MECHANICAL ENGINEERING NEWS

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For the Power, Petrochemical and Related Industries

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BULLETIN POLICY

The **COADE** Mechanical Engineering News Bulletin is published on a monthly basis from the **COADE/ McGraw-Hill** offices in Houston, Texas. The Bulletin is intended to provide information about software applications and development for Mechanical Engineers serving the power, petrochemical and related industries. Additionally the Bulletin will function as the official notification vehicle for software errors and bug reports. Software errors, bug reports, examples and "work arounds" will be provided for those mechanical programs offered by **COADE/ McGraw-Hill.**

The Bulletin will also contain examples and solutions to common engineering problems. Discussions will be directed toward design engineers and plant operations personnel. Topics will include dynamics, structural steel design, model building, code stress interpretations, mathematical restrictions, DOS/microcomputer applications and reviews of new machines and hardware.

PC HARDWARE FOR THE ENGINEERING USER

Approximately 50% of all **COADE** support calls are predicated by a misuse or misunderstanding of the microcomputer environment. This series of articles will hopefully alleviate some of the typical misconceptions.

CHKDSK

First and foremost, the DOS command **CHKDSK** should be used frequently. At **COADE**, this command is a standard entry in the file **AUTOEXEC.BAT. CHKDSK** scans the disk "file allocation table" and evaluates the system memory, RAM. The results from **CHKDSK** vary from system to system but certain features remain constant.

1) If **CHKDSK** reports lost clusters, **CHKDSK** should be rerun and the /F parameter specified so that the associated disk space will be reclaimed.

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BEND ELASTIC MODELS IN PIPING SYSTEMS

Just about everyone is familiar with the elastic/mechanical characteristics of straight beams, most probably because the basic beam formulation is taught in school in undergraduate machine design or structures related courses. Mechanical and Civil engineers have, at one time or another seen the expressions:

$$AE/L, \; Mc/I, \; JG/L \text{ or } PL^3/3EI$$

the basic axial stiffness, stress and flexibility expressions for straight beams. Similar expressions for curved beams or bends are usually left for graduate level engineering courses, if they are covered at all. For this reason there seems to be much less understanding of the basic elastic properties of bends.

There are several topics concerning bends which need clarification:

1) Bend stress intensification factors
2) Bend flexibility factors
3) Pressure stiffening
4) Bourdon pressure deflections
5) Axial shape functions

In the early 1900's several investigators found that the flexibility of curved pipe was significantly greater than that for a curved beam of similar cross section. The increase in flexibility is due to the change in cross section (ovalization) as bending occurs. Extensive correlations between theoretical and test predictions have been made since that time and have proved dependable. The current pipe bend element "stiffness matrices" are formulated using the basic equations for curved beams, modified by the bend "flexibility factors" to account for the ovalization of the bend cross section.

Stress intensification factors for bends are based on fatigue tests performed primarily by A.R.C. Markl in the 1950's.

Stresses and flexibilities for stand alone bends can be computed accurately and are not too sensitive to the bend geometry. (i.e. the B31 code expressions for sif's and flexibilities are good for a wide range of bend R/r ratios.) Flexibilities and stresses can however be sensitive to appendages attached to the bend and to other variations in the typical bend geometry, i.e. mitered bends and large diameter/thin walled bends.

The real basis for all bend flexibility calculations is the curved beam equations and as such are limited by the basic beam bending assumptions. Users of large diameter reducing miters, bend injector tie-ins, bend dummy legs and stauntions, and bends with additional plate weldments are urged to apply past design practice and experience when using these items in high pressure/temperature or hazardous material lines that are subject to a high number of loading cycles or that are particularly subject to internal corrosion.

Testing and plate finite element analysis are the only alternatives where new designs are encountered in critical systems.

Pressure Stiffening

Internal pressure in bends causes the cross section to remain circular when subject to bending moments and as such decreases the bend flexibility. Currently, of the power and petrochemical piping codes, only B31.3 recognizes and defines the effect of pressure on bend flexibilities. This effect can become significant in large diameter thin walled bends with high pressures.

Bourdon Pressure Effects

Pressure has two displacement effects on bends. The first is very similar to temperature in that it causes a relative translation between the two bend ends. This pressure effect is due to the axial elongation of each differential segment of pipe making up the bend curvature. The second pressure effect occurs only in bends that have some initially oval cross section, and causes the bend to "straighten out". When a bend with a slightly oval cross section is pressurized the bend ends will try to move away from one another and will try to rotate relative to one another. This effect, like pressure stiffening, is more important in large diameter, thin wall, high pressure bends. Bourdon pressure displacements are independant of pressure stiffening and each may be applied or withheld independent of the other.

The piping codes do not directly address bourdon pressure displacements in piping systems and as such have been omitted by some programs, added by others and left as options in still others.

Axial Shape Functions

Many original bend flexibility formulations omitted the effect of displacements due to axial deformation of the small differential segments that make up the bend. This mode of deformation is significant in small angle bends. Programs that omit this shape function from the bend formulation may have significantly stiffer small angle bends. Of the many programs on the market today about half include the axial shape function effect automatically.