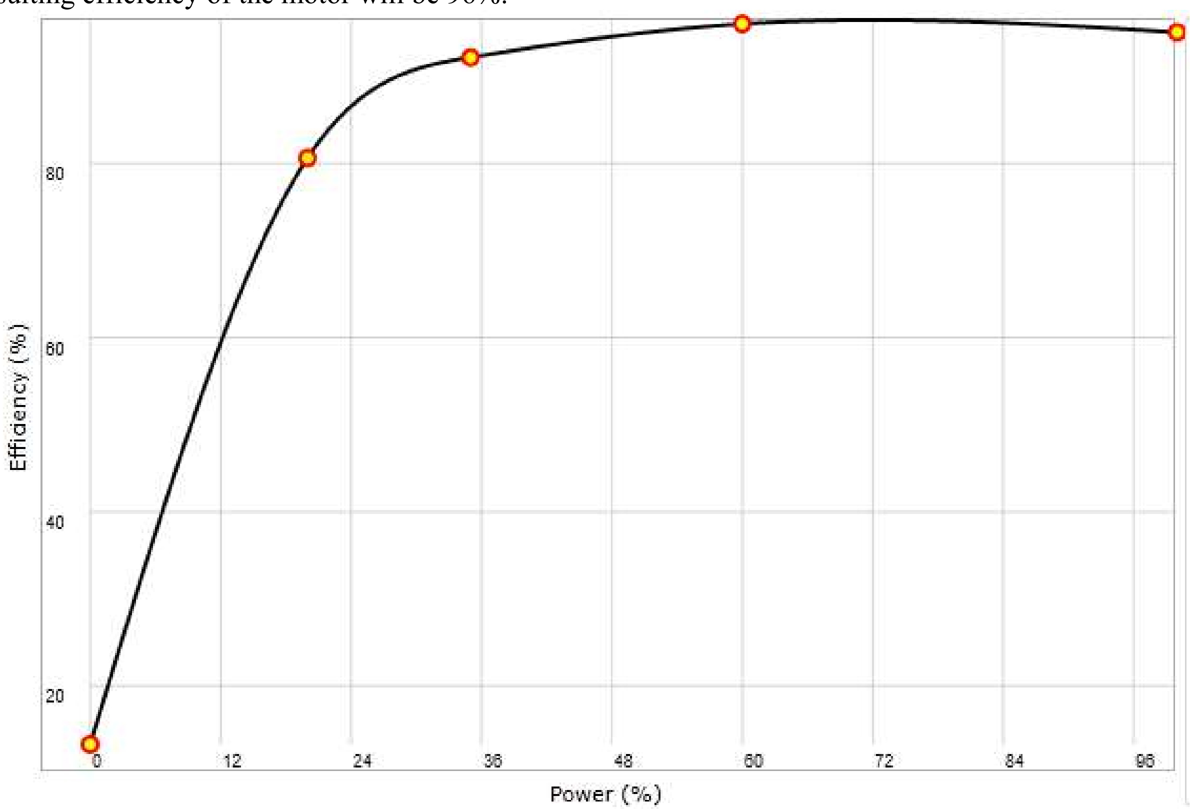


Figure 2 An example of the "Electrical Percent Power Efficiency Curve" attribute from which the equipment's efficiency will be derived, depending on its current operating point.

Online

If this attribute is set to true the motor will request power from the system. If this attribute is set to false, the motor will not request power from the system. This attribute can manually be changed by editing the attribute in the property tab or by double clicking the icon as described in section 1.1.3.

Rated Electrical Power

This attribute defines the maximum amount of power the equipment is capable of drawing. As indicated in the Model Limitations section, the equipment will continue to operate if the power drawn is above the Rated Electrical Power but the user will be notified by the Simulation Event "Electrical Power Greater Than Rating." The rated electrical power can be modified as long as the equipment that it is being modeled is notional and not representative of an actual device.

3.1.2 Port Attributes

Current Type [AC or DC]

This attribute specifies the type of current produced (Alternating Current or Direct Current) at a specific electrical port. In this case, the current type for the motor will be AC. The user will be warned if they attempt to connect the motor to equipment with that requires DC current.

Rated Frequency [Hz]

This attribute specifies the frequency of the electrical port. Typically, this will be 60Hz.

Rated Voltage [kV]

This attribute specifies the voltage requested at the electrical port. Attempting to simulate equipment connected at the same nodes that have different voltages specified for this port will produce a connection error.

4 User Guidelines

4.1 Test Cases

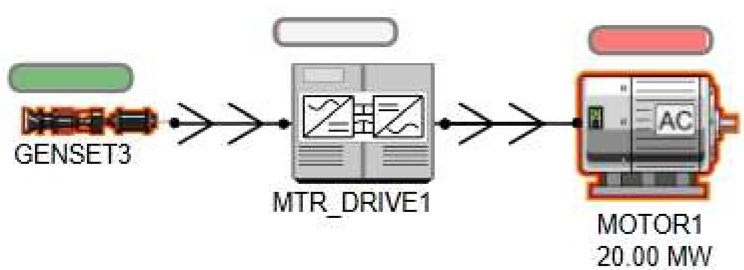


Figure 3 Genset providing power to a motor via a motor drive

Appendix A: Abbreviations and Acronyms

Acronym List	
ZIP	Standard steady-state load-flow model. Constant impedance (Z), constant current (I), constant power (P).