ISSN XXXX XXXX © 2019 IJESC

Research Article Volume 9 Issue No.1

A Review on Thermal Conductivity Measurements at Lower Temperatures

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Abstract:
This paper describe briefly the experimental facilities developed for the measurement of thermal conductivity of solids at lower temperatures for various materials. Various techniques have been used for measurement of thermal conductivity namely Laser photo thermal method (LPM), transient hot-strip(THS) method etc. This paper focuses on steady and transient state measurement of thermal conductivities of Ceramics, alloys, polymers etc. This paper portrays briefly the test facilities produced for those estimation about thermal conductivity from claiming solids in more level temperatures for different materials. Different systems need been utilized for estimation for thermal conductivity to be specific laser photo thermal method(LPM), transient hot-strip(THS) strategy and so on. This paper keeps tabs for unfaltering What's more transient state estimation for thermal conductivities from claiming Ceramics, alloys, polymers and so on.

I. INTRODUCTION

Thermal conductivity is the property of a material to conduct heat. Heat transfer occurs at lower rate across materials of high thermal conductivity than across materials of high thermal conductivity. This property is temperature dependent and its reciprocal is thermal resistivity. In the present day scenario, cryogenics and low- temperature refrigeration is playing a significant role. From the food industry, transportation, energy, and medical applications to the Space Shuttle cryogenic liquids must be stored, handled, and transferred from one point to another. Heat in-leak to a storage tank can be reduced by a thermal insulation. All cryogenic vessels are double walled, one inner and one outer wall, Heat path will be small in between these walls. This interspace can be evacuated to reduce the heat transfer. creating a very high vacuum can be quite expensive and we may not be able to maintain the same for long periods continuously. So use of low thermal conducting material in the interspace can be adopted. Material along with vacuum can also be used to produce better thermal isolation. Radiation heat transfer is typically controlled by the barrier placed around the inner vessel. Different type of materials having low thermal conductivity such as glass fibre, silica aerogel, or composites may be used as cryogenic insulations. Thermal conductivity is the property of a material to conduct heat. Heat transfer occurs at lower amount beyond abstracts of aerial thermal conductivity than beyond abstracts of aerial thermal conductivity. This property is temperature a based and its alternate is thermal resistivity. In the present day scenario, cryogenics and low- temperature algidity is arena a cogent role. From the aliment industry, transportation, energy, and medical applications to the Space Shuttle cryogenic liquids charge be stored, handled, and transferred from one point to another. Calefaction in-leak to a accumulator catchbasin can be bargain by a thermal insulation. All cryogenic argosy are bifold walled, one close and one alien wall, Calefaction aisle will be baby in amid these walls. This aperture can be abandoned to abate the calefaction transfer. creating a actual aerial exhaustion can be absolutely big-ticket and we may not be able to advance the aforementioned for continued periods continuously. So use of low thermal administering actual in the aperture can be adopted. Actual forth with exhaustion can additionally be acclimated to aftermath bigger thermal isolation. Radiation calefaction alteration is about controlled by the barrier placed about the close vessel. Different blazon of abstracts accepting low thermal application such as bottle fibre, silica aerogel, or composites may be acclimated as cryogenic insulations. VanapalliS et.al. Exaplained about A single-sided protected plate mechanical assembly has been created to quantify the Thermal conductivity of protection boards of sub-meter measure at sub-surrounding temperatures going from 250 to 300 K[1]. This device enables Thermal Conductivity estimations to be performed everywhere temperature contrasts mimicking the genuine working conditions in an application and can oblige boards of different thickness.The chilly plate in the contraption is cooled with a flow thermostat.The decrease in execution because of the warmth conductance along the edge of a vacuum protection board is significant at little board sizes and is detrimental to the end application.The powerful Thermal Conductivity of square vacuum protection boards of a few thickness and region is estimated, and is seen that the square boards of side 10 and 20 cm have about twice higher Thermal Conductivity than their bigger counterparts because of the warmth spill along the edges of these boards. Bi Dongmei et.al. Examined The laser Photothermal (LPM) which is a transient non-contact technique, was employed to measure the thermal physical parameters of stainless steel 304(SS304), Oxygen free copper(OFC) and Aluminum Nitride(ALN) ceramics[2]. The thermal diffusivity of SS304, OFC and ALN ceramic were measured by the LPM and some explanations for the tendency with the temperature were given. Compared with the reference values, it showed that the LPM is reliable in measuring thermal parameters. Following the thermal contact resistances(TCRs) of OFC-ALN ceramic, SS304-AIN, SS304-SS304 and AIN ceramic were measured in the temperature range from 70 K to 300 K and the contact pressure was on the order of 0.10 Mpa. Some explanations were given to make clear the changing trend of TCRs with the increase of temperature. Moreover, some empirical formulasof the TCRs were established. The accuracy of the establishing empirical formulas had been validated by the experiment, and the error was smaller than 9 %. When structuring and examining circuits working at cryogenic temperatures understanding nearby warming inside

the circuits is basic because of the temperature reliance of transistor and commotion conduct. Nearby warming impacts of a CMOs ring oscillator and current comparator were examined at T=4.2 K in two cases by J.Hamlet et.al. [3], the temperature close to the circuit was estimated with a coordinated thermometer. A lumped component proportionate electrical circuit SPICE display that represents the unequivocally temperature subordinate warm conductivities and ghastly 4.2 K warm sinking thought was created. The temperature reliance on power is illuminated numerically with a SPICE bundle, and the outcomes are regularly inside 3 σ of the deliberate qualities for nearby warming extending from < 1 K to more than 100 K. Adam L woodcraftet al. is examined Aluminum combinations are being utilized progressively in cryogenic frameworks. In any case, cryogenic Thermal Conductivity estimations have been made just a couple of the numerous sorts when all is said in done use[4].This paper portrays a technique for anticipating the Thermal Conductivity of any aluminum combination between the superconducting transition temperature (approximately 1 K) and room temperature, in view of estimation of Thermal Conductivity or electrical resistivity at a solitary temperature. Where forecasts depend on low temperature measurements(approximately 4 K and beneath), the precision is commonly superior to 10 %. Valuable expectations can likewise be produced using room temperature estimations for most amalgams, however with decreased exactness. This technique grants aluminum amalgams to be utilized in circumstances where the Thermal Conductivity is vital without making (or find) coordinate estimations over the whole temperature scope of intrigue. There is subsequently more prominent extension to picked amalgam dependent on mechanical properties and accessibility , instead of on whether cryogenic Thermal Conductivity estimations have been made. Prescribed Thermal Conductivity esteems are displayed for aluminum 6082(based on new estimation) and for 1000 arrangement, and types 2014, 2024,2219, 3003, 5052, 5083, 5086, 5154,6061,6063,6082,7039 and 7075(based on low temperature estimations in the writing) Gaosheng Wei et.al. Explained about portrays the exploratory assurance of Thermal Conductivity of powdered and granular silica aerogels utilizing thetransient hot-strip(THS) technique[5]. A vacuum heater was intended for the THS technique for estimating Thermal Conductivity at various temperature and weights. The explicit surface territory and normal mesopore width of the two examples were additionally estimated by cryogenic nitrogen adsorption technique. The outcomes demonstrate that the Thermal Conductivity of the powdered example achieved a consistent just when the weight was under 20 Pa, while the Thermal Conductivity of the granular example ended up steady when the weight was under 3 Pa due to the macropore EFFECT. The deliberate examples exhibited comparable examples in Thermal Conductivity initially declining gradually when p> 1000 Pa, than with quickened decrease one P< 1000 Pa. The Thermal Conductivity of the deliberate examples unmistakably expanded with height of temperature, demonstrating that silica aerogel materials with huge macropores display higher Thermal Conductivity than solid silica aerogel materials at hoisted temperatures A.Hofmann et.al. Described the presentation of the thermal conductivity of cryogenic insulation materials and integral mean values an empirical function is suggested with which experimentally found values can be extrapolated to other temperature levels[6].The selection of materials includes granulated and fibrous insulations under atmospheric pressure as well under vacuum and a multilayer insulation for most high performances. It is shown theoretically, how the constants in the empirical function can be determined. Their calculation is demonstrated practically by using real measurements. For a multilayer insulation a theory is developed, with which a measured value can be extrapolated to other temperatures, gas pressures and numbers of layers. Its application to a real insulation system is demonstrated too. James Tuttle et. al. investigated about Spacecraft and instruments on space missions are built using a wide variety of carefully-chosen materials [7]. It is common for NASA engineers to propose new candidate materials which have not been totally characterized at cryogenic temperatures. In many cases a material's cryogenic thermal conductivity must be known before se- lecting it for a specific space- flight application. We developed a test facility in 2004 at NASA's Goddard Space Flight Center to measure the longitudinal thermal conductivity of materials at temperatures between 4 and 300 K, and we have characterized many candidate materials since then. The measurement technique is not extremely complex, but proper care to details of the setup, data acquisition and data reduction is necessary for high precision and accuracy. We describe the thermal conductivity measurement process and present results for ten engineered materials, including alloys, polymers, composites, and a ceramic. Y. Yang et.al examined the recent accelerator-based experiments for particle physics require the superconducting magnets that can be operated under high radiation environment [8]. An electrical insulation tape, which is composed of polyimide fi lm and a boron free glass fabric pre-impregnated with epoxy resin blended with bismaleimide-triazine resin, is developed to enhance the radiation tolerance for superconducting magnets. Since the thermal conductivity of insulation tape is one of key parameters that aff ects the coil temperature during the operation, the influence of gamma-ray irradiation on the thermal conductivity of the insulation tape is investigated with a maximum dose of 5 MGy. The thermal conductivity is measured at cryogenic temperature from 5 K to 20 K cooled by a Giff ord- McMahon cryocooler. By comparing the thermal conductivity before and after the gamma ray irradiation, no significant degradation on the thermal conductivity has been observed. Sachiko Nakamura et.al. Carried out low temperature experiments, resins have many applications as glues or thermal and electrical insulators. Cyanate ester resins (CEs) are a high-temperature compatible thermoset resin whose glass-transition temperature Tg is ≈ 300 °C. Recently, we found that CEs also withstand low temperatures without microcracking by measuring 4He permeability [9]. Here, we measured specific heat C, thermal conductivity κ, and magnetic susceptibility χ of di ff erent kinds of CEs in the wide temperature range from room temperature to 0.5 K for C and 2 K for other two. The thermal properties, C and κ, of di ff erent kinds of CEs are surprisingly coincident with each other. We discuss chemical structures and crystallinity of CEs and their blends based on the measured thermal properties. Compared to Stycast 1266, a commonly-used epoxy resin in low temperature experiments, C of CEs is larger by a factor of 3 (≤ 30 K), κ is lower by a factor of 4 (≤ 10 K), indicating the small thermal di ff usivity. The χ values are as small as Stycast 1266, indicative of their high purity. Our results show that cyanate esters are a new option for cryogenic resins with thermal insulative properties in/for low temperature experiments. The advancement and portrayal of new materials is of outrageous significance in the plan of cryogenic mechanical assembly was investigated by Kong Chunhui et.al.[10] As of late a sort of open cell aluminum froth was utilized for warmth exchange upgrade at cryogenic temperature. Such aluminum froth was tried for cryogenic vitality stockpiling with a stage change material of nitrogen.

The Thermal Conductivity of the open cell aluminum froth was considered. The warm conductivities of the aluminum froth were estimated somewhere in the range of 50 and 170 K. The outcomes demonstrate that the Thermal Conductivity increments with the temperature diminishing. At that point the impacts of Thermal Conductivity of open-cell aluminum froths on the execution of aluminum froth stage change material warm capacity unit were researched. Nitrogen was chosen as the stage change material. Temperature varieties of the warm capacity unit amid cooling and dissolving forms were tried. Test outcome demonstrates that the most extreme temperature contrast between the up and base of the warm capacity unit is under 0.5 K, much lower than the case without aluminum froth. It is inferred that as the Thermal Conductivity of warm stockpiling unit increments, both the holder temperature distinction and temperature variety of the warm capacity unit decline. Yuting Tan et.al.explained about the cryogenic process is utilized for CO_2 refinement in oxy-fuel burning force plant, and multi-stream warm exchanger is a standout amongst the most vital parts [11]. Consistency and Thermal Conductivity are enter transport properties in the plan of plate-blade multi – stream warm exchanger. It is important to assess the effects of consistency and Thermal Conductivity models on the plan of the warmth exchanger. In this paper, diverse consistency models and Thermal Conductivity models for CO_2 blends with non condensable contaminations were first assessed independently by contrasting the determined outcomes and test information. Results demonstrate that for thickness, unquestionably the normal deviation of KRW show is the littlest, which is 1.3 %. For Thermal Conductivity demonstrate created by Ely and Hanley, with total normal deviation of 3.5 % is prescribed. The effect of property models on the structure of plate-balance multi stream warm exchanger was additionally examined. The Thermal Conductivity show noticeably affects the plat-blade multi stram warm exchanger plan, and the deviation in configuration size of warmth exchanger by utilizing distinctive Thermal Conductivity models may reach up to 7.5 %. The future work on the most proficient method to enhance the property models was talked about Alexey Drobizhev et.al. explained about design of low temperature holometric detectors fie rare event searches necessitates careful selection and characterization of structural materials based on their thermal properties [12]. We measure the thermal conductivities of polytetrafluroethylene (PTFE) and Al_2O_3 ceramic (alumina) in the temperature ranges of 0.17-0.43 K and 0.1 -1.3 K, respectively. For the former, we observe a quadratic temperature dependence across the entire measured range. For the latter, we see a cubic dependence on temperature above 0.3 K , with a linear contribution below that temperature. This paper presents our measurement techniques, results, and theoretical discussions TatangMulyana et.al.Investigation on lightweight car parts, in the journey for better vitality effectiveness [13]. These parts are delivered utilizing ultra high quality steel(UHSS) for reasons of high quality and unbending nature. In any case, for the parts clear to have expanded quality and hardness, the shaping procedure must be done under hoisted temperatures, accomplished through preheating and extinguishing. Notwithstanding guarantee a successful extinguishing, high Thermal Conductivity steel (HTCS), having a high Thermal Conductivity and a high wear obstruction, is utilized as shaping kick the bucket, perhaps bringing about weakened machinability. Along these lines, a successful coolant-oil system is required to guarantee enhanced efficiency. A cryogenic cooling strategy, for example, the utilization of supercritical carbon dioxide(SCCO2) was assessed in the machining processes.SCCO2 was chosen over the more normally utilized fluid nitrogen(LN2), as the cryogenic substance, because of its low gas extension esteem, in this manner guaranteeing lower ecological dangers to the labourers. To put it plainly, the non-dangerous SCCO2 advances a more advantageous, more secure and increasingly reasonable workplace. In this examination, a processing procedure of HTCS was performed, where the viability of SCCO2 coolant was contrasted and that of close dry machining and, dry machining strategies, as far as cutting temperature, cutting power, apparatus wear and wear component. Two techniques for SCCO2 cooling conditions were dissected, with and without ointment. Both of the cooling conditions were connected under three distinctive information chamber weights. In correlation with dry machining, SCCO2 with ointment was found to have essentially enhanced cutting power and cutting temperature, upto 60 % and 55 % individually. In correlation with dry machining and close dry machining, then, the slicing instrument life expanded to 150 % and 87% separately. All the more essentially, it was seen that, attachment, whittling down and scraped spot were the prevailing wearmechanisms. At the point when HTCS was processed under different coolant-oil conditions. The general outcomes uncovered that, cryogenic cooling, utilizing carbon dioxide gas under supercritical state, was the best alternative for a superior control and enhancement of hardware wear. The drawn out instrument life will guarantee a very sustainable generation, with less device wastage and increasingly proficient machining process. From the natural perspective, the utilization of SCCO2 as a cryogenic substance is profitable, as it fulfils the expanding requests for a cleaner assembling of HTCS Ricardo I.Amils et.al. Carried out experimentation about strain to build the affectability of instrumentation has pushed the utilization of cryogenic Low Noise Amplifier (LNA) innovation into a developing number of fields [14]. These territories extend from radio stargazing and profound space interchanges to central material science. In this setting producing for cryogenic situations requiresanappropriate warm information of materials to have the capacity to accomplish satisfactory plan conduct. In this work, we present test estimations of Thermal Conductivity of a silver filled conductive epoxy(EPO-TEK H2OE) which is broadly utilized in cryogenic electronic applications. The portrayal has been made utilizing an example planning which impersonates the down to earth utilization of this glue in the manufacture of cryogenic gadgets. We apply the information got to an itemized examination of the impacts of the conductive epoxy in solid warm commotion source utilized for high exactness cryogenic microwave clamor estimations. In this application the epoxy assumes a key job since its restricted Thermal Conductivity permits warming the chip with generally low power. As far as anyone is concerned, the cryogenic Thermal Conductivity information of this epoxy has not been accounted for before in the writing in the 4-300 K temperature go. A second non-conductive epoxy (Gray Scotch-Weld 2216 B/A), likewise generally utilized in cryogenic applications, has been estimated so as to approve the strategy by contrasting and past distributed information. Lili. E. Enrlich et.al investigation on The Thermal Conductivity of the cryoprotective agent(CPA) mixed drink DP6 in blend with engineered ice modulators (SIMs) is estimated in this examination, utilizing a transient hot-wire technique [15]. DP6 is a blend of 3 M dimethyl sulfoxide(DMSO) and 3 M propylene glycol, which got noteworthy consideration in the cryobiology network as of late. Tried SIMs incorporate 6 % 1,3Cyclohexaneidol, 6 % 2,3Butanediol and 12 % PEG400(percentage by volume). This

investigation incorporates the examining cryomacroscope for visual check of crystallization and vitrificaion occasions. It is exhibited that the Thermal Conductivity of the vitrifying CPA mixed drink decreses monotonically with decresing temperature down to-180℃. Conversely, the Thermal Conductivity of crystalline material increments with diminishing temperature in a similar temperature run. Aftereffects of this examination exhibit that the Thermal Conductivity may change by three overlap among indistinct and crystalline periods of DP6 underneath glass progress temperature of DP6(Tg= - 119 ℃). The chose SIMs exhibit the capacity to hinder crystallization in DP6, even at subcritical cooling rates. An extra ice concealment capacity is seen by the EURO Collins as a vehicle arrangement, unbalanced to its volume proportion in the mixed drink. The ramifications of the watched Thermal Conductivity contrasts between the shapeless and crystalline periods of a similar mixed drink on cryopreservation reproductions are critical at times and should be considered in warm examination of cryopreservation conventions.

II. CONCLUSIONS

The thermal conductivity of Different in combination with SIMs and EC has been measured usinga hot-wire transient method. This experimental study used a scanning cryo-macroscopefor visual verification of crystallization and vitrification events. It is demonstrated that the thermal conductivity of the vitrifying CPA cocktail decreases monotonically with the decreasing temperature down to -180°C and also cryogenic temperature. By contrast, the thermal conductivity of the crystalline material increases with the decreasing temperature in the same temperature range. Similarly this paper describes thermal conductivity behaviour for various temperatures and materials and different properties. This paper also showed that experimental results good agreements with theoretical and analytical results.

III. REFERENCES

[1]. VanapalliS et.al. “An apparatus to measure the thermal conductivity of insulation panels at sub-ambient temperature”, International Journal of Refrigeration, Vol.44,pp.644-650 (2017).

[2]. Bi Dongmei et.al. “Measurement of thermal diffusivity/ thermal contact resistance using Laser Photothermal method at cryogenic temperatures”, Applied thermal Engineering, Vol.111,pp 768-775(2017)

[3]. J.Hamlet et.al. “ modelling of circuits with strongly temperature dependent thermal conductivities for the cryogenic CMOS”, Microelectronics Journal, Vol.no 42, pp 936-941 (2011)

[4]. Adam L woodcraftet. al., “Predicting the thermal conductivity of aluminium alloys in the cryogenic to room temperature” Cryogenics, Vol.45, pp 421-431(2005)

[5]. Gaosheng Wei et.al.”Thermal conductivity investigations of granular and powdered silca aerogels at different temperatures and pressures”Energy and Buildings, Vol.118, 226-231(2016)

[6]. A.Hofmann et.al. “The thermal conductivity of cryogenic insulation materials and its temperature dependence”, Cryogenics, Vol.46, pp.815-824(2006)

[7]. James Tuttleet. al. “Cryogenic thermal conductivity measurements on candidate materials for space missions”, Cryogenics, Vol.88,pp.36-43(2017)

[8]. Y. Yang et.al. “Influence of gamma ray irradiation on thermal conductivity of bismaleimide-triazine-based insulation tape at cryogenic temperature”,Cryogenics,Vol.89, pp.107-112(2018)

[9]. Sachiko Nakamura et.al. “Specific heat, thermal conductivity, and magnetic susceptibility of cyanate ester resins – An alternative to commonly used epoxy resins”, Cryogenics,Vol.95, pp.76-81(2018)

[10]. Kong Chunhui et.al. “Thermal Conductivity of Open Cell Aluminum Foam and Its Application as Advanced Thermal Storage Unit at Low Temperature”,Rare Metal Materials and Engineering,Vol.4, pp.1049-1053(2018)

[11]. Yuting Tan et.al. “ Eevaluation of viscosity and thermal conductivity models for CO_2 mixtures applied in CO_2 cryogenic process in carbon capture and storage (CCS)”, Applied thermal engineering, Vol.123, pp.721-733(2017)

[12]. Alexey Drobizhev et.al. “Thermal conductivity measurements of PTFE and Al_2O_3 ceramic at sub Kelvin temperatures”, Cryogenics, Vol.85, pp.63-70(2017)

[13]. TatangMulyana et.al. “The influence of cryogenic supercritical carbon dioxide cooling on tool wear during machining high thermal conductivity steel”, Journal Cleaner Production, Vol.164, pp.950-962(2017)

[14]. Ricardo I.Amils et.al. “Thermal conductivity of silver loaded conductive epoxy from cryogenic to ambient temperature and its application for precision cryogenic noise measurements”, Cryogenics, Vol.76, pp.23-28(2016)

[15]. Lili. E. Enrlich et.al. “Thermal conductivity of cryoprotective cocktail DP6 in cryogenic temperatures, in the presence and absence of ice modulators”,Cryobilogy, Vol.73, pp.196-202(2016)