CHAPTER II

THE STUDY OF THE EXISTING LITERATURE AND THE STATE-OF -THE-ART

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2.1 Introduction

The piezoelectric effect was first discovered by brothers of Curie.[12] In direct piezoelectric effect electric charges appear on the surfaces of some crystals when they are acted upon by mechanical forces. Conversely, the deformation of the crystal takes place under the influence of electric field.

2.2 Piezoelectric Material

More than four hundred piezoelectric substances have been discovered so far. Among these the best studied crystals are of Quartz (SiO_2), —— both natural and synthetic, Rochelle salt ($NaKC_4$. H_4O_6, $4H_2O$), Ammonium dihydrophosphate (ADP, $NH_4H_2PO_4$), Potassium Tartrate ($C_4H_4O_6$), Tourmaline etc.

Besides these, the materials widely used in modern piezoelectric equipment is synthetic piezoelectric system (ceramic) which is polycrystalline aggregate comprising small ferroelectric crystals whose vectors of spontaneous polarisation are oriented by the external field and retain their orientation after the field is withdrawn (polarised ceramic).

The strong piezoelectric effect in Polyvinylidene fluoride polymer (abbreviated as PVDF) was discovered by Kawai [34] in 1969. This material is available in large sheets and inexpensive to cut or shape into complex configuration.

Bimorph, a composite transducing element is often used to reduce the mechanical impedence without lowering the output voltage [25] and to ensure greater ruggedness with minimum weight in an electromechanical appliance. This requirement can be met within a body composed of layers made of quartz as a concrete aggregate, placed one above the other with increasing or decreasing densities. [23]

2.3 Early uses of Piezoelectric Material

The piezolectric substance found its application in practical field during the first World War(1914-1918) when Langevin (1921) [26] attempted to generate ultrasonic waves to detect submarines under water, with a device composed essentially of a mosaic of quartz glued between steel plates.

Nicholson (1919) [27] observed that Rochelle salt has a larger piezoelectric effect than quartz. The said author used Rocehlle salt crystals to construct electroacoustical devices, such as Loud speaker, microphones, gramaphone pick-up.

Cady (1922)[28] was first to utilise quartz crystals for stabilising the frequency of electronic oscillators. Mason (1940)[29] used a small temperature co-efficient quartz in highly stabilised electric clocks.

The evaluation of mechanical or electrical response of piezoelectric transducers of various shapes under prescribed input covers a major part of studies in the electroacoustics. Redwood (1961)[30], the pioneer investigator in this field, developed an approximation technique for finding the transient performance in a peizoelectric transducer due to prescribed input voltage. In the same year the said author[31] reported the generation of electric impulse by piezoelectric method. Following Redwood's technique Sinha (1962)[32] investigated the mechanical response of a piezolelectric transducer with periodic step input voltage. Sinha[33] also found out the mechanical response of a piezoelectric transduces owing to an impulsive voltage input. Sinha[34][35] discussed the mechanical response in piezoelectric transducers made of ceramic materials when acted upon by a step electrical voltage under the influence of a body force. Mechanical response of plate transducer due to partly periodic and partlu transient voltage input was obtained by Giri (1966)[36]. Roy (1967)[37] determined the mechanical response in a peizoelectric plate transducer for a prescribed input.

Chatterjee (1970)[38] determined the mechanical and electrical response in a piezoelectric plate transducer subjected to body force. Mechanical response in a composite piezoelectric transducer was investigated by Roy (1970)[39]. Das et al (1979)[40] investigated the stress distribution and the voltage developed in an annular disc of inhomogeneous piezoelectric material. Das and Ray[40][41] discussed the voltage developed in a non-homogenous peizoelectric quartz bar due to finite bending. Lee and Moon (1989)[42] developed the theory of laminated piezoelectric plates for torsion and bendig sensors. S.J. Zian et al (1993)[43] described the construction and evaluation of an acoustic sensor composed of two small pieces of piezoelectric bonded together.

The generation of peizoelectric waves in different structures under various mechanical and electrical conditions became an important subject of study. The higher order theory (wave propagation) of a single layer piezoelectric plate had been extensively studied by Mindlin (1961)[44]. Stuetzer (1967)[45] observed the multilayer reflection of acoustic waves within a free piezoelectric plate.

In 1961 Mindlin[46] derived the constitutive equations of peizoelectric substance in the presence of thermal field. Das and Ray (1978)[47] investigated the deformation, the stress components and electric field

within an inhomogeneous piezoelectric body under the simultaneous action of mechanical, electrical and thermal fields.

Vibration control of flexible structures has been a major research topic over the last ten years. Hanagud et al (1986)[48] discussed the uses of piezoelectric sensors and actuators in vibration control of a structure.

Haskin and Walsh[49] in a statical problem derived the constitutive equations of a piezoelectric substance in the absense of thermal field. Mindlin[46] extended the analysis by considering thermal influence. But both of them failed to consider in their problem that piezoelectric bodies, in general, are inhomogenous in respect to their physical properties in the presence of electric field.[7] Appropriate electric field in such a body under elevated temperature influences its physical properties.