

## Axial Channel Water Jacket cooling

### Description

This document gives a brief description of how to set up a Motor-CAD model for an axial channel water jacket cooled machine.

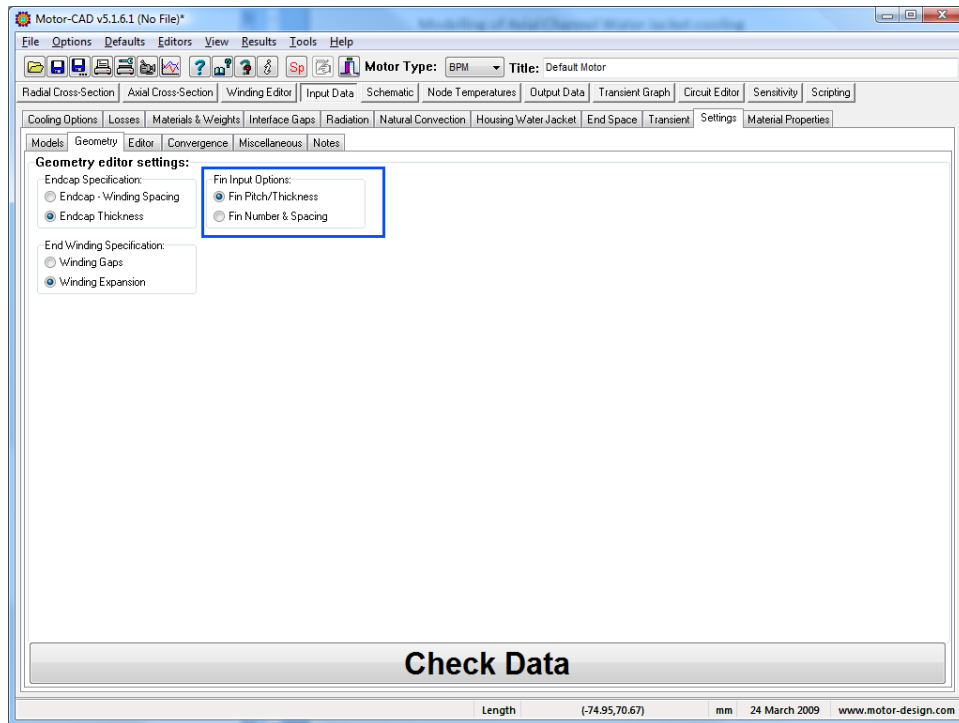
### Setting up the housing and axial channels

The housing type should be set up to be covered axial fins as shown below.

The number and size of the fins can be set using the parameters given. The fin pitch is calculated from the fin thickness and fin pitch/thickness ratio.

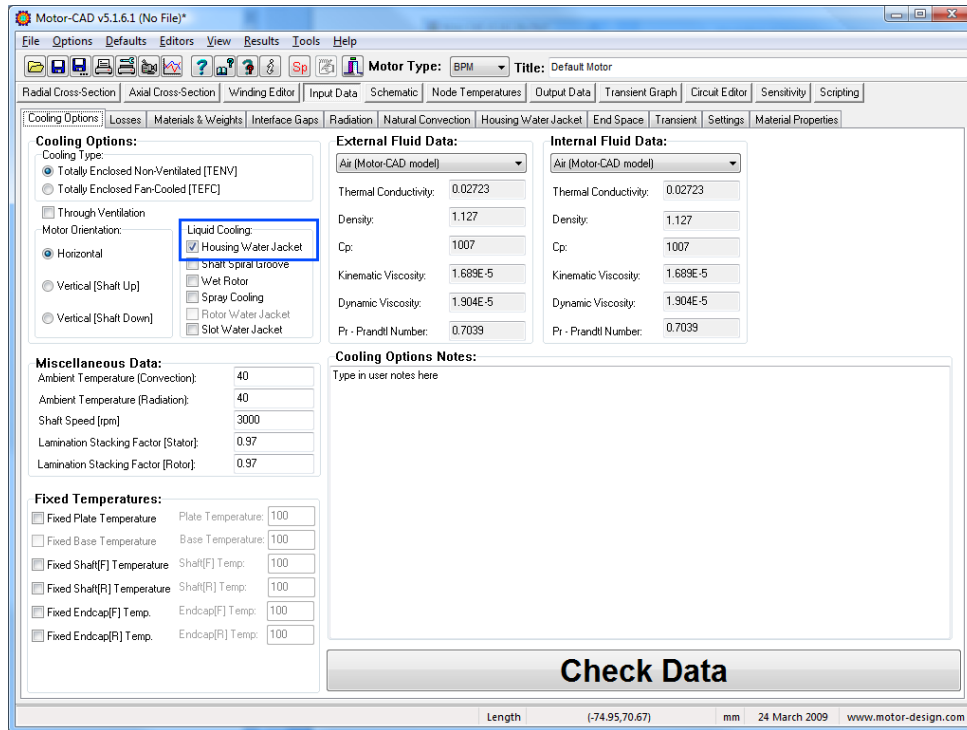
Stator Dims.	Data	Rotor Dims.	Data
Slot Number	18	Pole Number	6
Housing Dia	140	Magnet Thickness	4
Stator Lam Dia	130	Magnet Arc [ED]	140
Stator Bore	80	Airgap	1
Tooth Width	7	Banding Thickness	0
Slot Depth	18	Shaft Dia	25
Slot Corner Radius	0	Shaft Hole Diameter	0
Slot Opening	3		
Tooth Tip Depth	1		
Tooth Tip Angle	30		
Sleeve Thickness	0		
Fin Base Thickness	1.5		
Fin Cover Thickness	1.5		
Fin Thickness	20		
Fin Pitch/Thick	3		
Fin Pitch [Calc]	80		
Plate Height	350		
Plate Width	350		
Stator Ducts	0		
Stator Duct Ratio	0.7		
Stator Duct Gap	2.5		

The fin size can also be set using fin number and spacing by setting the option shown below.

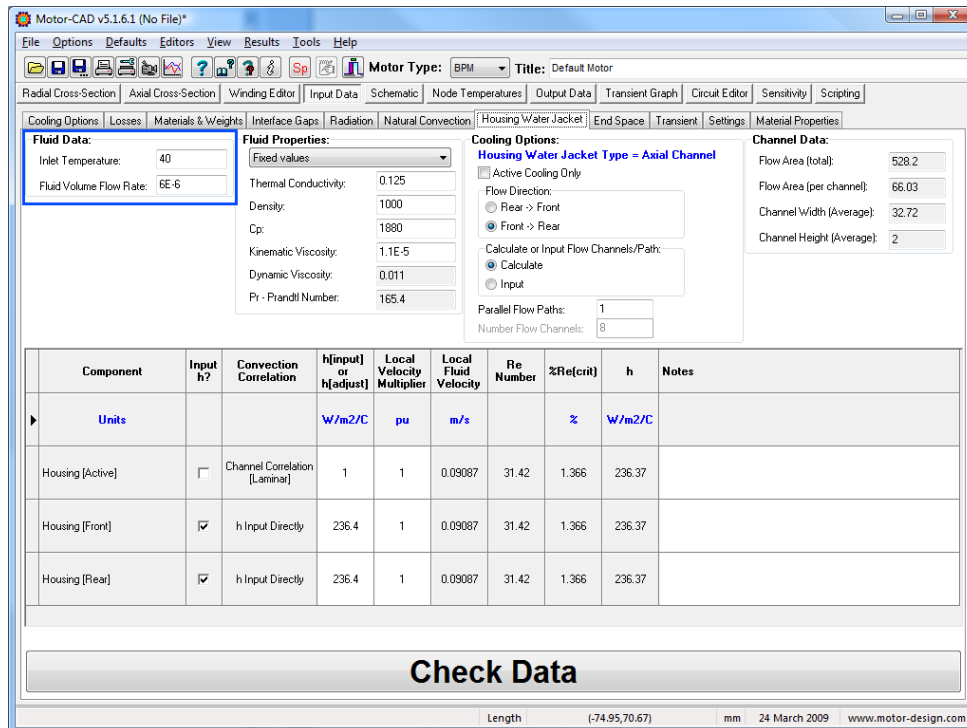


## Setting the water jacket fluid and flow rates

The water jacket cooling option shown below should be set.



The fluid inlet temperature and flow rate is set as shown below.



## Setting up the fluid properties

The fluid properties can be set at fixed values in the table shown below or a fluid selected from the fluids database. If the fluid is selected from the fluid database then the variation in fluid properties with temperature will be considered by Motor-CAD.

**Fluid Data:**  
 Inlet Temperature: 40  
 Fluid Volume Flow Rate: 6E-6

**Fluid Properties:**  
 Thermal Conductivity: 0.6233  
 Density: 992.3  
 Cp: 4178  
 Kinematic Viscosity: 6.58E-7  
 Dynamic Viscosity: 0.0006539  
 Pr - Prandtl Number: 4.383

**Cooling Options:**  
 Housing Water Jacket Type = Axial Channel  
 Active Cooling Only  
 Flow Direction:  
 Rear -> Front  
 Front -> Rear  
 Calculate or Input Flow Channels/Path:  
 Calculate  
 Input  
 Parallel Flow Paths: 1  
 Number Flow Channels: 8

**Channel Data:**  
 Flow Area (total): 528.2  
 Flow Area (per channel): 66.03  
 Channel Width (Average): 32.72  
 Channel Height (Average): 2

Component	Input h?	Convection Correlation	h[input] or Local Velocity	Local Fluid	Re Number	%Re(crit)	h	Notes
Units used in Water Jacket Convection Input Editor								
			W/m2/C	pu	m/s	%	W/m2/C	
Housing [Active]	<input type="checkbox"/>	Channel Correlation (Laminar)	1	1	0.09087	524.5	22.8	1122.1
Housing [Front]	<input checked="" type="checkbox"/>	h Input Directly	1122	1	0.09087	524.5	22.8	1122.1
Housing [Rear]	<input checked="" type="checkbox"/>	h Input Directly	1122	1	0.09087	524.5	22.8	1122.1

**Check Data**

Units used in Water Jacket Convection Input Editor      Length: (-74.95,70.67)      mm      24 March 2009      www.motor-design.com

If the cooling fluid being used is not in the fluid database then a new fluid can be created in the fluid database editor as shown below. An existing fluid can be copied and then modified using the “Copy Fluid” button or a new fluid can be created by entering the name in the list box as shown below and then adding the fluid properties to the tables.

**Thermal properties of Fluids**

Fluids Database:  
 C:\Users\Dougie\Documents\Motor-CAD Data\materials\fluids.mdb

Select Database  
 Create new Database

Permanently Delete the selected fluid:  
 Delete Fluid

Copy the selected fluid:  
 Copy Fluid

Fluid Name	Notes
Air at sea level	Holman data
Brayco Micronic 756	Aviation Hydraulic Fluid - meets MIL-H-5606G
Dynalene HF-LD	Heat Transfer Fluid
EGW 50/50	Ethylene-Glycol/Water - E.Cooling Feb09
EGW 60/40	Ethylene-Glycol/Water - E.Cooling Feb09
Engine Oil (Unused)	Holman data
Mobil Jet Oil II	Gas Turbine Lubricant - meets MIL-PRF-23699
Paratherm LR	Low Range Heat Transfer Fluid
PGW 50/50	Propylene-Glycol/Water - E.Cooling Feb09
PGW 60/40	Propylene-Glycol/Water - E.Cooling Feb09
Skydrol 500 B-4	Aviation Hydraulic Fluid
Skydrol LD-4	Aviation Hydraulic Fluid
UCON HTF500	Heat Transfer Fluid
Water	Pure Water
LucidTherm 300	Heat Transfer Fluid
Copy New Fluid	test fluid

Conductivity    Specific Heat    Density    Kinematic Viscosity

Temperature	Thermal Conductivity
C	W/m/C
#	

Thermal Conductivity

Conductivity [W/m.C]

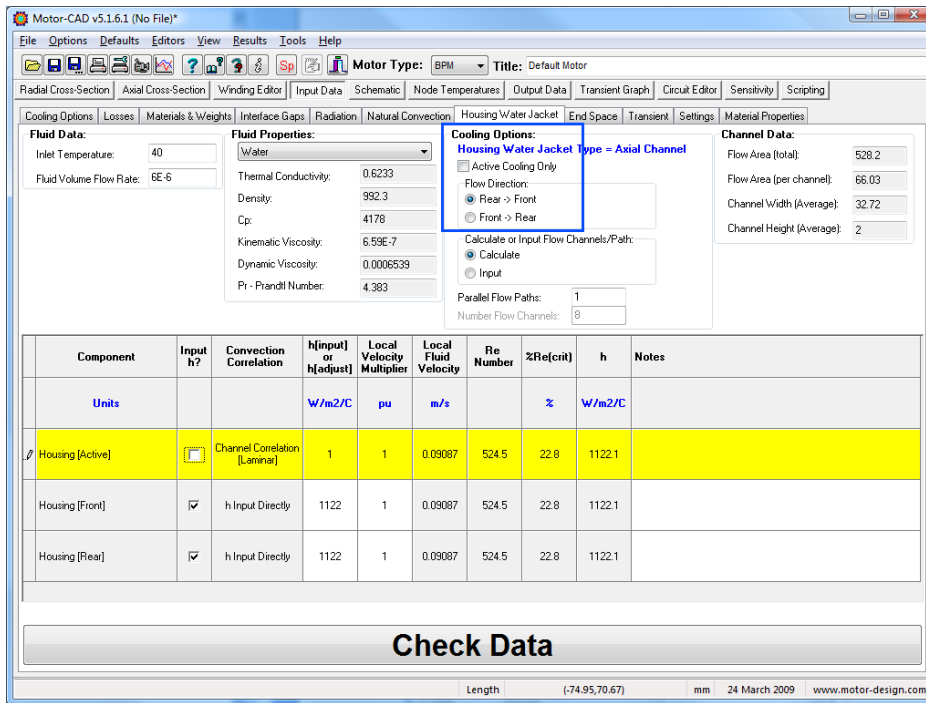
Temperature [C]

Permanently Delete the selected point  
 Delete Conductivity Data Point

Length:      mm      24 March 2009      www.motor-design.com

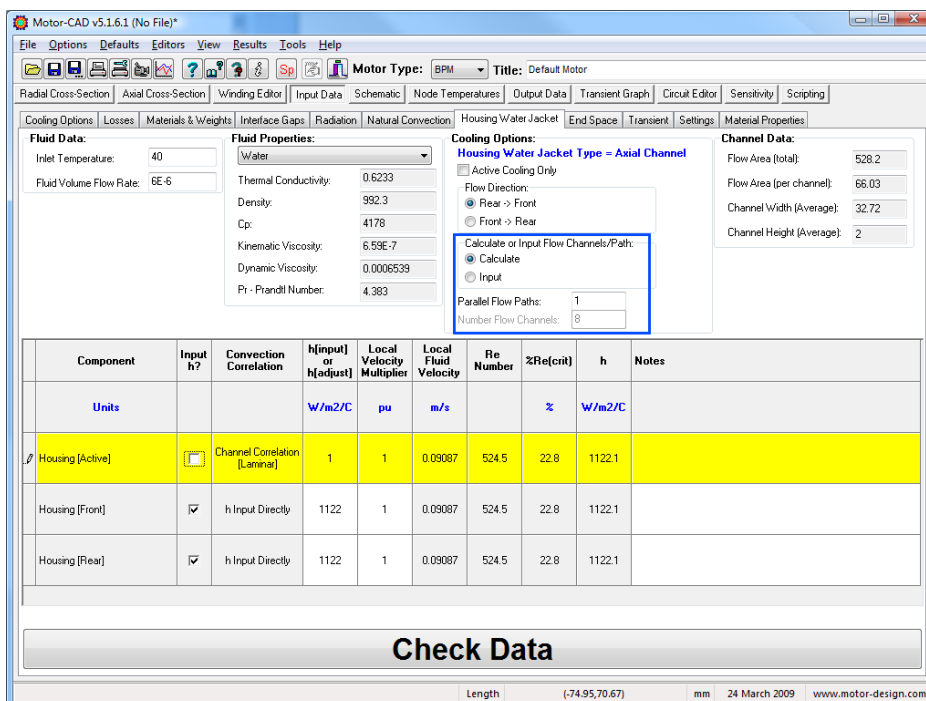
## Defining the flow paths

There are different cooling options available to select the cooling area and the flow direction as shown below.



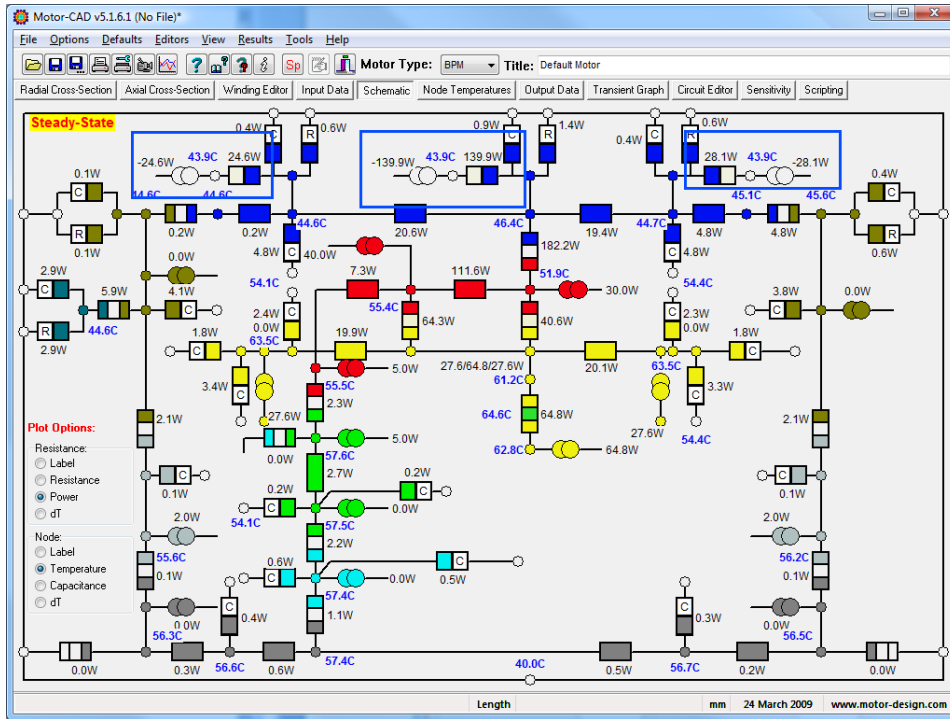
With the “calculate” option set the number of flow channels is calculated automatically from the geometry and shown the the “Number Flow Channels” box.

The number of paths is set using the “parallel flow paths” edit box. With value set at 1 then the flow fill be serpentine passing through the 8 channels in this model in series. In this model if the value is set to 8 then all the 8 channels will be in parallel.



## Viewing the results

The power removed from the machine by the water jacket is shown in the steady state schematic.



The fluid temperatures are shown in the output data sheet as shown below.

Temperature	Value [C]	Temperature	Value [C]	Temperature	Value [C]
T [Ambient]	40	T [Rotor Surface]	57.58	T [Winding Average]	62.93
T [Housing - Active]	46.37	T [Magnet]	57.54	T [Active Winding Average]	62.76
T [Housing - Overhang (F)]	44.59	T [Rotor Lamination]	57.43	T [End Winding Average]	63.12
T [Housing - Front]	44.61	T [Shaft - Center]	57.37	T [Winding Layer = 1]	61.2
T [Endcap - Front]	44.64	T [Shaft Ohang - Front]	56.59	T [Winding Layer = 2]	63.12
T [Bearing - Front]	55.56	T [Shaft - Front]	56.27	T [Winding Layer = 3]	64.24
T [Flange Mounted Plate]	44.57	T [Shaft Ohang - Rear]	56.71	T [Winding Layer = 4]	64.58
T [Housing - Overhang (R)]	44.7	T [Shaft - Rear]	56.49	T [EWdg (F)]	63.48
T [Housing - Rear]	45.11	T [End Space - F]	54.14	T [EWdg (R)]	63.5
T [Endcap - Rear]	45.62	T [End Space - R]	54.38		
T [Bearing - Rear]	56.16	WJ Fluid Inlet Temp [Active]	40		
T [Stator Lam (tooth)]	55.35	WJ Fluid Outlet Temp [Active]	47.75		
T [Stator Lam (back iron)]	51.9	WJ Fluid Average Temp [Active]	43.88		
T [Stator Surface]	55.54	WJ T[Fluid - A] Network	43.88		