Motor-CAD Software

We develop Motor-CAD, the most complete and integrated electrical and thermal motor design software.

Motor-CAD is recognized worldwide as class-leading motor design software, providing integrated and highly accurate electrical, thermal and performance predictions for all your motor design needs.

EMag - An ultra fast 2D finite element module for accurate electromagnetic and electrical performance predictions.

Therm - Combines a lumped circuit and finite element thermal calculation for optimising the cooling system of a machine.

Lab - Works together with EMag and Therm to help develop new design concepts. Provides efficiency mapping and duty cycle / drive cycle transient outputs within a few minutes.





Motor-CAD Scripting Control for Duty Cycle analysis (August 2015)

Description

This document gives a brief description of how the internal Motor-CAD scripting can be used to vary parameters during a duty cycle analysis. This can be useful for example for varying losses, for varying imposed temperatures, varying thermal paths or modifying flow rates using user specified functions.

This tutorial will show an example of the scripting being used to vary the housing water jacket flow rate during a duty cycle.

Model Definition

For this example a default machine geometry will be used. The housing is set to have axial water jacket channels as shown below:

O Motor-CAD v9.3.4	(No File)*			
<u>File Edit M</u> odel	Motor Type	Options Defaults	Ed <u>i</u> tors <u>V</u> i	ew <u>R</u> esults Too <u>l</u> s Li <u>c</u> ence <u>P</u> rint <u>U</u> pdates <u>H</u> elp
🖸 Geometry 📘 W	ìnding 🛛 🗹 I	Input Data 🕹 Temper	atures 🖽 (Dutput Data 🖉 Transient Graph 🌃 Grcuit Editor 🚰 Sensitivity 🜍 Scripting
🖸 Radial 🕂 Axial	° ∞® 3D			
Housing: Water Ja	acket(Axial 🔻	Mounting: Flange	•	Motor-CAD
Slot Type: Parallel	looth 🔻	Rotor Type: Surface I	Parallel 🔻	
Stator Ducts: None	•	Rotor Ducts: None	•	
Stator Dimensions	Value	Rotor Dimensions	Value	
Slot Number	18	Pole Number	4	
Housing Dia	140	Magnet Thickness	4	
Stator Lam Dia	130	Magnet Reduction	0	
Stator Bore	80	Magnet Arc [ED]	140	
Tooth Width	7	Magnet Segments	1	
Slot Depth	18	Airgap	1	
Slot Comer Radius	0	Banding Thickness	0	
Tooth Tip Depth	1	Shaft Dia	25	
Slot Opening	3	Shaft Hole Diameter	0	
Tooth Tip Angle	30			
Sleeve Thickness	0			
Fin Base Thickness	1.5			
Fin Cover Thickness	1.5			
Fin Thickness	2			
Fin Pitch/Thick	5			
Fin Pitch [Calc]	10			
Plate Height	350			
Plate Width	350]		
				Redraw Draw plate Draw base
				Length (56.67,-12.80) mm 11 December 2015 www.motor-design.com

The default housing water jacket settings are used as shown below. For this example have set a flow rate of 0.002m3/s with a coolant of engine oil and the flow passing through all 43 ducts in parallel from front to rear of machine.

O Motor-CAD v9.3.4 (DutyCycleScriptin	ig.mot)*									E	- • •
Eile <u>E</u> dit <u>M</u> odel MotorType <u>O</u> ptions <u>D</u> efaults Editors <u>V</u> iew <u>R</u> esults Too <u>l</u> s Li <u>c</u> ence <u>Print</u> <u>U</u> pdates <u>H</u> elp											
💽 Geometry 🌄 Winding 🔟 Input Data 🚦 Temperatures 🖽 Output Data 🖉 Transient Graph 🐩 Circuit Editor 💱 Sensitivity 📀 Scripting 💥 Flow											
🕸 Cooling 🗮 Losses 🛍 Materials I Interfaces 🕅 Radiation 🔛 Natural Convection 😤 Housing Water Jacket 松 End Space 🖆 Duty Cycle 🟠 Settings 📥 Material dal 💷											
Flow Options Fluid Flow Heat Transfer											
Fluid Data:	Fiuid Fropen	ies.			Cooling Opti	ons:				Channel Data:	
Fluid Volume Row Rate 0.002 Engine Oil (Unused)										Duct Wall Thickness	0
Inlet Temperature:	Thermal Cond	uctivity:	0.1432		Endcap Co	oling Only oling	ivon Sp	oiral ducts		Cutout Width (Average):	7.959
	Density:		876		No Endo	ap Cooling (default)				7.000
	Cp:		1.964		 Separate Endcap 	e Endcap Co Cooling in Se	oling circuits eries			Cutout Height (Average):	2
	Kinematic Viso	cosity:	0.00024		Flow Directi	on:	-			Flow Area (total):	676.2
	Dynamic Visco	osity:	0.2103		Rear ->	Front				Flow Area (per channel):	15.73
	Pr - Prandtl Nu	umber:	2883		Front ->	Rear				Channel Width (Average):	7.859
			2003		Calculate or	nput Numb	er How Chani	nels:		Channel Height (Average):	2
					Input	-				ondrinor noight (tronggo).	2
					Parallel Flow	Pathe	43				
					Number Flow	Channels:	43				
Company	Converting	h Constal	Land	Land	D-	*D=(==it)	Curfman		D 4	Nataa	
component input h?	Correlation	or h[adjust]	Velocity Multiplier	Fluid Velocity	Number	4ne(chit)	Area		n	notes	
Units		W/m2/C	pu	m/s		%	mm ²	W/m2/C	C/W		
Housing [Active]	Channel Correlation [Laminar]	1	1	2.958	39.29	1.708	7.631E04	823.4	0.0159	2	
Housing [Front]	Channel Correlation [Laminar]	1	1	2.958	39.29	1.708	4.663E04	1476	0.0145	3	
Housing [Rear]	Channel Correlation [Laminar]	1	1	2.958	39.29	1.708	4.663E04	669.7	0.0320	2	
			~		. I. D						
			C	neo	CK Da	ata					
					Length				mm 1	1 December 2015 www.r	notor-design.com

O Motor-CAD v9.3.4	(DutyCycleSo	cripting.mot)*		
<u>F</u> ile <u>E</u> dit <u>M</u> odel	Mo <u>t</u> or Type	Options Defaults	Ed <u>i</u> tors <u>V</u>	iew <u>R</u> esults Too <u>l</u> s Li <u>c</u> ence <u>P</u> rint <u>U</u> pdates <u>H</u> elp
🖸 Geometry 📘 W	inding [🚺 li	nput Data ╞ Temper	atures 🖽 (Dutput Data 🛛 🖉 Transient Graph 🛛 🙀 Circuit Editor 🛛 🖓 Sensitivity 💽 Scripting 💢 Flow
🖸 Radial 🕂 Axial	∿ote 3D			
Housing: Water Ja	icket(Axial 👻	Mounting: Flange	•	Motor-CAD
Slot Type: Parallel 1	Footh 👻	Rotor Type: Surface F	arallel 🔻	
Stator Ducts: None	•	Rotor Ducts: None	•	
Stator Dimensions	Value	Rotor Dimensions	Value	
Slot Number	18	Pole Number	4	
Housing Dia	140	Magnet Thickness	4	
Stator Lam Dia	130	Magnet Reduction	0	
Stator Bore	80	Magnet Arc [ED]	140	
Tooth Width	7	Magnet Segments	1	
Slot Depth	18	Airgap	1	
Slot Comer Radius	0	Banding Thickness	0	
Tooth Tip Depth	1	Shaft Dia	25	
Slot Opening	3	Shaft Hole Diameter	0	
Tooth Tip Angle	30			
Sleeve Thickness	0			
Fin Base Thickness	1.5			
Fin Cover Thickness	1.5			
Fin Thickness	2			
Fin Pitch/Thick	5			
Fin Pitch [Calc]	10			
Plate Height	350			
Plate Width	350			
				Redraw
				Length (-28.13,26.56) mm 11 December 2015 www.motor-design.com

This flow is shown in the machine cross sections as shown below:



Have setup a simple duty cycle with a period of 5000 seconds where the machine is operating a 3 times per unit torque as shown below:

🧿 м	otor-C/	AD v9.3.4 ((DutyCycl	eScripting.	.mot)*										
<u>F</u> ile	<u>E</u> dit	<u>M</u> odel	Mo <u>t</u> or Tyj	pe <u>O</u> ptio	ns <u>D</u> efaul	lts Ed <u>i</u> to	rs <u>V</u> iew	<u>R</u> esults	Too <u>l</u> s L	.i <u>c</u> ence <u>P</u>	rint <u>U</u> pdates <u>H</u>	<u>l</u> elp			
0	Geometr	y 📘 Wi	nding 🕐	🕇 Input Dat	a 🖡 Tem	peratures	E Outp	ut Data 🛓	⊻ Transien	t Graph 👖	Circuit Editor 💈	🕻 Sensitivity 🧲	Scripting 🔀	Flow	
*	Cooling	🔆 🔆 Los	ses de	Materials	1 Interface	es 🧐 R	adiation	Natural	Convection	Hous	sing Water Jacket	End Space	庄 Duty Cycle	Settings	Aterial dat
0	Setting	ns 🗜 De	finition												
D	Ity Cyc	de Data:													
	Ē														
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		0	5	00	1,000		1,500	2,00	о Т	2,500 ime [secs]	3,000	3,500	4,000	4,500	5,000
	Ē	Г													
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		ò		500	1,00	0	1,500	2,	000	2,500 Time [sec:	3,000 \$]	3,500	4,000	4,500	5,000
P	Period	Bapsed Time	Time	Points	Torque	Speed [Start]	Speed [End]	Fault	Ambient Temp [End]	Altitude [End]					
	Units	secs	secs		pu 🗈	rpm 🗈	rpm 🗈		C 🗈	m 🗈					
	1	5000	5000	100	3	3000	3000		40	0					
	uty Cy	cle Contro	ol:					Detric					emal Duty Cycle D)ətə:	
		Add Per	riod		Remo	ve Perio	1	Toral	ae ⊔aαa Den ue (Fixed) - S	inition: Speed	Duty Cycle pu or Va	aue input: Eu	e: No File Selecte	d	
								C Loss	- Speed		🕑 pu		oad Data	Save Data	Clear Data
	Check Data Torque (Variable) - Speed Value Save External Duty Cycle Data in mot file														
															1
										Length	(-45.44,7	1.30)	mm 11 Dece	mber 2015 w	ww.motor-design.com

Run the transient analysis by clicking on the transient graph tab. The transient temperatures are shown below. It can be seen that the machine reaches a steady state operating point with the winding hotspot at 174C.



Adding water jacket flow control using scripting

The water jacket pump in this application is to be switched off 2500 seconds into the duty cycle. This pump control can be added using the internal scripting.

The internal scripting engine uses ActiveX to communicate with Motor-CAD. It is important that ActiveX has been enabled. This is done from the menu->Defaults->Register for ActiveX->Multiple Clients:



The ActiveX parameter names can be obtained from menu->Help->ActiveX parameter names. The list can be searched and filtered to find the required parameter names as shown below:

🤨 ActiveX Par	ameters								×
Search Text: Filter:	: Find Next Direction: ○ Up : housing Matches: 1157 ◎ Down		n: View: Inputs Outputs n Inputs and Outputs	Save To File	Ref	resh Close Win	dow		
Number	Input/Outpu	ActiveX Name		Category	Units	Current Value	Data Type	Des	<u>^</u>
21	i/p	InitialHousingTemperature		Calc_Options	С	40	double	The	
98	i/p	HousingWJ_Fan_Definition	n	Water_Jacket_Data		0	byte	The	
99	i/p	HousingWJ_Shaft_Speed		Water_Jacket_Data	фm	3000	double	The	
100	i/p	WJ_Fluid_Volume_Flow_I	Rate	Water_Jacket_Data	m ³ /s	0.002	double	The	
104	i/p	TVent_HousingCircDucts		Through_Vent		True	boolean	Whe	
108	i/p	HousingWJ_RotorWJ_Co	nnection	Calc_Options		False	boolean	Whe	
109	i/p	HousingWJ_SprayCooling	_Connection	Calc_Options		False	boolean	Whe	-
114	i/p	TVent_HousingWJ_Conn	ection	Calc_Options		False	boolean	Whe	
117	o/p	TVentStatorDucts		Through_Vent		0	byte	The	
438	i/p	IncludeWJDuctWallFrictio	n	Water_Jacket_Data		True	boolean	Whe	
439	i/p	WJ_Duct_Wall_Roughne	ss_Active	Water_Jacket_Data	mm	0.0025	double	The	
440	i/p	WJ_Duct_Wall_Roughness_Front		Water_Jacket_Data	mm	0.0025	double	The	
441	i/p	WJ_Duct_Wall_Roughne	ss_Rear	Water_Jacket_Data	mm	0.0025	double	The	
503	o/p	HousingWJ_Channel_CS.	Area_A_Calculated	Water_Jacket_Data	mm ²	15.7262794527731	double	The	
504	i/p	HousingWJ_Channel_CS	Area_A_Adjustment	Water_Jacket_Data	mm ²	0	double	This	
505	o/p	HousingWJ_Channel_CS	Area_A	Water_Jacket_Data	mm ²	15.7262794527731	double	The	
506	o/p	HousingWJ_Channel_CS.	Area_F_Calculated	Water_Jacket_Data	mm ²	15.7262794527731	double	The	
507	i/p	HousingWJ_Channel_CS	Area_F_Adjustment	Water_Jacket_Data	mm ²	0	double	This	
508	o/p	HousingWJ_Channel_CS	Area_F	Water_Jacket_Data	mm ²	15.7262794527731	double	The	
509	o/p	HousingWJ_Channel_CS	Area_R_Calculated	Water_Jacket_Data	mm ²	15.7262794527731	double	The	
510	i/p	HousingWJ_Channel_CS	Area_R_Adjustment	Water_Jacket_Data	mm ²	0	double	This	
511	o/p	HousingWJ_Channel_CS.	Area_R	Water_Jacket_Data	mm ²	15.7262794527731	double	The	
512	o/p	HousingWJ_Channel_CS	Area_L1_A_Calculated	Water_Jacket_Data	mm	0	double	The	
513	i/p	HousingWJ_Channel_CS	Area_L1_A_Adjustment	Water_Jacket_Data	mm	0	double	The	
514	o/p	HousingWJ_Channel_CS	Area_L1_A	Water_Jacket_Data	mm	0	double	The	
515	o/p	HousingWJ_Channel_CS	Area_L1_F_Calculated	Water_Jacket_Data	mm	0	double	The	
516	i/p	HousingWJ_Channel_CS	Area_L1_F_Adjustment	Water_Jacket_Data	mm	0	double	The	
517	o/p	HousingWJ_Channel_CS	Area_L1_F	Water_Jacket_Data	mm	0	double	The	_
	,			w		-		-	1

Similarly the ActiveX commands are also available from menu->Help->ActiveX commands:

O ActiveX Methods	
Method	Description
LoadFromFile(filename)	load a *mot data file
SaveToFile(filename)	save to a *mot data file
SetVariable(variablename, value)	set input variable
SetArrayVariable(array variablename, index, value)	set input array variable (array range [1.n])
GetVariable(variablename, value)	get value for variable
GetArrayVariable(array variablename, index, value)	get value for array variable (array range [1.n])
GetNodeTemperature(NodeNumber, value)	get temperature of specified node number
GetNodeCapacitance(NodeNumber, value)	get capacitance of specified node number
GetNodePower(NodeNumber, value)	get power on specified node number
GetNodeToNodeResistance(NodeNumber, NodeNumber, value)	get resistance between specified node numbers
GetNodeExists(nodeNumber)	returns true if node already exists, false if node does not exist
GetOffsetNodeNumber(NodeNumber, AxialSlice, CuboidNumber, value)	gets the node number value of a node for specified slice (1n) and cuboid (1n), return -1 if does not exist
GetMagneticGraphPoint(graphNumber, pointNumber, xValue, yValue)	Gets the x and y values for a point from a specified graph series
Do Steady State Analysis	carry out steady state calc
DoTransientAnalysis	cany out transient calc
Do Slot Finite Element	cany out slot finite element analysis
DoMagneticCalculation	cany out magnetic calculation
Do Magnetic Thermal Calculation	carry out coupled magnetic and themal calculation
DoWeightCalculation	calculate the component weights
Speed_Import_Export	run Speed from Motor-CAD
ShowMessage(messagestring)	show a message on the screen
Quit	quit Motor-CAD
SetVisible(boolean)	sets Motor-CAD visible or not
DisplayScreen(screenname)	Sets which screen to display (Losses, Schematic, Radial, Axial, FE, Scripting, Circuit Editor, StatorWinding, DutyCycleDefinition, Control)
AvoidImmediateUpdate(boolean)	set to true to speed up the setting of inputs, the steady state calc will only now be calculated when DoSteadyStateAnalysis is called
DisableErrorMessages(boolean)	set to true to display message in message display window, when set false user must respond when messages are displayed
ShowMagneticContext	call this method to display the magnetic context
ShowThermalContext	call this method to display the thermal context
ClearDutyCycle	clears the duty cycle
LoadDutyCycle(fileName)	loads a duty cycle from a file
SaveDutyCycle(fileName)	saves the duty cycle to a file
•	

To control the housing water jacket flow have written the script shown below.

The **CurrentTime** parameter gets the current time in the duty cycle. The water jacket flow rate is set using the **WJ_Fluid_Volume_Flow_Rate** parameter.

Note: all parameters used in ActiveX are in SI units.

Before running the script in the duty cycle it is best to test the script itself by running using the Run button shown below:

O Motor-CAD v9.3.4 (DutyCycleScripting.mot)*				
<u>File Edit Model Motor Type Options Defaults Editors View Results Tools Licence</u>	<u>P</u> rint <u>U</u> pdates <u>H</u> elp			
💽 Geometry 🌄 Winding 🕅 Input Data 🗼 Temperatures 📰 Output Data 📈 Transient Graph	Circuit Editor	ity 📀 Scripting 💢 Flow		
Script Control:	Status:			
Run Pause Stop None (default)	10:27:48 : Script Ended			*
Run before Analysis	10:27:48 : Script Ended 10:27:49 : Script Ended			
Save Load Run during Analysis	10:42:08 : Resume Requested			
Script file: No File Selected	10:42:08 : Script Ended			-
1 II avample Semint				
2 ' this is the main function called by when the run script bu	tton is pressed			
3 ' the function is passed the current title of the motor proj	ect			
4 Function MainFunction (Title)				
5 dim mcad				
<pre>6 set mcad = createobject("motorcad.appautomation")</pre>				
7	an an an de			
 speed up the set by setting to avoid immediate update of 1 call mcad avoidImmediateUndate(true) 	nput			
10				
11 ' display the messages in a separate window				
12 call mcad.SetVariable("ERROR_MESSAGES_DISABLED",1)				
13				
14 'get the current time in the duty cycle				
15 call mcad.GetVariable("currentlime", currentlime)				
17 if currentTime < 2500 then				
18 ' time before 2500 set flow rate to 2e-3 m3/s				
19 call mcad.SetVariable("WJ_Fluid_Volume_Flow_Rate", 2e-3)				
<pre>20 call mcad.showmessage("WJ_Fluid_Volume_Flow_Rate = " + CSt</pre>	r(2e-3))			
21 else				
22 ' time after 2500 set flow rate to 0 m3/s				
<pre>23 call mcad.SetVariable("WJ_Fluid_Volume_Flow_Rate", 0) 24 call mcad showmeesage("WJ_Fluid_Volume_Flow_Rate = " + CSt</pre>	r (D))			
R5 end if	- (9/)			
26				
27 End Function				
28				
29				
30				
Saving File Completed	Length	(-45.44,71.30)	mm 11 December 2015	www.motor-design.com

If the script has run successfully it can then be added to the duty cycle calculation. This is done by selecting the **Run during Analysis** option shown below:

O Motor-CAD v9.3.4 (DutyCycleScripting.mot)* <u>File Edit Model Motor Type Options D</u> efaults Editors <u>V</u> iew <u>R</u> esults Tools Ligence	<u>Print Updates Help</u>	
💽 Geometry 🌄 Winding 📝 Input Data 🖡 Temperatures 🧮 Output Data 📂 Transient Graph	🗽 Circuit Editor 🖓 Sensitivity 📀 Scripting	
Script Control: Run Pause Stop Soript Control: None (default) Gras bafore. Analysis Script file: No File Selected	Status: 10.2724 8: Script Ended 10:2749 : Script Ended 10:2749 : Script Ended 10:42:08 : Resume Requested 10:42:08 : Script Ended	
<pre>1 '' example Script 2 ' this is the main function called by when the run script bu 3 ' the function is passed the current title of the motor proj 4 Function MainFunction (Title) 5 dim mead 6 set mead = createobject ("motorcad.appautomation") 7 7 8 ' speed up the set by setting to avoid immediate update of i 9 call mead.AvoidImmediateUpdate(true) 10 11 ' display the messages in a separate vindov 12 call mead.SetVariable("ERROR_MESSAGES_DISABLED",1) 13 14 ' get the current time in the duty cycle 15 call mead.GetVariable("CurrentTime", currentTime) 16 17 if currentTime < 2500 then 18 ' time before 2500 set flow rate to 2e-3 m3/s 19 call mead.SetVariable("WJ_Fluid_Volume_Flow_Rate",2e-3) 20 call mead.SetVariable("WJ_Fluid_Volume_Flow_Rate = " + CSt 22 ' time after 2500 set flow rate to 0 m3/s 23 call mead.showmessage("WJ_Fluid_Volume_Flow_Rate = " + CSt 45 67 End If 67 67 End Function 28 29 30</pre>	tton is pressed ect nput r (2e-3)) r (0))	
	Length (-45.44,71.30) mm 11 December 2015 ww	vw.motor-design.com

Now when the transient analysis is run the script will be run for each step of the transient analysis. Can see the increase in the machine temperatures after 2500 seconds when the housing water jacket flow is stopped:



Conclusion

This example shows how the internal scripting inside Motor-CAD can be used to vary the housing water jacket flow rate. The internal scripting in Motor-CAD provides a great degree of flexibility for customising transient duty cycles.

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