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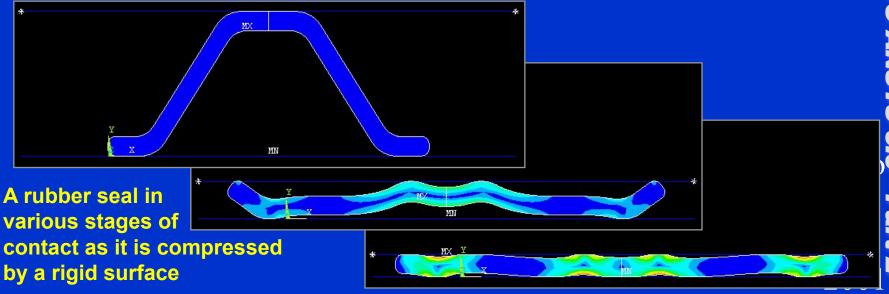
Module 9

Bonded Contact

9. Bonded Contact



- Contact between two objects is one of the most frequently encountered phenomena in engineering analysis.
- It is also one of the most difficult nonlinearities to handle because the stiffness can suddenly disappear or reappear depending on whether the objects are out of contact or in contact.



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...Bonded Contact



 Most contact analyses require advanced analytical techniques that are beyond the scope of this training course.

However, one class of contact analysis, known as *assembly contact,* can often be performed without knowledge of advanced techniques.

- Assembly contact uses the "bonded" option of ANSYS contact elements and is also called *bonded contact*.
- In this chapter, we will briefly describe how to set up and solve a bonded contact analysis:
 - A. Definitions
 - **B. Typical Procedure**
 - C. Workshop

Bonded Contact **A. Definitions**



- Bonded Contact is a special case of contact analysis where the two contacting surfaces are assumed to be "glued" together throughout the analysis.
- The two contacting surfaces form a contact pair.
 - One of the surfaces is designated as the *target surface*.
 - And the other surface is called the contact surface.

Target surface (inner surface of cylinder)

Contact surface

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Advantages of bonded contact:

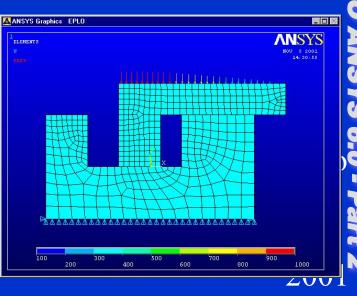
- Faster solutions since there are no contact convergence issues. Convenient for a quick analysis of assemblies, for example.
- Small-deflection cases can be run as linear analyses with one substep and one equilibrium iteration.
- Also allows large-deflection (nonlinear) analyses. (Coupling and constraint equations are not recommended for nonlinear analyses.)





Training Manual

- Seven main steps:
 - 1. Create or import the geometry.
 - 2. Mesh all of the contacting bodies. (Required for step 3.)
 - 3. Create the contact pair.
 - 4. Specify the analysis type and solution controls.
 - 5. Apply loads and boundary conditions.
 - 6. Save the database.
 - 7. Solve and review results.
- We will expand on steps 3 and 4 next.



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- Once the contacting bodies have been meshed, the next step is to create the contact pair, which consists of *target surface* elements and *contact surface* elements.
- The contact wizard provides an easy way to do this.
 - Preprocessor > Create > Contact Pair > Contact Wizard...

| Add Contact | Pair | |
|-------------|--|--|
| | A contact pair consists of surface. You will first def | f a target surface and contact fine the target surface. |
| | Target Surface: | Target Type: |
| | • Lines | © Flexible |
| _ | O Body (area) | O Rigid |
| | O Nodes | |
| | O Nodal Component | |
| | | Pick Target |
| | | |
| | < <u>B</u> ack <u>N</u> e | xt> C <u>a</u> ncel <u>H</u> elp |

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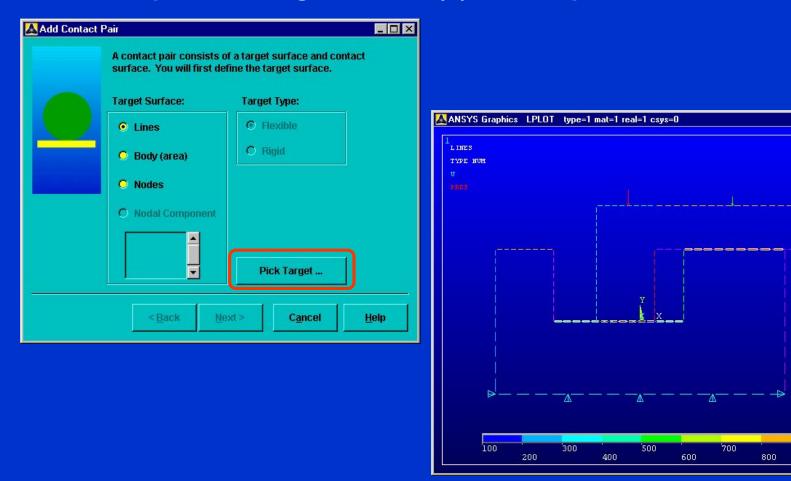
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Bonded ContactTypical Procedure

• First pick the target surface(s) on one part.

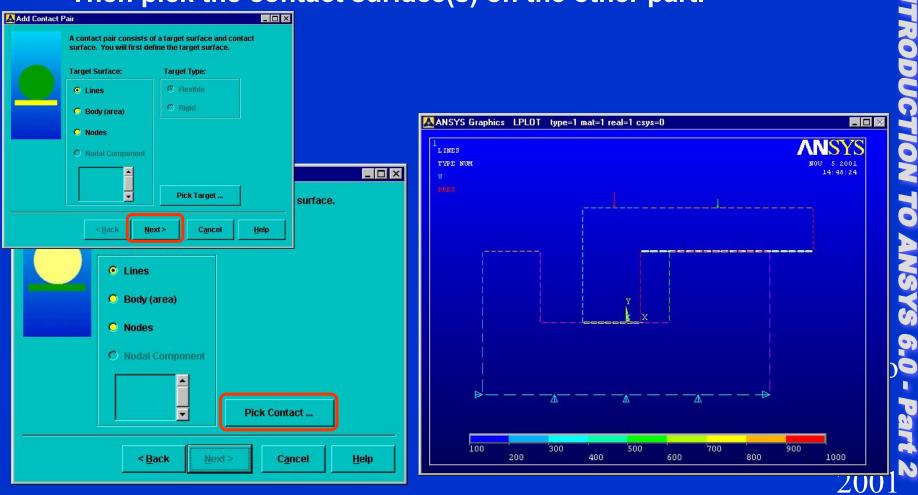




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Then pick the contact surface(s) on the other part.



Bonded ContactTypical Procedure

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- Then establish contact settings. Many settings are available, but the common ones for bonded contact are:
 - Coefficient of friction = 0
 - Then under Optional Settings > Basic tab:
 - Behavior of contact surface = "Bonded (always)"

| Add Contact Pair | Basic Friction Initial Adjustment Misc Rigid target Thermal ID |
|--|---|
| The contact pair is now ready to be created using the following settings: Only Structural DOFs have been detected Image: Include initial penetration Friction: Material ID 1 Coefficient of Friction 1 Thermal Conductance 0 Optional setti | Normal Penalty Stiffness 1.0 factor constant Penetration tolerance 0.1 factor constant Pinball region <auto> factor constant Behavior of contact surface Bonded (always) Contact stiffness update None Contact algorithm Augmented Lagrange method</auto> |
| | <u>O</u> K Cancel <u>H</u> elp |

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- Contact settings (cont'd):
 - Then under Optional Settings > Initial Adjustment tab:
 - Initial penetration = "Exclude everything"

| Add Contact P | | Basic Friction |
|---------------|--|--|
| \bigcirc | The contact pair is now ready to be created using the following settings: Image: Control of the context of the created using the following settings: Only Structural DOFs have been detected Image: Control of the context of the | Contact surfa Automatic co Initial contact |
| | Material ID 1 Coefficient of Friction I Thermal Conductance 0 | - Initial Allo Lower bo Upper bo |
| | Optional settings < <u>Back Create > Cancel H</u> elp | |

| Initial penetration Exclude everything Contact surface offset 0.0 Automatic contact adjustment No automated adjustment Initial contact closure <auto> <aut< th=""><th></th><th>c Friction Initial Adjustment Misc Rigid target Thermal ID </th></aut<></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto></auto> | | c Friction Initial Adjustment Misc Rigid target Thermal ID |
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| Automatic contact adjustment No automated adjustment Initial contact closure <auto> <i><auto> <iauto> <</iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></iauto></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto></i></auto> | | al penetration Exclude everything |
| Initial contact closure <auto> < <a>factor constant Initial Allowable Penetration Range Lower boundary © factor © constant</auto> | | tact synface offset 0.0 |
| Initial Allowable Penetration Range Lower boundary factor factor constant | • | matic contact adjustment No automated adjustment |
| Lower boundary | nt | al contact closure 🛛 <a closure="" constant<="" contact="" td="" trial=""> |
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| | | |





- Finally, generate the contact pair.
 - ANSYS will create the contact and target elements, and identify the contact pair with a real constant set number.
 - The contact pair is plotted with their element normals, which should be pointing toward each other. (If not, you can flip them using Preprocessor > Create > Contact Pair > View and Edit ...)

| | Add Contact Pair | | |
|------------------|--|---------------------|---|
| Add Contact Pair | The contact pair has been creat | | aphics EPLOT type=3 mat=1 real=3 csys=0 |
| following | act pair is now ready to be created using the settings: Instruction of the second | Finish <u>H</u> elp | NOU 5 2001 15:45:57 |
| Friction: | ide initial penetration | | |
| Material | ID 1 I I I I I I I I I I I I I I I I I I | | |
| Thermal | Conductance 0 💌 Optional settings | | дааалалалалалалалалалалаладд |
| < | Back Create > Cancel Help | | Inve |

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Analysis type and solution controls

- Both static and modal analyses can be performed.
- Typical solution control settings for static analysis:

Solution > Sol'n Control...

- Small displacement static.
- One substep [nsubst,1], which is the default.
- One equilibrium iteration [neqit,1]. This will cause a warning to be issued, but it is generally acceptable for bonded contact.

| ition Controls | _ _ × |
|-------------------------------------|---|
| asic Transient Sol'n Options Nonl | inear Advanced NL |
| | |
| Analysis Options | Write Items to Results File |
| Small Displacement Static | All solution items |
| | Basic quantities |
| Time Control | User selected |
| Time at end of loadstep 0 | |
| Automatic time stepping Prog Chosen | Nodal DOF Solution |
| • Number of substeps | Element Solution |
| | Element Nodal Loads Element Nodal Stresses |
| C Time increment | Frequency: |
| Number of substeps 1 | Write last substep only |
| Max no. of substeps 0 | |
| Min no. of substeps 0 | where N = 1 |
| olution Controls | |
| | |
| Basic Transient Sol'n Options No | nlinear Advanced NL |
| Nonlinear Options | Cutback Control |
| Line search Prog Chosen 💌 | Limits on physical values to |
| DOF solution Prog Chosen | perform bisection: |
| predictor | Equiv. Plastic strain 0.15 |
| | Explicit Creep ratio 0.1 |
| - Equilibrium Iterations | Implicit Creep ratio |
| Maximum number of 1 | Incremental displacement |
| iterations L ⁴ | Points per cycle 13 |
| Creep Option | |
| | Cutback according to predicted number of iterations |
| Include strain rate effect | Always iterate to 25 equilibrium iterations |
| | a minayo ner die to 25 equilisment ner allons |
| | |
| Set convergence criteria | |
| Set convergence criteria | |





• Demo:

- Resume contact.db (contains two bodies made of aluminum, meshed with PLANE82 elements)
- Bring up contact wizard and create contact pair using:
 - target surfaces on bottom part
 - contact surfaces on top part
 - *MU* = 0
 - initial penetration = exclude everything
 - contact behavior = bonded (always)
- Enter Solution and issue the following commands (in order):
 - solc,off
 - neqit,1
- Solve
- Plot SEQV, then animate it. Also show UX and UY contours to demonstrate continuity due to bonded contact.

Bonded Contact **C. Workshop**



 This workshop consists of the following problem: W8. Swaybar and Shaft Assembly
 Please refer to your Workshop Supplement for instructions.

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