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A new steel expansion joint for industrial plants: Bubble joint

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Abstract

In power, steel, chemical and other industrial plants, ducts are essential to carry air and effluent gases. Ducts are designed such that under the temperature they can expand and contract freely in order to eliminate internal thermal stresses. To allow for free movements, expansion joints are introduced at the points of change in direction and also in long duct runs. Whenever large lateral movements are encountered, either a very deep single expansion joint or a toggle section with two joints is currently used in practice. In this article, a new type of steel expansion joint is proposed by introducing a bubble in the center of the single expansion joint with the goal of increasing its lateral movement capacity. The lateral movement capacity of the proposed joint is investigated by finite element simulation taking into account both material and geometrical nonlinearities. The results show that the new steel bubble joint can accommodate substantially more lateral movements than the conventional steel expansion joint. The new bubble joint provides an economical solution for retrofitting an existing plant where the available space is limited.

Keywords: Bubble joint; Ducts; Steel expansion joint; Power plants

1. Introduction

1.1. Expansion joints in ducts

In power, steel, chemical and other industrial plants, ducts are essential to carry air and effluent gases. The cross-sectional shape of the duct is usually circular, rectangular, or trapezoidal which may be constant or variable. The routing of the duct is dictated by the availability of space between the connecting equipments. A straight run of the duct from start to finish is rare, while change in direction of the duct, both horizontally and vertically, is a common occurrence. A typical duct arrangement in a fossil-fueled power plant is shown in Fig. 1.

In fossil-fueled power plants, ducts carry air and gases, which can be hot; the temperature ranges from 250 to 900 °F. Ducts are designed such that under the temperature they can expand and contract freely. This practically eliminates internal thermal stresses in the duct in most cases. To allow for free movements, expansion joints are introduced at the points of change in direction and also in long duct runs.

A typical support system for a duct run is shown in Fig. 2. The expansion joints are primarily subjected to axial movements, either tensile or compressive. But sometimes they may be subjected to lateral movements as well. Fabric and metal (steel) joints are often used as expansion joints. Fabric joints are made of fabric coated with vulcanized rubber and steel reinforcements. Such joints are flexible and can accommodate both axial and lateral (shear) movements effectively. Fabric joints are not desirable for high temperature applications because of their short life in such environments. For high temperature applications steel joints are used. Although steel joints easily permit axial movements, they have very limited capacity to allow for lateral movements.

1.2. Metal expansion joints subjected to lateral movement

The metal Expansion Joint Manufacturer's Association [1] provides two different schemes for accommodating lateral movements in metal joints. In the first scheme, the lateral deformation is contained entirely within the individual joint. The expansion joint reaches the limit of permissible movements when the folds or convolutions press against each other (Fig. 3). In this case, the convolutions become very stiff and behave like a compressive strut diagonally when subjected to

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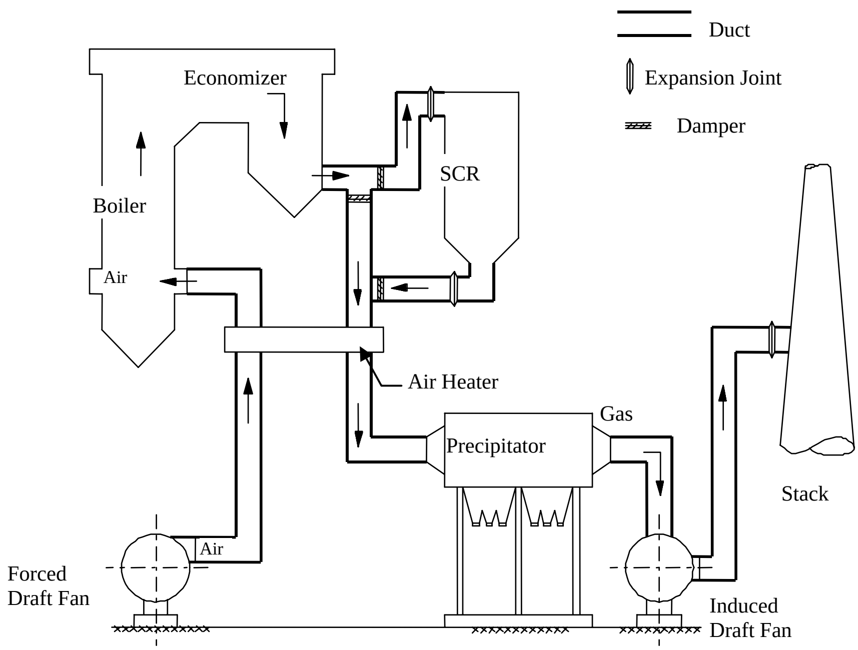

Fig. 1. Typical duct arrangement in a fossil-fueled power plant.

additional lateral movements. The metal joint has only a small capacity to undergo shear movement in this manner.

In the second scheme, a toggle section is introduced between two closely spaced joints as shown in Fig. 4. In this case, the shear movement is converted to angular movements. The two joints rotate in opposite directions while the duct piece between them acts as a rigid toggle. The length of the toggle section is in the range 2 ft (0.6m)–5 ft (1.5 m). This arrangement accommodates for larger lateral movements in the ducts. Whenever large lateral movements are encountered, either a very deep single expansion joint or a toggle section with two joints is currently used in practice.

The internal pressure can affect the stiffness of the joint. The pressure in the duct system lies in the range of 0.2–1.3 psi, which is very low when compared to that in a piping system. The stiffening does not have a significant effect on the joint performance because of the magnitude of low pressure and the joint being constructed out of flexible thin gage metal.

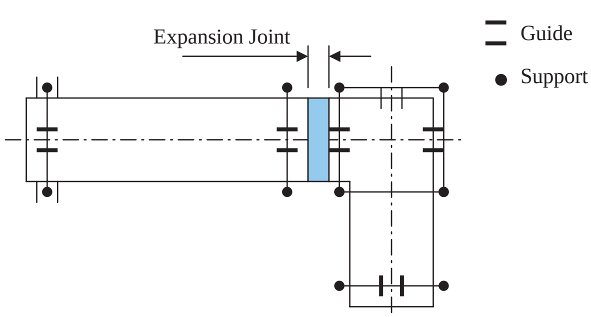

Fig. 2. Plan view of a typical duct support system.

1.3. Motivation and the need for a new type of expansion joint

This research was performed and the new bubble joint was created out of necessity. In a typical 600 MW coal burning power plant, there are between 30 and 50 expansion joints,

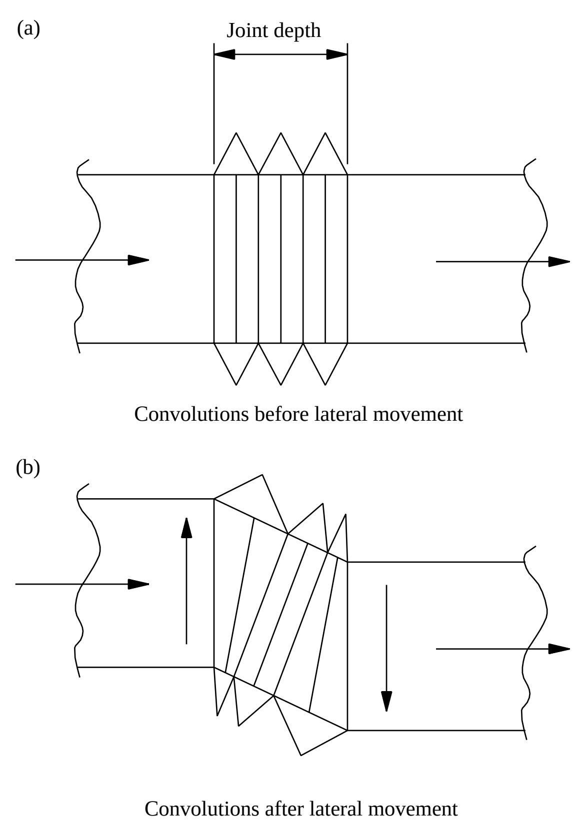

Fig. 3. Metal expansion joint.