CHAPTER 1

INTRODUCTION

From the survey of the previous work, the purpose of this thesis is therefore directed to find experimentally the flexibility and bending stresses around ninety degree mitered pipe bend. The first part of the experiment is to find the flexibility, flexibility factor and the most suitable equivalent radius of unreinforced and reinforced pipe bend that make the same flexibility as of the smooth bend of same size. Flexibility factor is defined as the ratio of the flexibility of the bend to that of a cylinder having the same second moment of area. Eighteen pieces of specimen are tested, half of them are reinforced pipe bends and the remainders are unreinforced pipe bends. All of them are tested under in-plane bending loads and deflections at the corresponding loads are measured, then flexibility, flexibility factor and equivalent radius can be found. The details are described in the experimental procedure and theory. The second part of the experiment concerns the analysis for stresses due to in-plane bending moment around the pipe at the same circular cross-section by the use of strain gage technique. In both parts the specimens are tested below yield points.

The origin of these experimental studies stem from the fact that pipes are employed to transmit fluid, either gas or liquid from places to places such as in chemical plants, some industrial plants and power station. Most piping systems contain some form of pipe bends. It is necessary to find out the behavior of such a structure under different types of loading so that an accurate calculation and a better design methods can be determined.

One form of loadings to which pipe bends may be subjected is bending moments. These bending moments tend to reduce the angle between the legs of the pipe bends i.e. to increase the curvatures. Hence calculation of stresses in pipe bend caused by this loading is very important. Another form of loadings which will be in the form of internal pressure, when the pipes are used to carry hot fluid, relative dimensional changes between the pipe lines and their anchorages will produce in the pipe line, which calculation of stresses in it is also very important.

If the pipe line is too rigid, thermal expansion causes end loads which will produce high stresses on anchor points. To prevent this, pipe bend is used to connect a long straight pipe line since it is known that a pipe bend is more flexible than a straight pipe of the same cross-section. Conversely, where relative movement is required between two joints connected by a pipe line, pipe bends can allow the movement without requiring excessive forces. Hence the flexibility of the pipe bend is also of practical importance. One form of the pipe bends used is mitered pipe bend.

A mitered bend is defined as a pipe bend produced by welding together miter-cut pieces of straight circular cylinder pipes to form one pipe with a discontinuous bend. The bend can contain a single mitered joint, or a number of mitered joints as shown in Fig. 1-1.

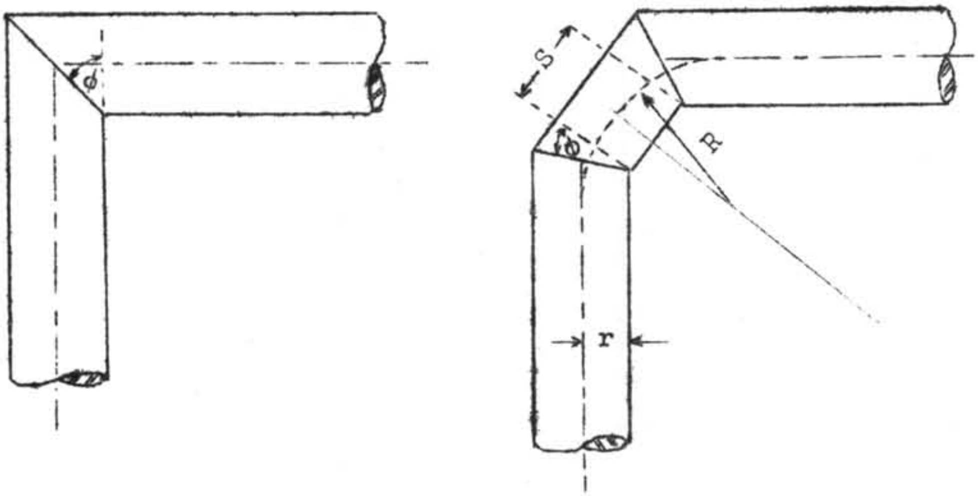

Fig. 1-1. SINGLE AND DOUBLE MITERED BENDS AS DEFINED IN KASIPAR'S WORK.

Two types of ninely degree single mitered bends are tested. One has no reinforcement at the intersection, The other has a reinforced plate at the joint to represent cascade band and blade unit in the actual duct corner. Although their strenght is less than smooth pipe bend but it is most suitable to use at the place where several changes in directions of the flow are necessary but the space is restricted, such as ducts carrying coolant to and from a reactor vessel which space is restricted in the biological shield, a coolant duct containing single mitered bends may be used.

The previous work about ninety degree single mitered bend with and without reinforcement had previously been done by Chana Kasipar.(14) He tested several of these bends and measured outside and inside surfaces strains due to internal pressure by the use of a strain-gage technique. His investigations were divided into three parts as follow:

First, the reinforced single mitered bend of the same outer diameter but with different thickness, i.e. having different $\frac{t}{r}$ ratio were tested. The experimental results indicated that the theory he obtained for a cylindrical shell rigidly fixed in an oblique cross-section subjected to in-plane bending is not satisfactory. Some ovalizations of the normal cross-section occur even at a remote distance from the center of intersection.

Second, he determined the flexibility of the bend, an attemp was made to find an equivalent radius R supposing that the single mitered bend was replaced by a smooth bend of the same dimension. Both reinforced and unreinforced single mitered bends were tested to find the overall deflections. The flexibility factor was calculated using an expression for smooth bend of Gross and Ford(9) which is

$$Y = \frac{F}{12EI}\left[4C^3 + KR\left\{3\pi C^2 + 6CR(4-\pi) + 6R^2(\pi-3)\right\}\right]$$

and was then compared with that obtained by using the third approximation of Von Karman's analysis which stated that

$$K = \frac{252 + 73912\lambda^2 + 2446176\lambda^4 + 2822400\lambda^6}{3 + 3280\lambda^2 + 329376\lambda^4 + 2822406\lambda^6}$$

where λ is pipe factor = $\frac{tR}{r^2}$

He concluded that the flexibility under in-plane bending of unreinforced single mitered bend was the same as that of smooth bend of the same dimensions having an equivalent radius of four times the pipe bore mean radius. He concluded further about the Kellogg's formula for flexibility factor of the unreinforced mitered bend, which is

$$K = \frac{1.52}{\lambda^{5/6}}$$

where λ was pipe factor = $\frac{tR}{r^2}$

R was the effective radius of the bend

$$= \frac{r}{2}(1 + \mathrm{Cot}\phi)$$

ϕ = miter angle

he concluded that this formula was not satisfactory.

Third, he determined the behaviour of the bend beyond the yield point to find the ratio of maximum load and the first yield load. The maximum strain at the intersection when the maximum load had been reached was found. For the reinforced single mitered bends he concluded that the ratios of maximum load to yield load and approximate ratios of deflection at maximum load to deflection at yield load indicated that after yielding had taken place, the mitered bend could carry considerably more load without suffering undue deflection. Bending strains at maximum loads for unreinforced single mitered bend under in-plane bending beyond yield point vary considerably and further tests were needed before any conclusion could be drawn.

As for this research, the first part is similar to Kasipar's work in the sense that the quantity of flexibility is interested, but this experiment here uses smaller pipes with longer series while Kasipar used larger and shorter series and it was thought worthwhile to check this aspect first. The second part differs from Kasipar's entirely since it aims to measure bending stresses and also try point a way to obtaining a simple theory explaining the bending stresses around a mitered pipe bend.