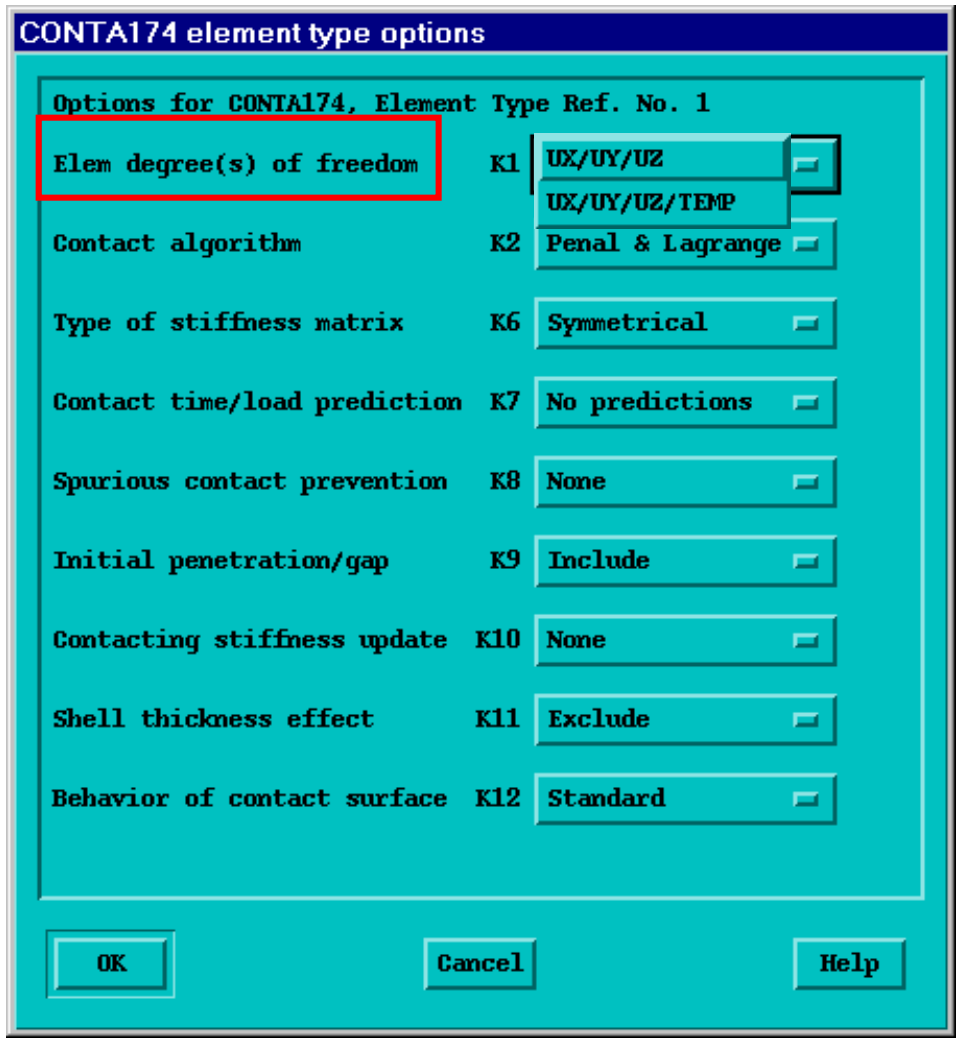
Thermal Contact Development

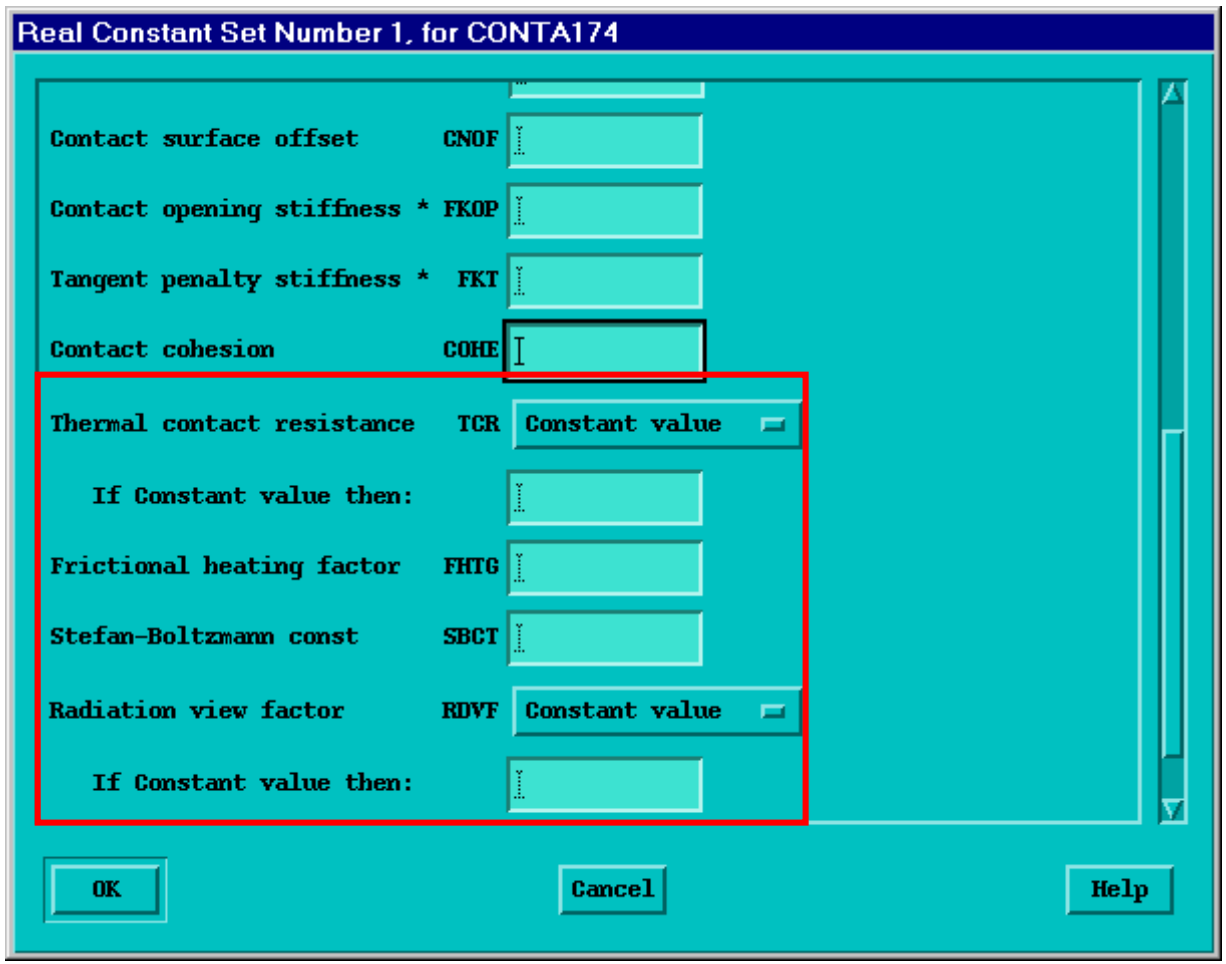
Yongyi Zhu

June. 1999

Activate Thermal Contact



Thermal Contact Parameters



Objectives of Thermal Contact

- Provide general thermal contact analysis capability
- Cover new features that ABAQUS and MARC support
- Support general metalforming and assembly contact applications
- Support lots of typical users who work on gas turbine analysis

Thermal Contact Overview

- Heat conduction between two contacting surfaces
- Heat convection between
  - Free surface to environment
  - Two separated surfaces with small gap
- Heat radiation between
  - Free surface to environment
  - Two separated surfaces with small gap
- Heat generation due to frictional dissipated energy
- Heat flux input

Thermal Contact Overview

- Support 2D/3D thermal contact
  - 2D: CONTA171,172 + TARGT169
  - 3D: CONTA173,174 + TARGT170
  - Target temperature bases on
    - target element nodes if no pilot node
    - pilot node temperature (rigid target with pilot node)
- Support lower/higher order surface-surface contact
- Support rigid-flexible/flexible-flexible contact
- Support coupling transient or static analysis
  - For pure thermal analysis, fix all structural DOF

Heat Conduction

$$q = TCR * (T_T - T_C)$$

- T_T : Target surface temperature
- T_C : Contact point temperature
- *TCR*: Thermal contact resistance (film) coefficient
  - unit: heat/(time*temp*area)
  - allow table input as the function of pressure and temperature
- Active even with gap for no-separate or bonded contact

Heat Convection

$$q = HF * (T_T - T_C)$$

- T_T :
  - Target surface temperature for small gap
    - target must be inside of pinball region
  - Environment temperature
    - free surface, no target surface is detected
    - input by SFE,elem,,CONV,2, T_T
- *HF*: Convection coefficient
  - input: SFE,elem,,CONV,1,HF or user routine USERCV

Heat Radiation

$$q = RAVF * EMIS * SBCT * \left[(T_T + TOFFST)^4 - (T_C + TOFFST)^4 \right]$$

- T_T :
  - Target surface temperature for small gap
    - PINB becomes important
  - Environment temperature
    - input by SFE,elem,,CONV,2, T_T
- *TOFFST:* Temperature offset
- *EMIS*: Emissivity input as material property
- *SBCT*: Stefan-Boltzmann constant constant
- RAVF:View factor as function of gap and temperature

Heat Generation Due to Friction

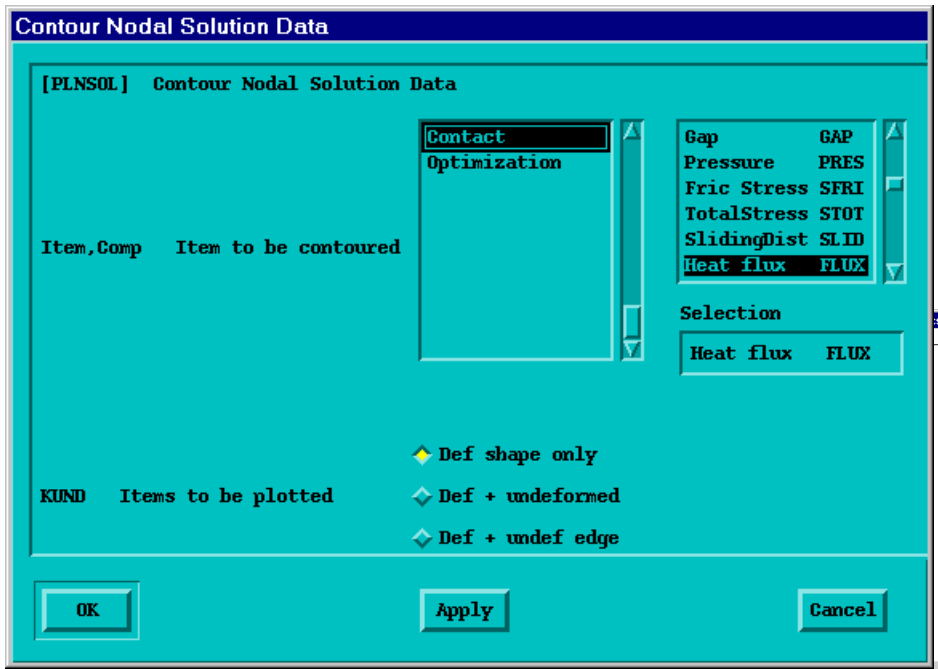
$$q = FHTG * |\tau| * SLDT$$

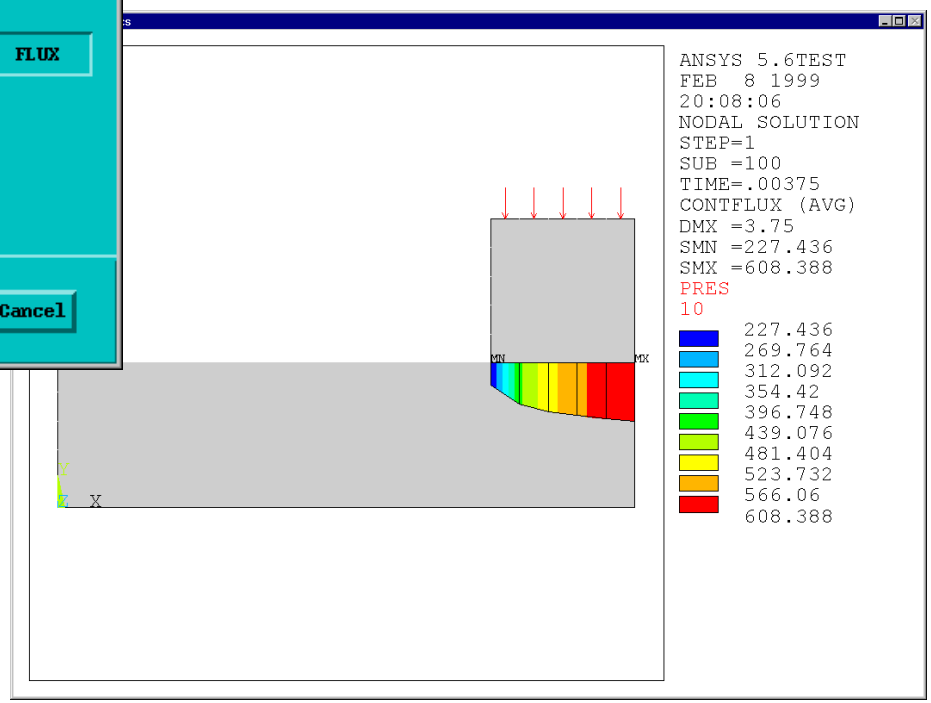
- *SLDT*: Sliding rate
- $|\tau|$: Equivalent frictional stress
- *FHTG*: Fraction of frictional dissipated energy converted into heat (default=1.0)
- Half energy transferred to contact surface, another half to target surface
- Only active for structure-temperature analysis

Pilot Node

- Provides entire rigid target temperature
- Be applied on free thermal contact surface
  - No other target segment
  - Behave as an extra node in SURF19,22
  - No matter the temperature on pilot node
  - Bulk temperature input from SFE
- Monitors reaction heat flow
  - Negative: net heat loss
  - Positive: net heat gain

Post-Processor





- New item FLUX
  - Heat flux
    - Heat flow rate per area

Post-Processor - ETABLE

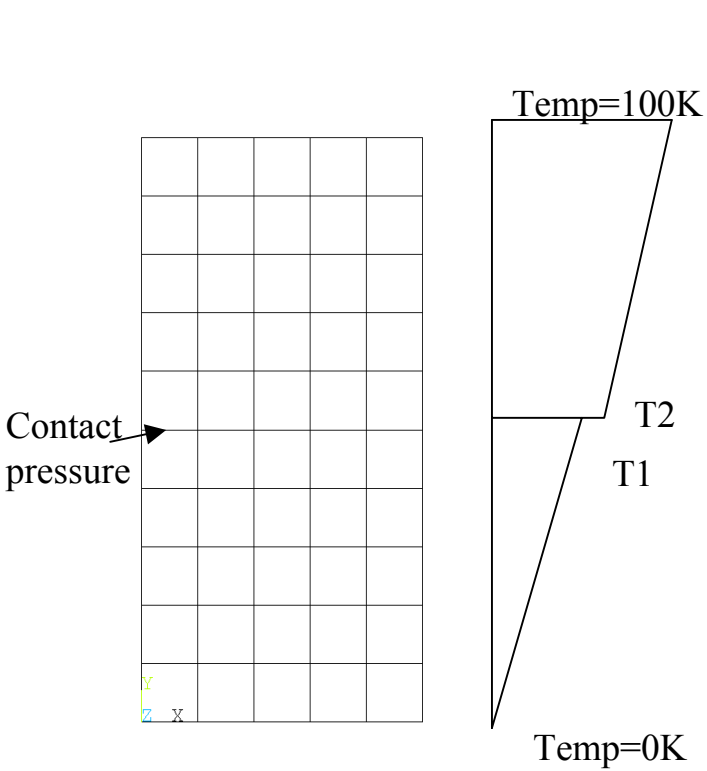
Name	Item	E	I	J	K	L
PRES	SMISC	13	1	2	3	4
TAUR	SMISC	-	5	6	7	8
TAUS	SMISC	-	9	10	11	12
FLUX	**SMISC**	**-**	**14**	**15**	**16**	**17**
FDISS	**SMISC**	**-**	**18**	**19**	**20**	**21**

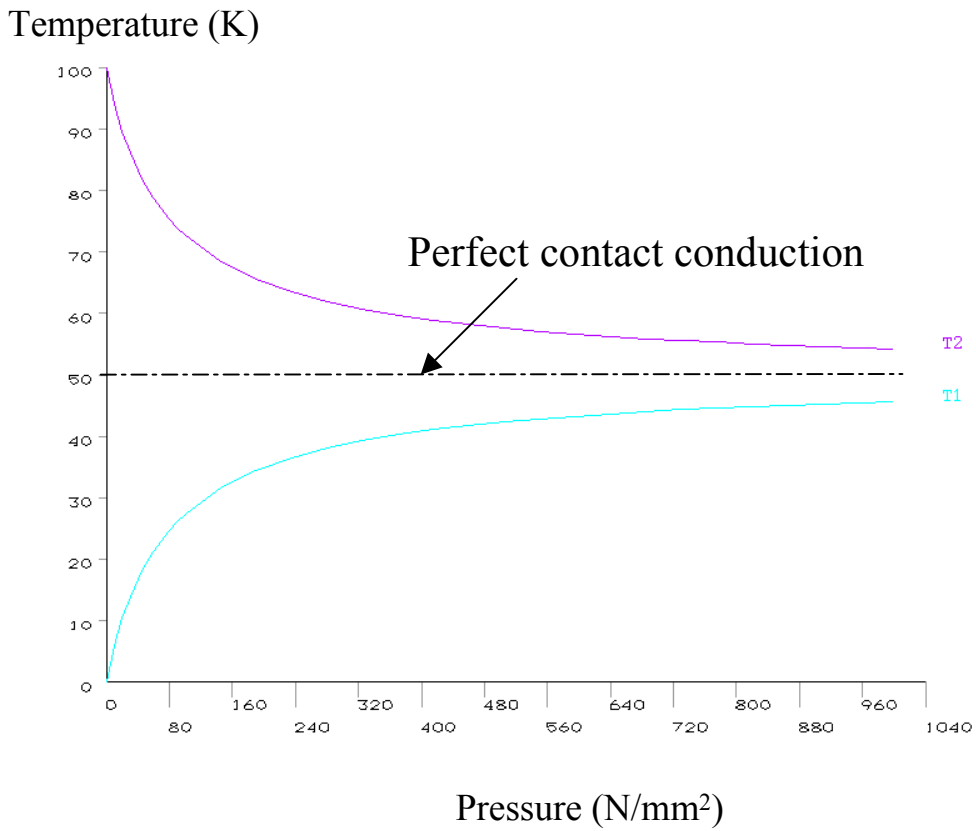
STAT[1]	NMISC	41	1	2	3	4
OLDST	NMISC	-	5	6	7	8
PENE[2]	NMISC	-	9	10	11	12
DBA	NMISC	-	13	14	15	16
TASR	NMISC	-	17	18	19	20
TASS	NMISC	-	21	22	23	24
KN	NMISC	-	25	26	27	28
KT	NMISC	-	29	30	31	32
TOLN	NMISC	-	33	34	35	36
IPENE	NMISC	-	37	38	39	40
PINB	NMISC	42	-	-	-	-
CNTX	NMISC	43	-	-	-	-
CNTY	NMISC	44	-	-	-	-
CNTZ	NMISC	45	-	-	-	-
TRGE	**NMISC**	**-**	**46**	**47**	**48**	**49**
TCR	**NMISC**	**-**	**50**	**51**	**52**	**53**

- FLUX
  - heat flux
- FDISS
  - Dissipation energy of friction
- TRGE
  - Target element number
  - For debug purpose
  - Estimate contact quantities on target surface (or averaging for symmetric contact) through MACO
- TCR
  - Thermal contact resistance coefficient

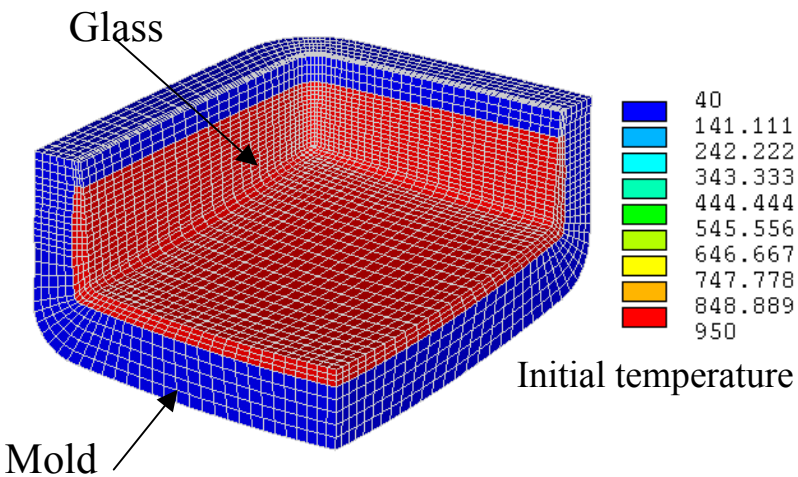
Simple Heat Conduction Problem

$$TCR = 300 * \left(\frac{pressure}{932} \right)^{0.95}$$

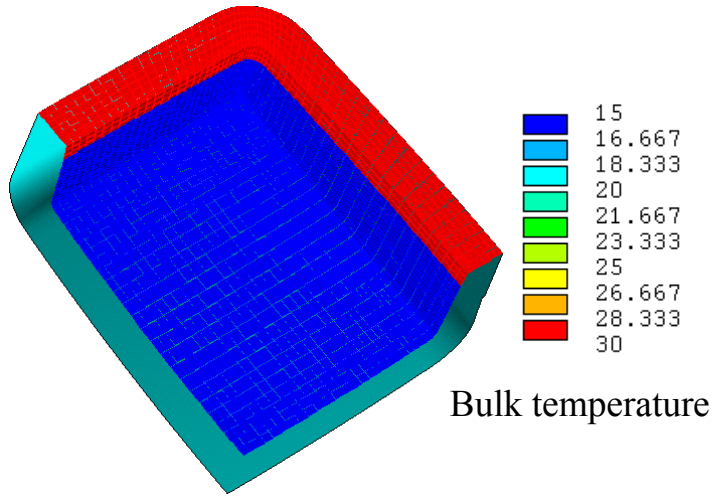




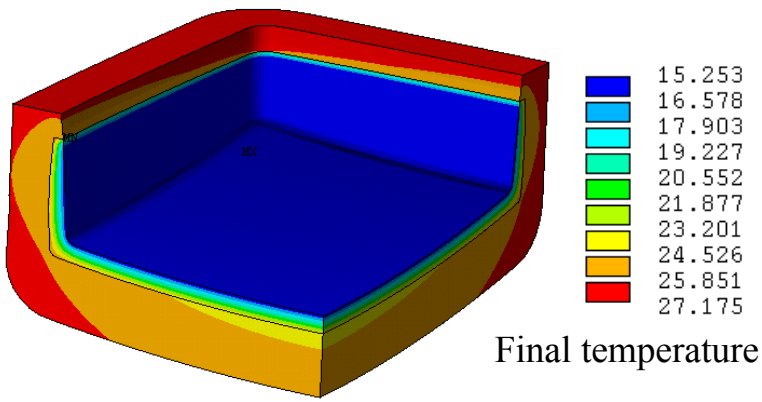
3D Heat Conduction Problem



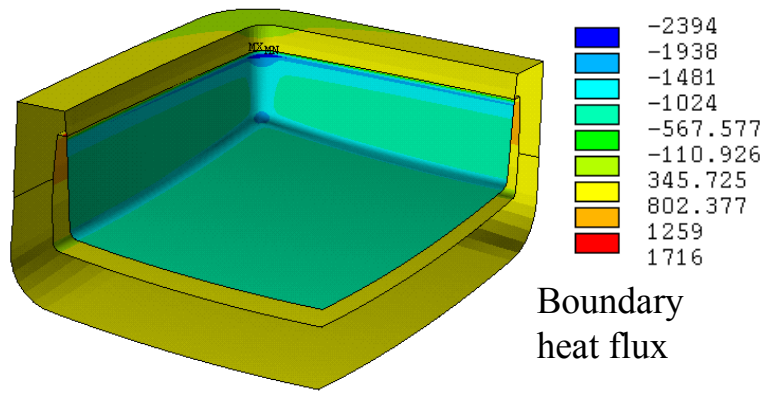
Initial temperature



Bulk temperature



Final temperature

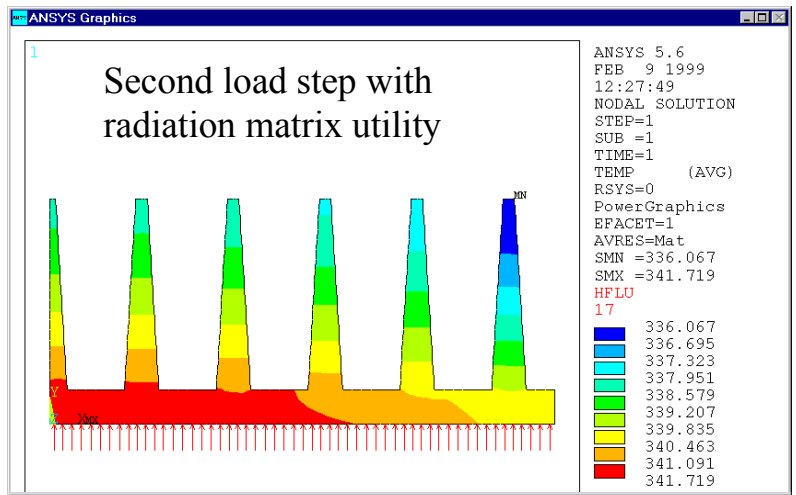


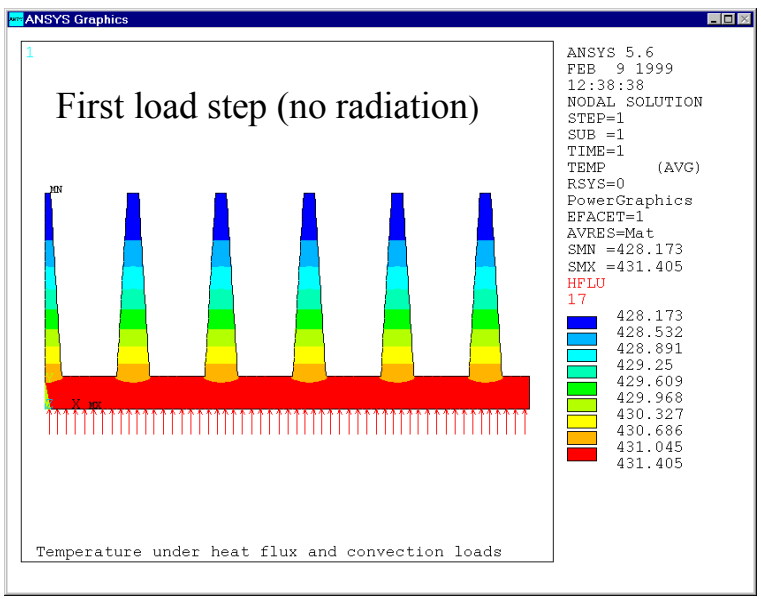
Boundary heat flux

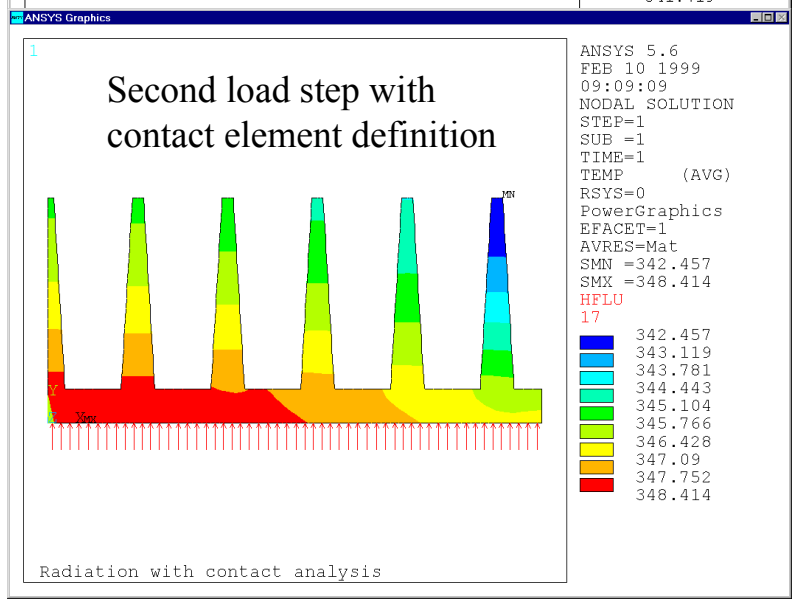
Heat Sink Analysis with Radiation

Loads:

Heat flux
Convection
Radiation
Surrounding Temperature = 90

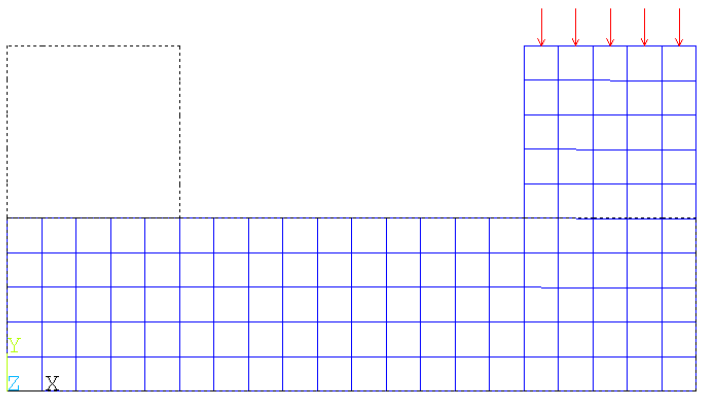


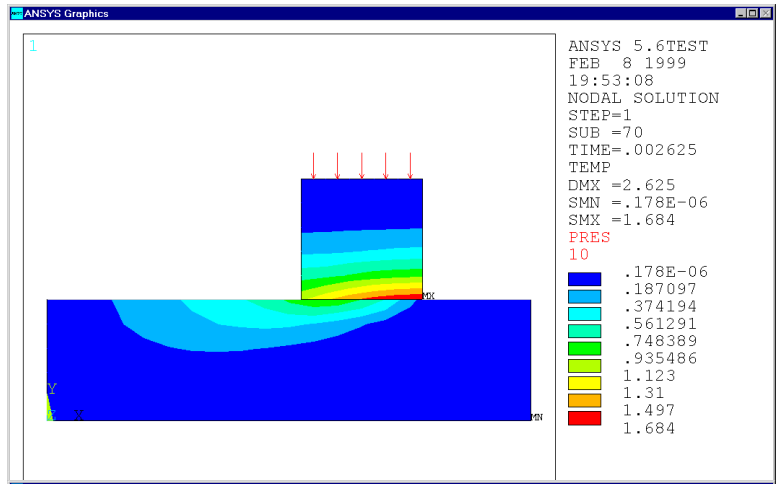


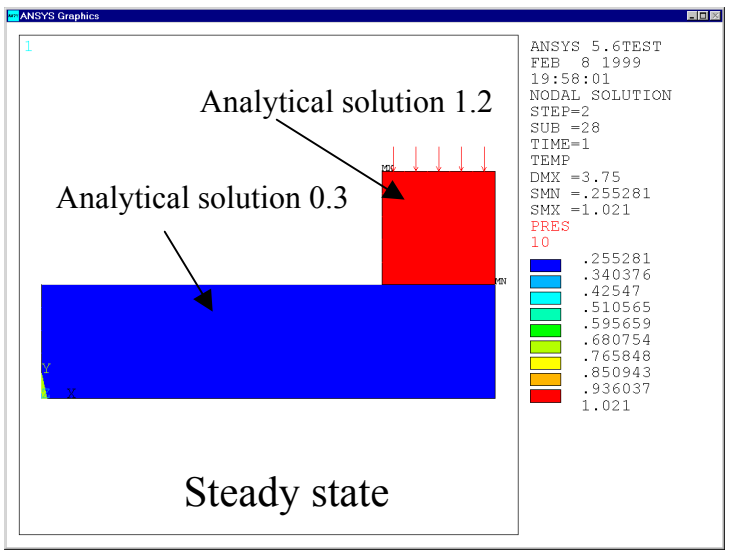


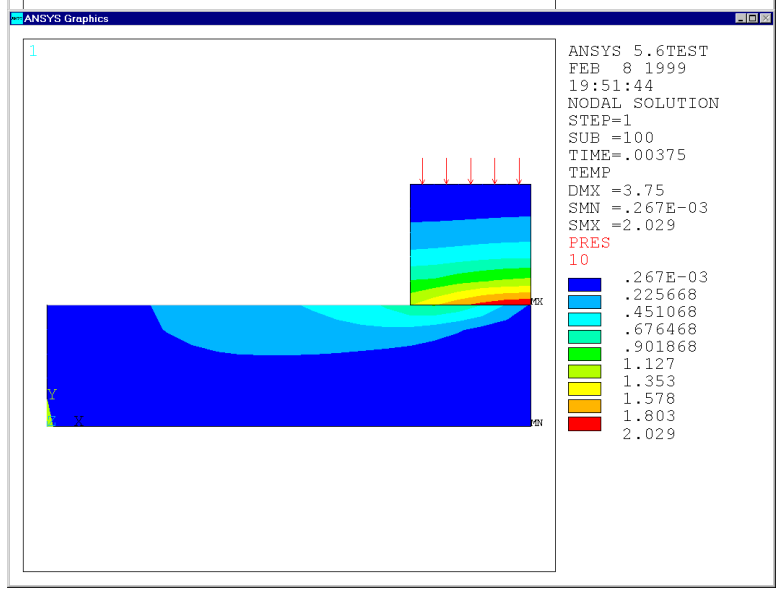
Frictional Dissipation Application

$P=19N/mm^2$

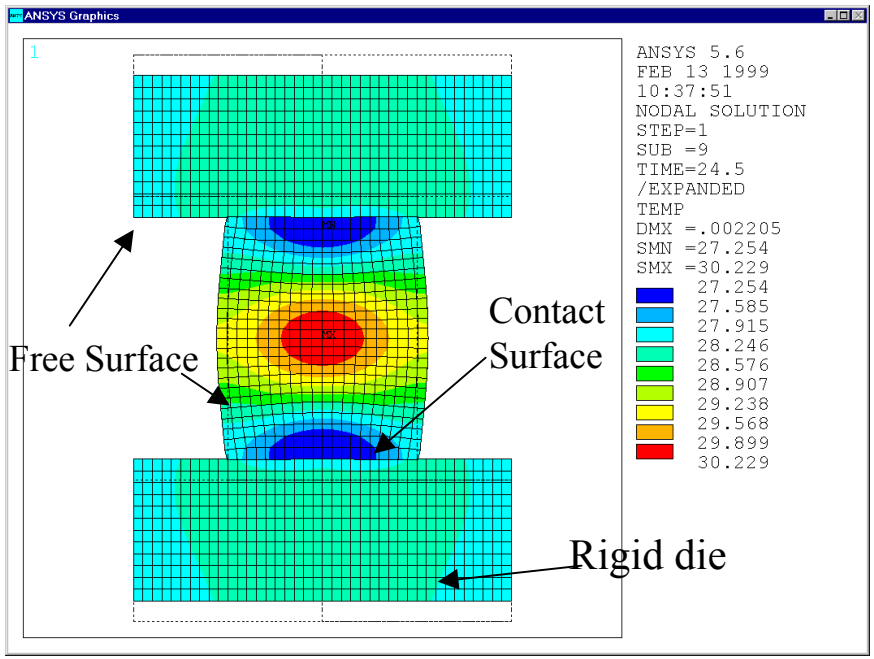


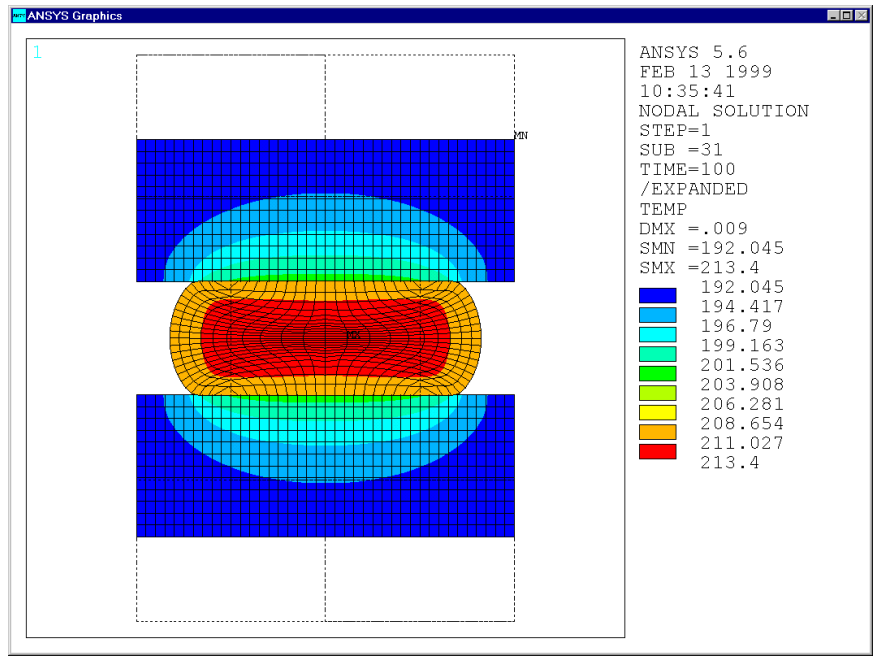






Upsetting of a Billet





- Heat generation due to plastic work
- Heat convection and radiation on free surface
- Heat conduction and frictional heating on contact surface