REVIEW OF RESEARCH IN THE FIELD OF PULSE TUBE CRYOCOOLER

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Abstract—Pulse Tube cryocooler is a developing technology which finds various applications in the field of space research. A research in field of cryocoolers has come a long way right from being a laboratory curiosity to the point where it is. This paper deals with the review of work done in the field of pulse tube cryocoolers. Geometrical dimensions of important parts of pulse tube cryocooler are briefly studied in this paper.

Keywords—Cryocooler, Pulse tube, Inertance tube, Regenerator

Introduction

Cryocoolers are used to cool to cryogenic temperatures. Pulse tube cryocoolers are used in industrial applications such as semiconductor fabrication and in military applications such as for the cooling of infrared sensors. In contrast with the other cryocoolers, pulse tube cryocooler can be made without moving parts in the low temperature part of the device, making the cryocooler suitable for a wide variety of applications. There are many applications in which cryocoolers are part of the system such as cooling of super conducting circuits and magnets. Recuperative and regenerative are two main types of cryocoolers. Compressor, regenerator, pulse tube and inertance tube are main parts of cryocoolers. A brief discussion on geometrical parameters of these components is discussed in this paper.

A. Compressor

In “Numerical Study and Analysis of Inertance-type Pulse Tube Refrigerator” compressor of diameter 0.01908 m and length 0.0075 m is used. It is subjected to adiabatic conditions. A compressor of 34 mm radius and length 72 mm is used in “Numerical Analysis of pulse tube Cryocooler”. Compressor swept volume is 254.22 cm$^3$. It is made of steel material. “Modelling and Analysis of Pulse Tube Refrigerator” compressor of length 50 mm and diameter 100 mm is used. A compressor of 70 mm diameter is used in “Modelling of Pulse Tube Refrigerators with inertance tube and mass-spring feedback mechanism”. In “A high efficiency coaxial pulse tube cryocooler operating at 60K” a compressor of swept volume 10 cc is used. A compressor of swept volume 8.2 cc is used in “A model for parametric analysis of Pulse Tube Losses in Pulse Tube Refrigerator”.

B. Regenerator

In “Numerical Study and Analysis of Inertance-type Pulse Tube Refrigerator” regenerator of diameter 0.008 m and length 0.058 m is used. It is subjected to adiabatic conditions. A regenerator of 24 mm radius and length 40 mm is used in “Numerical Analysis of pulse tube Cryocooler”. Regenerator walls are made up of steel material. In “Modelling and Analysis of Pulse Tube Refrigerator” regenerator of length 120 mm and diameter 24 mm is used. A regenerator of 45 mm length and 30 mm diameter is used in “Modelling of Pulse Tube Refrigerators with inertance tube and mass-spring feedback mechanism”. A regenerator of outer diameter 12.2 mm and length 38 mm is used in “An efficient miniature 120 Hz pulse tube cryocooler using high porosity regenerator material”. In “A high efficiency coaxial pulse tube cryocooler operating at 60K” a regenerator of 55 mm length and 31.8 mm diameter is used. A regenerator of outer diameter 0.02 m and length 0.1 m is used in “A model for parametric analysis of Pulse Tube Losses in Pulse Tube Refrigerator”. In “Design and analysis of stirling type inertance Pulse Tube Cryocooler” a regenerator of 45 mm length and 20 mm diameter is used.

C. Pulse Tube

In “Numerical Study and Analysis of Inertance-type Pulse Tube Refrigerator” pulse tube of diameter 0.005 m and length 0.125 m is used. It is subjected to adiabatic conditions. A pulse tube of 9.5 mm diameter and length 100 mm is used in “Numerical Analysis of pulse tube Cryocooler”. It is made up of steel material. In “Modelling and Analysis of Pulse Tube Refrigerator” pulse tube of length 450 mm and diameter 17.6 mm is used. A pulse tube
of 85 mm length and 16 mm diameter is used in “Modelling of Pulse Tube Refrigerators with inertance tube and mass-spring feedback mechanism.

A pulse tube of inner diameter 6 mm and length 48 mm is used in “An efficient miniature 120 Hz pulse tube cryocooler using high porosity regenerator material”. In “A high efficiency coaxial pulse tube cryocooler operating at 60K” a pulse tube of 55 mm length and 15 mm diameter is used. A pulse tube of diameter 0.01 m and length 0.1 m is used in “A model for parametric analysis of Pulse Tube Losses in Pulse Tube Refrigerator”. In “Design and analysis of stirling type inertance Pulse Tube Cryocooler” a pulse tube of 45 mm length and 20 mm diameter is used.

D. Inertance Tube

In “Numerical Study and Analysis of Inertance-type Pulse Tube Refrigerator” inertance tube of diameter 0.0085 m and length 0.84 m is used. It is subjected to adiabatic conditions. A inertance tube of 3 mm radius and length 3000 mm is used in “Numerical Analysis of pulse tube Cryocooler”. It is made up of copper material. In “Modelling and Analysis of Pulse Tube Refrigerator” inertance tube of length 1000 mm and diameter 4 mm is used. A inertance tube of 1.970 m length and 4 mm diameter is used in “Modelling of Pulse Tube Refrigerators with inertance tube and mass-spring feedback mechanism.”

A inertance tube of inner diameter 2 mm and length 1.4 m is used in “An efficient miniature 120 Hz pulse tube cryocooler using high porosity regenerator material”. A inertance tube of diameter 2.5 m and length 1.5 m is used in “A model for parametric analysis of Pulse Tube Losses in Pulse Tube Refrigerator”. In “Design and analysis of stirling type inertance Pulse Tube Cryocooler” a inertance tube of 03 m length and 1000 mm diameter is used.

Conclusions

It is concluded that pulse tube cryocooler gives best results when compressor of diameters ranging from 20 to 70 mm and length ranging from 10 to 50 mm , regenerator of diameter ranging from 5 to 30 mm and length ranging from 40 to 120 mm , pulse tube of diameter ranging from 5 to 20 mm and length ranging from 100 to 500 mm ,inertance tube of diameter ranging from 2 to 8 mm length ranging from 1000 to 3000 mm are used.

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