Radiation Between Surfaces - Numerical Results

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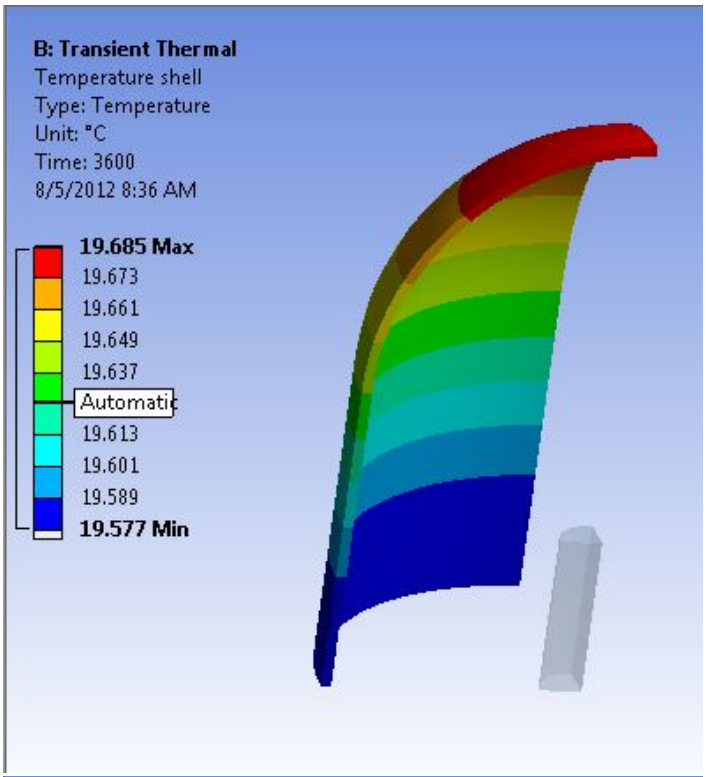
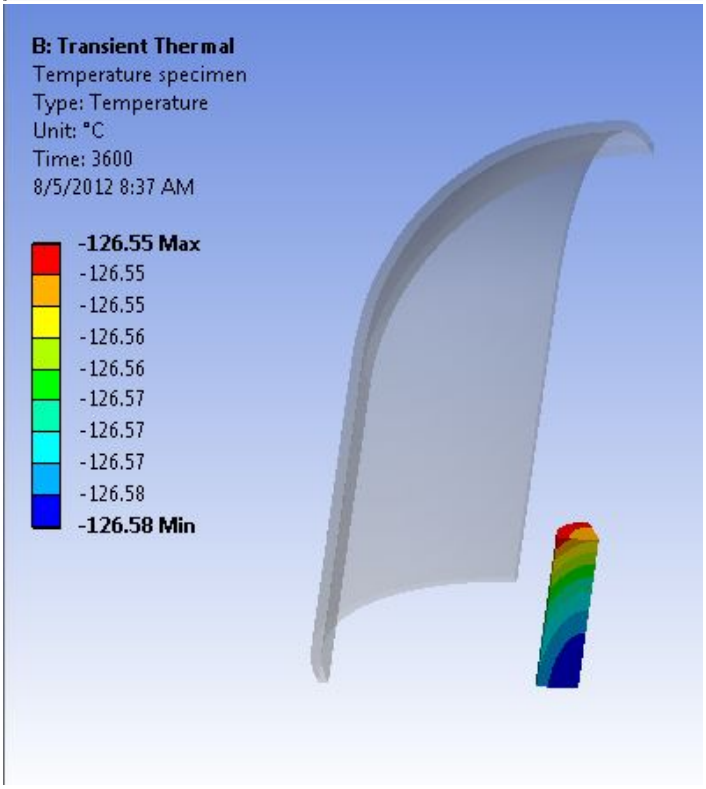
Numerical Results

You may receive a warning that says "The initial time increment may be too large for this problem. Check results carefully." . Our initial time step is set to 36 seconds, which is rather large for transient analysis. The warning can be eliminated by turning off ***Auto Time Stepping*** under ***Analysis Settings*** and manually specify the initial time step.

By the end of end step time, ***3600 seconds***, the shell temperature dropped to approximately 19 degrees Celsius and the specimen temperature rose to approximately -126 degrees Celsius.





We will now examine the radiation heat transfer between the surface of the shell and the specimen. Click on ***Radiation shell*** under the solution tree and expand the ***Tabular Data***, located in the lower right corner.

Energy Balance

The net radiation heat flux of a surface can be found by writing the energy balance equation on the surface.

$$q_r = \varepsilon\sigma T^4 + (1-\varepsilon)q_i - q_i$$

Where

ε is the emissivity

σ is the Stefan-Boltzmann constant

The three radiation terms on the right hand side of the equation represent different types of radiation associated with a given surface.
The first term is the ***emitted radiation***.
The second term is the ***reflected radiation***.
The third therm is the ***incident radiation***.
The sum of these three terms gives the ***net radiation heat flux*** of a surface.

Tabular data of the shell

Tabular Data

	Time [s]	Radiation shell (Net Radiation) [W]	Radiation shell (Emitted Radiation) [W]	Radiation shell (Reflected Radiation) [W]	Radiation shell (Incident Radiation) [W]
1	36.	0.22162	5.5929	1.3433	6.7145
2	72.	0.22104	5.5829	1.3482	6.7101
3	108.	0.22034	5.5739	1.3458	6.6994
4	216.	0.21927	5.5509	1.3401	6.6718
5	540.	0.21743	5.5054	1.3293	6.6173
6	900.	0.21611	5.4732	1.3215	6.5786
7	1260.	0.21518	5.4527	1.3166	6.5542
8	1620.	0.21437	5.4397	1.3136	6.5389
9	1980.	0.21354	5.4316	1.3119	6.53
10	2340.	0.21243	5.4267	1.31	6.5242
11	2700.	0.21064	5.4241	1.307	6.5204
12	3060.	0.20764	5.4232	1.3044	6.5199
13	3420.	0.20375	5.4238	1.3039	6.524
14	3600.	0.2015	5.4245	1.3045	6.5276

Tabular data of the specimen

Tabular Data

	Time [s]	Radiation specimen (Net Radiation) [W]	Radiation specimen (Emitted Radiation) [W]	Radiation specimen (Reflected Radiation) [W]	Radiation specimen (Incide
1	36.	-0.21672	1.5787e-010	0.1434	0.36012
2	72.	-0.21615	2.5421e-009	0.14367	0.35982
3	108.	-0.21547	1.2752e-008	0.14373	0.3592
4	216.	-0.21442	2.0044e-007	0.14327	0.35769
5	540.	-0.21262	7.5851e-006	0.14214	0.35477
6	900.	-0.21134	5.7488e-005	0.14129	0.35269
7	1260.	-0.21042	2.1805e-004	0.14073	0.35138
8	1620.	-0.20964	5.8971e-004	0.14032	0.35054
9	1980.	-0.20882	1.3038e-003	0.13991	0.35004
10	2340.	-0.20774	2.5192e-003	0.13943	0.34968
11	2700.	-0.20599	4.403e-003	0.13901	0.3494
12	3060.	-0.20305	7.1669e-003	0.13901	0.34923
13	3420.	-0.19925	1.0961e-002	0.13906	0.34926
14	3600.	-0.19705	1.3313e-002	0.13898	0.34935

The positive sign indicates heat is being transferred to the surrounding through radiation and the negative sign indicates heat is being absorbed from the surrounding. Because the specimen is so cold compared to the shell, some radiation emitted by the shell is absorbed and stored within the specimen. The specimen emits a very small amount of radiation because its initial temperature is near absolute zero but its emitted radiation gradually increases as the specimen gets warmer with time.

The emitted, reflected, and incident radiation over time are also shown in the tabular data.

Go to Step 7: Verification & Validation

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