Analysis of an Electromagnetic Clutch

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Abstract: ***The clutch is an important part in the transmission system of automobiles. It transmits power from the engine to gear box at various speeds. The function of the clutch is to temporarily disconnect the engine from the gear box unit. When the gear has to be changed from the first to the second, it should be done after disconnecting the engine from the gear box. If this is not done, the gear teeth might break. The clutch is thus helpful when starting, shifting gears and idling. The electromagnetic clutch is very important in vehicles and machinery to transmit the power from driving member to driven member by using clutch linkage. Already the electromagnetic clutch exists, but that clutch has number of problems like wear problem, slipping problem and complicated linkages. The difference Between the electromagnetic clutch and regular clutch is the way they control the movement of pressure plate. In normal clutch spring used to engage the clutch whereas in EM clutch an electromagnetic field is used for engagement. The electromagnetic clutch comes in various form including magnetic particle clutch and multi disc clutch. But the most widely used form is a single face friction clutch.***

Keywords: electromagnetic clutch, idling, Magnetostatic module, kinematic results

1. Introduction

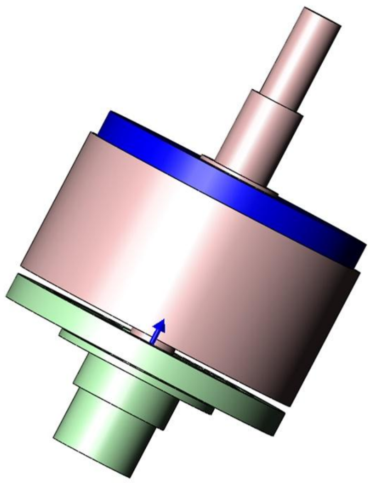
The main components of EM clutch shown in the figure below (Figure 2) are a coil shell, an armature, rotor, and hub. The armature plate is lined with friction coating. The coil is placed behind the rotor. When the clutch activated the electric circuit energizes the coil, it generates a magnetic field. The rotor portion of clutch gets magnetized. When the magnetic field exceeds the air gap between rotor and armature and then it pulls the armature toward the rotor. The frictional force generated at the contact surface transfer the torque. Engagement time depends on the strength of magnetic fields, inertia, and air gap. When voltage is removed from the coil, the contact is gone. In most design a spring is used to hold back the armature to provide an air gap when current is removed.

Application-They can be used for remote application because they do not require linkage to actuate the clutch. They are used in printing machinery, conveyor drives, copier machines and factory automation. In an automobile, it replaces clutch pedal by a simple switch button. A smaller EM clutch is used to drive the compressor of air conditioning system.

2. Description of the Problem

When a coil is excited, an electromagnetic force is induced causing the pulling of armature to the rotor. This example treats this kind of phenomena. A motion study is setup using SW motion then the Magneto static Study of EMS is coupled to it. The EMS solver and the motion solver will be communicating at each step to exchange information about the force and location of the plunger. EMS will calculate the force at the initial position then the force value is passed to the SW Motion, which in turn takes the force value, applies it to the plunger, calculates the new position and then sends it back to EMS. Then, EMS solver recalculates the force based on the new location and so on. Both solvers keep going back and forth until all steps are covered.

The Magnetostatic module of EMS coupled with the Solid Works Motion is used to compute and visualize the flux density and the motion of the armature. After creating a motion analyses in SW and a Magnetostatic study in EMS, four important steps shall always be followed: 1 - apply the proper material for all solid bodies, 2- apply the necessary boundary conditions, or the so called Loads/Restraints in EMS, 3 - mesh the entire model and 4- run the solver.

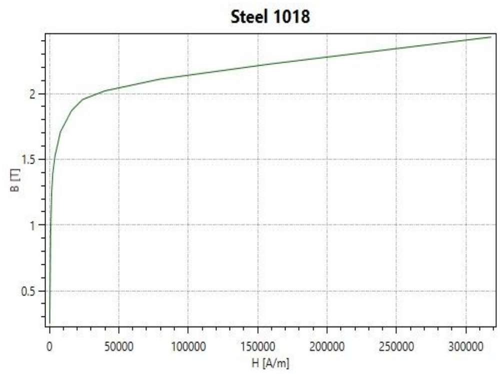


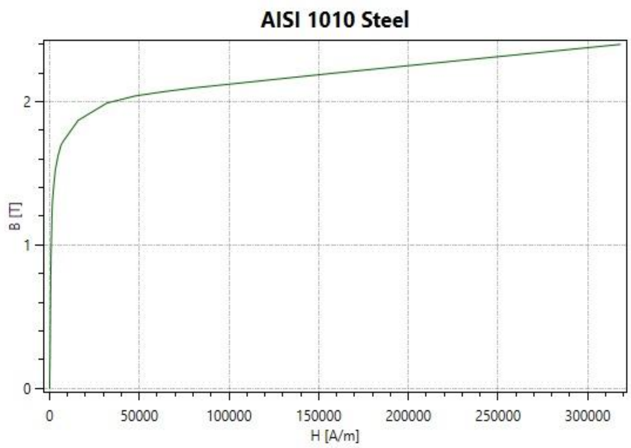
3. Materials

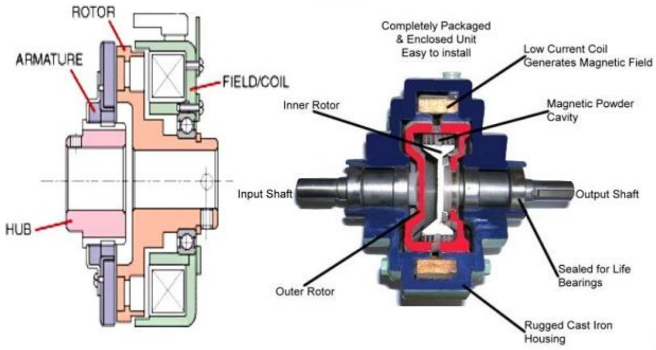
In the Magnetostatic Analysis of EMS, the required Material property is the Relative Permeability

Components/Bodies	Material	Relative Permeability
Coil	Copper	0.999991
Shell Coil	AISI 1010 steel	Non linear
Inner Air	Air	1
Band	Air	1
Armature	AISI 1010 Steel	Non linear
Hub	Steel 1018	Non linear
Rotor	AISI 1010 Steel	Non linear
Shaft	Steel 1018	Non linear

EMS Materials library contains all the materials properties and allows to users to add other materials they need.







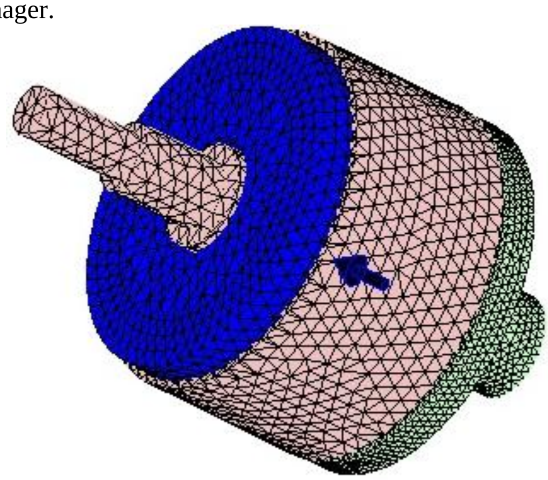
A. MESHING

Meshing is a very crucial step in the design analysis. EMS estimates a global element size for the model taking into consideration its volume, surface area, and other geometric details. The size of the generated mesh (number of nodes and elements) depends on the geometry and dimensions of the model, element size, mesh tolerance, and mesh control. In the early stages of design analysis where approximate results may suffice, you can specify a larger element size for a faster solution. For a more accurate solution, a smaller element size may be required.

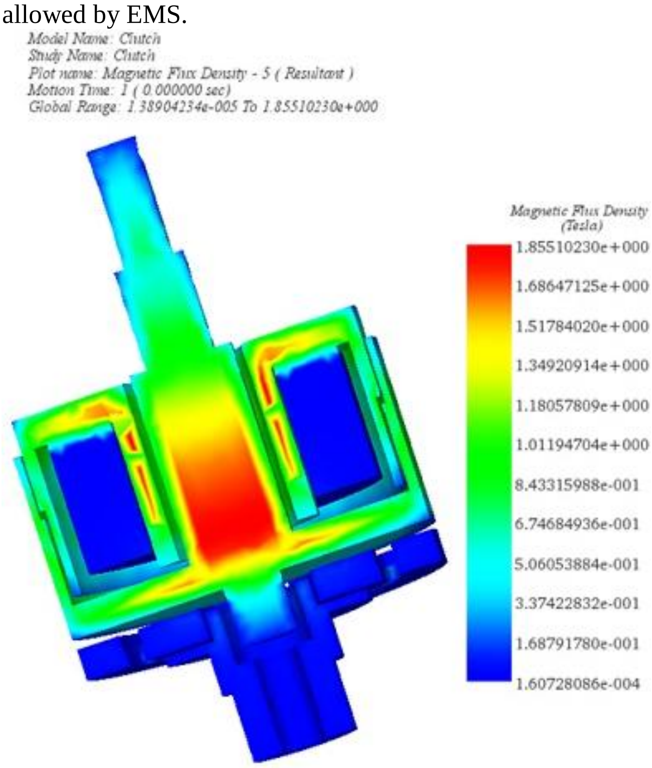
The air region is split into two separate parts: an inner air and an outer air. This strategy is actually recommended for most problems because it allows you to mesh densely around the inner air regions, where the field is significant, and mesh coarsely in the outer air regions, where the field is usually small and decaying. Thus capturing the field variation in the relevant areas without requiring a very large number of mesh elements. In the study with motion coupling we should use a component named Band around the moving parts. This technique allows the re-meshing of the moving parts and the Band in each step of simulation.

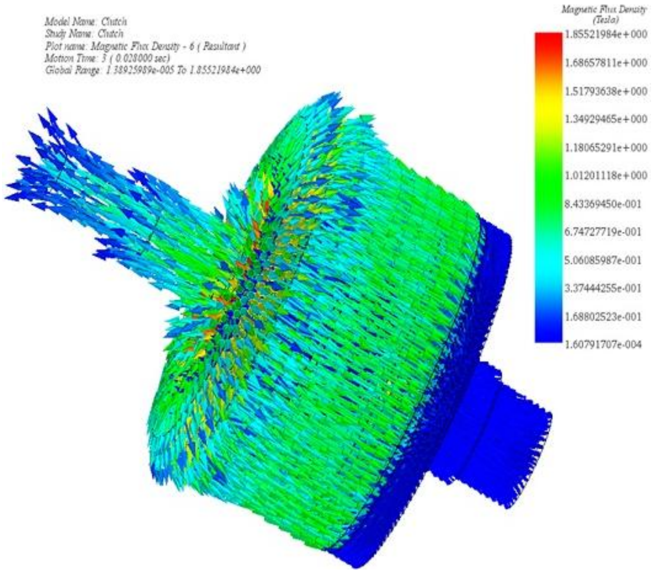
B. Results

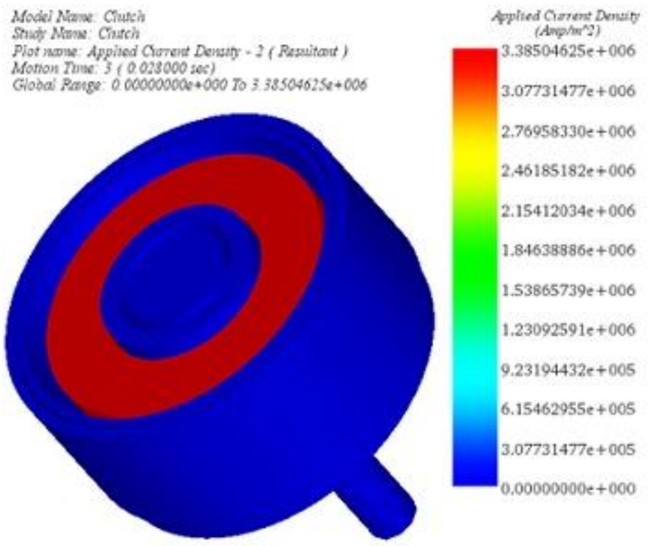
The regular flux, field, current, etc. plots are available in motion studies at each position, i.e. time step. These results can be viewed at each step separately or animated to examine the effect of the motion. Similarly, the tabular results such as force/torque, inductance, flux linkage, etc. can now be visualized at each time step. They can also be plotted versus time, position, speed, and acceleration, e.g. torque vs. speed. Furthermore, the kinematic results such as position versus time can also be visualized right in the tabular results. A more complete motion and kinematics results are readily available in the Solid Works Motion Manager.



After running the simulation of this example we can obtain many results. Magnetostatic Module generate the results of : Magnetic Flux Density Magnetic Field Intensity , Applied Current Density Force density and a results table which contains the computed parameters of the model, the force and the torque … 2D plots and animation for motion also are allowed by EMS.







4. Conclusion

Electromagnetic simulation in EMS coupled with motion in SW helps engineers to know all the aspect of an electromagnetic clutch. Moreover a thermal coupling in EMS also can provides more necessary information which can be taken to dimension this machine. Hence, in addition of being fully integrated in Solid Works and Inventor, EMS is also accurate and easy to use.

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