DIN 2413 Part 2 Design of steel bends used in pressure pipelines

1 Scope and field of application

This standard covers the design of steel bends and bent pipes of circular cross section used in pressure pipelines ("bends' for short) and is to be applied in conjunction with DIN 2413 Part 2. Other relevant literature in this regard is numbered [1] through [9].

The basis of design is to account for the fact that stresses on the inside of the bend are higher, and on the outside, lower, than those which act on a straight pipe section of the same wall thickness and diameter.

2 Quantities, symbols and units

Additional quantities, symbols and units are given in table 1 of DIN 2413 Part 1. Figure 1 illustrates the principal dimensions of bends and their relevant symbols.

3 Required wall thickness

The symbols x and x are used to designate the minimum design wall thicknesses of the inside and outside of a bend, respectively. The factors x and x are used to allow for the lower limit deviation for wall thickness and for corrosion or wear, respectively.

The required wall thickness shall be calculated from the following equations:

a) for the inside of the bend:

b) for the outside of the bend:

The design wall thickness of existing bends with the inside and outside wall thicknesses x and x respectively, shall be deter-mined from the following equations:

a) for the inside of the bend:

b) for the outside of the bend:

Where the transition zone between bend and pipe is provided with rounded edges to provide a smooth transition and to prevent offset, this need not be taken into account for design purposes.

4 Design

4.1 Design wall thicknesses

The minimum design wall thickness on the inside of the bend, not including relevant design factors, x, shall be calculated from the following equation:

where x is to be determined in accordance with table 3 of DIN 2413 Part 1.

The minimum design wall thickness on the outside of the bend, not including relevant design factors, x, shall be calculated from the following equation:

Subclauses 4.1.1 to 4.1.3 deal with the design factors x and x, the formulae having been brought into line with Technische Regel fur Dampfkessel (Code of practice for steam boilers) TRD 301 Supplement 2. Subclause 4.1.4 specifies simplified formulae for determining x and x that are intended to be used where s does not exceed 0.02 (i.e. thick-walled bends), since the results are accurate and err on the safe side.

4.1.1 Design factors x and x for a known inside diameter

The design factors x and x, to be used where the inside diameter of the bend is known, shall be calculated in accordance with equations (7) and (8), respectively.

Actual values of x and x, as a function of the x ratio, may be taken from figure 3.

4.1.2 Design factors x and x for a known outside diameter

The design factors x and x, to be used where the outside diameter of the bend is known, shall be calculated in accordance with equations (9) and (13), respectively.

Since the radius of curvature, R, is normally also known when x is known, x is to be determined from the following equation:

The same results will be obtained with equations (7) and (9) only when the following criteria are satisfied:

and

Where R is known, x shall be determined in accordance with equation (10).

Actual values of x and x, as a function of the x ratio, may be taken from figure 4.

The same results will be obtained with equations (8) and (13), provided that the relationship between x, x, r and R is as expressed by equations (11) and (12).

4.1.3 Design factors x and x where x and x are the same

Where the wall thickness on the inside and outside of the bend are the same (i.e. where x is equal to x), the required wall thick-ness ma be calculated as follows:

In the above equation, B shall be equal to x (determined in accordance with equation (7)) in the case of a known inside diameter or, in the case of a known outside diameter, B shall be equal to:

Actual values of B, as a function of the x ratio, may be taken from figure 5.

Equation (7), when used in combination with equation (14), will only provide the same results as equation (15) when the following criteria are satisfied:

and

4.1.4 Simplified formulae for determining x and x

The design factors x and x, to b used where x does not exceed 0.02, shall b calculated in a accordance with equations and (19), respectively.

Actual values of x and x are illustrated in figure 4, these applying only for the curves with x=0.

4.2 Analysis of stress for bends of known dimensions

Table 2 specifies design formulae for determining reference stresses in bends as a function of the service conditions involved (referred to as load cases Ⅰ to Ⅲ, as defined in DIN 2413 Part 1). These formulae are based on the maximum shear theory. Where analysis is based on the formulae specified for load case Ⅲ, bends will be subjected to higher stresses, even when used under less severe conditions, but the stresses will still remain within permissible limits.

Table 2: Analysis of stress (based on the maximum shear theory)

Load case		
I		
II		
III		

4.3 Accounting for ovality under fatigue loading

The fatigue strength of oval bends, i.e. those with a degree of ovality, U, as a percentage, of

will decrease in direct proportion to their degree of ovality. This phenomenon is illustrated in figure 2 and is also dealt with in [4], [5] and [6].

The design will thickness of such bend, x, shall be determined in accordance with DIN 2413 Part 1, for load case III, and the characteristic strength value, K, shall be multiplied by the factor x.

Standards and other documents referred to

DIN 2413 Part 1	Design of steel pressure pipes
TRD 301 Supplement 2	Berechnung von Rohrbogen (Design of pipe elbows and bends)*)