



# The Implications of Insulation and its Impacts – A Review

<sup>1</sup>Ravi Teja D, <sup>2</sup>Afreen Bhumgara

<sup>1</sup>Alumnus of Amrita School of Engineering, Bengaluru

<sup>2</sup>Alumnus of Nowrosjee Wadia College, Pune

**Abstract - Insulation describes a power savings measure that provides opposition to heat movement. Naturally, heat moves from a hotter to a colder space. Through insulating a home, one can decrease the warmth loss in structures in cold climate or environment, and decrease the heat excess in warmer climate or environment. Insulating a home has several advantages such as power savings, cost discounts and increased relaxation. Barriers to take on energy savings steps may be divided incentives, fairly high expense charges, and the effort and time needed to understand the energy benefits. There are numerous kinds of insulation towards heat loss inside cold environments, each using its own specialized characteristics and economic costs and advantages. Insulation steps are generally the most economical energy benefits steps. Thus, insulation restricts the want for warming or chilling the house. Warmth losses or warmth surpluses arise due to differences among the interior and outside air temperature. Normally, heat moves from a hotter to a chillier area, and the conditions will converge towards an equilibrium heat, a physical trend based on systems like transmitting (the heat movement through components) and venting (heat movement by atmosphere). Insulation seeks at decreasing the rate of that convergence of temp to be able to reduce the want for warming or chilling. This technology outline targets insulation towards heat loss however includes some referrals on insulation regarding cooling. Many kinds of insulation steps exist. Beneath insulation steps for home buildings are explained. The research focuses on insulation and reviews it effectively while also providing sufficient literature review and empirical evidence and measuring their efficacy. The study adopts an empirical based research and aims to follow a descriptive research paper. The research shows various kinds of implications that could further be adopted and implemented.**

**Keywords – insulation, moulting, conductance, resistance**

## I. INTRODUCTION

### A. Wall, roof and floor insulation

Walls, roof as well as floor insulation might be carried out by repairing insulation materials to the walls, roof or even floor, possibly within outside, e. g. through using insulation system. Different components for walls, roofing and flooring require different kinds of insulation steps. Buildings might for example possess cavity surfaces consisting of 2 'skins' divided by an ineffective space. This area already offers some insulation however can be stuffed up with extra insulation materials, e. g.

foam, for boosting the insulation impact. Roof insulation regarding flat roofs varies from insulation with regard to steeper roofing. Floors are usually created of wooden or cement, each needing specific insulation steps. Another choice to decrease heat cutbacks to the floor is earth insulation, as an example through placing insulation materials on the earth within a so-called “crawl area” (a really low basement).The time of a construction is an essential factor identifying the kind of insulation as well as the method where it is put in, e. g. when insulation is placed on the outdoors or within of the building.

### B. Window as well as door insulation

Windows as well as exterior doors possess a large effect on the cooling and heating needs of a construction. New components, coatings, and styles have resulted in considerably improved energy effectiveness of fresh, high-performing doors and windows. Innovative high-quality windows might be around 6 times more power effective than lower-quality, old windows (Pew Centre, 2009). A few of the newest developments regarding improved windows consist of several glazing, using 2 or even more panes of glass or even other films regarding insulation, as well as low-emissivity coatings decreasing the movement of infrared power from the construction to the atmosphere (Pew Centre, 2009). Attention requires to be given not simply to the window alone, but additionally to the window shape, which can considerably affect a window’s insulation amount.

### C. Closing Breaks

An additional insulation assesses that decreases the quantity of heat reduction is closing breaks inside the ‘shell’ associated with the construction. Cracks trigger infiltration of chilly air from outdoors or seepage of hot air towards the outside. Pieces or other substance can be utilized to seal breaks in moving components, such as doors and windows, and in locations where various construction components are connected together. Growing insulation is officially feasible for nearly all structures, although it will be most effective to include insulation throughout the construction stage. Due to the variety of insulation steps, a suitable choice is generally obtainable for nearly every construction, since many buildings possess room for enhancement regarding insulation. Alongside technical needs, human choices

regarding comfort as well as aesthetics additionally are involved, e. g. regarding windows greater insulation includes reduced insulation, i. e. fewer light. Inside practice, and the suitability regarding insulation steps depends mostly on the present technical condition of a home. Particularly the insulation currently in place restricts extra insulation. This will be because of the physical room remaining for insulation as well as the suitability associated with the existing building (e. g. accessibility to a hole wall or adequate cavity thickness, enough shape space to put in better insulated however usually heavier windows, sufficient crawl area under the flooring), but also since the law regarding diminishing returns is applicable: Every extra coating of insulation produces less energy benefits than the past one. The amount of insulation which can be accomplished by various insulation supplies, i. e. the insulation worth, is typically indicated as the particular R-value. The R-value signifies the insulation material's opposition to heat movement. The greater the R-value, the superior the insulation associated with a wall, roofing or flooring. For windows the worth U is utilized, mathematically various but analogue towards the R-value. Reverse to the R-value, the reduced the U worth the greater the insulation involving the window. Table 1 offers typical insulation valuations for walls, roofing, flooring and window (glass as well as frame) insulation within Dutch structures based on their age.

#### D. The use of feathers as insulating material

The use of the after-slaughter throw away feather will be a serious issue because of pathogenic microorganisms found in this throw away on one hand, and technical criteria which should meet stringent sanitary as well as environmental safety requirements on the other. The traditional techniques of feather utilization provide thermal procedures or composting which is possibly extensive or time-consuming. The created innovative technology removes the above described inconveniences while allowing effective execution in SMEs at reduced investment expenses.

The feathers obtained from after-slaughter include around 70 - 75 % of water. These are saved gradually to fill the reactor. Subsequently the reactor will be closed and goes through the procedure of hydration associated with oxygenic lime within the sum of 8 -12 %, together with 8 - 10 % of lignite as well as peat. The acquired mass is combined with a rate of 5 - 8 spins each minute for around 2 hours and kept to cool. Following the procedure of hygienisation the feathers tend to be unloaded throughout mixing and the path of reactor's spins is changed frequently. Next the feathers go through the procedure associated with mechanic disintegration. The acquired end item is secure and set for utilization like fertilizer and includes no pathogenic organisms Furthermore, the task is an instance of non-energetic usage of lignite.

## II. LITERATURE REVIEW

### Environmental impact of the task/technology

The technology assists in solving the issue of waste administration from chicken slaughter homes in an effective and costs efficient method. The acquired product may be used to improve earth quality as well as deacidification reasons. Inside birds, feathers based of different kinds serve 3 main features - regarding insulation, regarding flight, and regarding display. Chemically they tend to be comparable to the hair as well as nails in mammals, along with scale associated with reptiles. These are all created of the identical hardened fibrous protein which is recognized as keratin. The particular structure of keratin inside feathers is a lot more processed then this within other keratin components [Tudge, 2008]. Chicken feathers include of around 91% keratin, 1% of lipids as well as 8% of water [Miller, wool. 2007]. Feathers seem on bird's system in tracts or even areas known as pterylae. Muscles mounted on the feathers follicle enables to construct the feather through where it arise to improve the quantity of air caught within growing the insulation capabilities of the feather coating. This capability also allows the birds in order to manage their body heat in hot periods by erecting these to be able to discharge of extra warmth [PoultryHub, 2010].

Within the fowls presently there are 5 kinds of feathers:

1. Contour feathers
2. Plumules
3. Filoplumes
4. down (chick)
5. Bristles

Contour feathers are discovered on a bird's rear, tail, along with wings. They contain rachis, the external and internal vanes that slopes obliquely to the tip as well as includes parallel barbs, barbules, along with barbicels which hooks and keep the barbs collectively to style the vane. This method strengthens the feather and provides it strong and sleek area that allows the bird to travel, as well as repel water. Lower feathers are a coating of fine feathers discovered under outside feathers. They are small, soft and cozy. They insufficient the barbules as well as hooklets, consequently they are not really for soaring. Their loose framework traps air that helps to control the bird's system temperature at about 40°C. Poultry hatch along with their lower feathers. They are brief and cozy. When the hens moult the teen feathers look like adult contour feathers however are softer and ultimately replaced by conclusive (final) plumage [Poultrypedia]. Semi plumes tend to be situated beneath the contour feathers as well as are gentle, have a brief shaft using radiating, free barbs as well as barbules. Barbules aren't interlocked as well as hooklets. They supply insulation. Filoplumes comprise of a slim rachis along with a few brief barbs associated with barbules from the tip. These get noticed such as a hair as well as are located next to contour feathers. They are frequently quite difficult during the digesting the live chicken into

meat, because they often stay near to body and tend to be hard to get rid of. Bristles possess a brief, tapered rachis as well as few, when any barbs which seem at the bottom of the feather. These are for safety and are located close to the eyes, from the bottom of the beak, as well as addressing the nostrils. Hen has about 140 grams of feathers which makes about 6% of its weight. The hen matures to pick in 6-8 weeks [Schmidt].

### III. MOULTING

Moulting inside hen is an organic process of losing and reviving feather to maintain them cold in the summer as well as hot during the winter. In natural ailments, moulting inside adult birds may occur annually in about March and April. In those times chicken drop a lot of the feathers and fresh ones begins to develop when the old ones dropped away. It takes around 6 to 7 weeks for fresh feathers to develop [Houser, June 30, 2009].

### IV. STURDINESS OF FEATHERS

Jeffrey W. Kock [2006] by the School of Civil and Environmental Engineering [Georgia Institute of Technology] inside his investigation "Physical as well as mechanical qualities of hen feather components" has discovered that hen feathers possesses the Young's modulus inside the array of 3 - > 50 GPa as well as, thus equivalent to the Young's modulus associated with other organic fibres. Glass fibre-E offers 72 GPa [Saheb and Jog, 1999]. Kock, additionally discovered that keratin inside chicken feathers possess good chemical sturdiness and opposition to destruction, but also found that highly alkaline atmosphere that may be noticed in concrete enhance destruction. Therefore, chicken feathers might need to be specifically handled if utilized touching concrete.

### V. SUPPLY OF CFP

United Kingdom is the 2nd in Europe following France hen meat producer. It creates simply less than 1.6 million tons annually of hen meat [Eurostat, 2010]. The total quantity of hen on agricultural holdings inside 2010 inside the UK had been 163.867 million birds, exactly where 93% are hens (69% broilers as well as 31% breeding and putting fowl), 2.4% turkeys, and 1.5% ducks, as well as 3% associated with all others such as geese [Defra, 2010]. The hen will have around 0.1 kilogram of feathers through market time, [S. Leeson and T. Walsh, 2004]. This number is difficult to calculate; consequently it is obtained as the smallest. Quantity of feathers upon bird is dependent of many elements. Those elements are: kind of chicken (chicken might have fewer feathers compared to turkey or even goose), kind of hen (broilers tend to be slaughtered following 10-12 weeks in addition to laying hens chicken tend to be kept for around a year), the age and sex. That gives about 163 million kilograms associated with feathers annually. For the test 500grams regarding feathers had been utilized to sense 0.009m<sup>2</sup> testing area. When this quantity of feathers must be utilized to insulate the home; 5.5 kg of feathers may be required to

protect 1 m<sup>2</sup> of walls. When one wall associated with a typical home is 7m x 5m = 35 m<sup>2</sup> we might require 192.5 kg of feathers regarding one wall and 1600 tones regarding feathers might be adequate to protect 2.9 million m<sup>2</sup> associated with building walls. The typical dual bedroom house might have area of exterior walls about 100 m<sup>2</sup>, subsequently 2.9 million m<sup>2</sup> regarding this substance would be adequate to protect 29000 houses annually. In modern chicken farming almost all the feathers as well as uneatable areas of the hen are combined together and got rid of away in landfills. It assists in decomposing the feathers; consequently feathers need to be divided during the washing procedure.

### VI. SEPARATING TECHNIQUE

Based on Schmidt [1998] hen feathers can't be used from the hen and straight used into the fresh material, however must be divided first. It's only the gentle, cozy substance of the feathers that's helpful as feather substance [1998]. Schmidt as well as his group at the agriculture Research Service (ARS) U. S. have produced and trademarked a procedure to split quill as well as fibre along with a utilization of turbulent ventilation. Chopped, washed and dried feathers tend to be passed into a little cylinder pipe (Figure x). They fit in a big canister tube in which turbulent airflow movements quill and large parts towards the bottom of the system for elimination while barb components are supplied to the top exactly where they may be gathered for further usage.

### VII. FEATHER CLEANSING PROCEDURE

Inside Indonesia, Tangerang the initial factory Feather World LTD. had been founded in 2002 to clean as well as sterilize down along with feathers. This item would be marketed to the client for manufacturing of bedding products, furniture as well as winter coats. Down along with feathers are initially washed in washer, where they're water cleaned, detergent cleaned and chemical cleaned to be able to acquire raw sterilized item. Subsequently they are transferred into high pressurized drying device where they're held for 30 minutes inside temp of 120 degree. Through there they're going via 10 minutes cooling procedure to improve quality and power associated with the down as well as feathers. Subsequent they will sort device, where they may be categorized into various classes beginning with 100% tiny feather till the finest 100% lower. The final action is pre-dusting device, where the item is washed from any dirt and small contaminants. The final item is clear and hygienic, categorized into various classes and prepared to market to clients. Comparable technique may be utilized to make the hen feathers regarding a further marketplace selling.

## VIII. DISTRIBUTION AND QUALIFIED INDIVIDUALS

If you intend to construct an Expansion, execute a Modify of Use or even refurbish a construction then it's better to notify Creating Management a minimum of 5 days prior to any function is commenced. In addition if you desire to make sure conformity with Part L1B subsequently I would highly recommend that all data are completed and posted to Building Control well before any focus on the floor is began. Building Control can probably request these anyhow and apart from its greatest to make sure that, in writing a minimum of, what you intend to do conforms, normally you threat some very costly changes when its left till after the establish is finished before any conformity check is created. We pointed out earlier regarding competent individuals, in this framework Part L1B guide to qualified individual are gas fitter as well as electricians as an example that, once the function is finished, will post a document of conclusion that Building Control need without additional query. The reason being they are people of a plan that guarantees they can execute the function safely and correctly.

When it comes to energy assessors, we're also included in similar type strategies, meaning that our data and accounts can be recognized by Building Control like proof of complying along with the Rules. Nevertheless, we may just base the work upon the information supplied by the customer. Building Control may be accountable for examining that exactly what was prepared actually was put in. Assessors additionally use the data and accounts to demonstrate conformity prior to work is commenced and additionally in some situations once function is finished. If it's a Modify of Use, a home to houses or vice versa, not just will Building Rules be required, though that is whenever an Energy Performance Certificate (EPC) will be needed. For extensions merely, it's not likely an EPC will be needed at all. It's vital that an precise computation is completed before function starts to ensure that everybody, the contractor, the electricians and so on know precisely what its they require to do to be able to conform. There are some instances exactly where notification doesn't need to get, where function has been done due to an emergency for instance, or where there isn't any health as well as safety danger associated into it. Things such as installing the stand-alone set electric heating unit or upgrading/installing attic insulation will be exempt through notification.

## IX. STANDARDS ASSOCIATED WITH MATERIALS & CRAFTSMANSHIP

There tend to be references all through ADL1B in order to named requirements or strategies, and you will find other schemes exactly where products will be asked to meet their unique standards, HETAS with regard to example with regard to wood burning up stoves. In most cases in the event that it's a typical or scheme known the

suggested work should meet individuals standards, basically if an item states this meets the particular plan standard, Building Manage should make sure that the scheme under consideration is the valid one which meets what's needed of the actual Regulations.

## X. BUILDING REGULATIONS

### A. Reference Technique

The Research method is actually purely demonstrating how the above overall performance requirements with regard to thermal components and managed fittings are inside the limits. Other methods for demonstrating conformity is region weighted ought value information, again generally for plug-ins, but its combined with a Materials Change useful too, by doing this if 1 element is actually slightly away, or since the building offers maybe Detailed Status or another reason the reason why a measure can't be implemented, like it's not economical to do this, showing a place weighted ough value computation which even comes close the because designed extension to 1 that elementally fulfills the regulations might help show conformity. The difficulty is, often this isn't enough possibly.

### B. Heat Reduction Calculations

This isn't clearly listed within the document however it is a choice and one I personally use constantly. This is actually where the calculation is performed to show heat losses in the as created extension or even wholesome, elementally as well as area weighted, and when compared with an expansion or entire dwelling (the Notional) which elementally fulfills the Rules.

### C. Whole Home Method

This really is used hardly ever for plug-ins, although a great deal for makeovers and Change useful, and is actually when SAP2009 can be used to determine the CO2 emissions for the whole building because designed, as well as compared to some full SAP of the identical creating, the Notional, which elementally fulfills the legislation minimum needs for energy elements, managed fittings as well as controlled providers. This computation includes the present dwelling along with the extension, and also the glazing within the Notional building should be a maximum of the 25% from the floor mentioned above previously above. You should meet this particular requirement very first as a minimum of you tend to be showing how the basic design is at the Rules. I show a place weighted Ough value computation of both as prepared extensions along with a Notional someone to compare, as this particular identifies exactly where any improvements should be created where 1element or even more is not really performing higher enough. This is advantageous when you're combining each new as well as upgraded current elements, or where a current element can't be upgraded because of to monetary payback would be too long, or how the building offers conservation or even listed standing meaning a current part can't be upgraded, or perhaps a new component must first comply with visual

appearance and to do this it cannot satisfy the minimum needs. I additionally show warmth loss information, which may be the area of every element increased by its U ideals, and evaluate the as made to the Notional, to see when there is a brief fall. This really is probably the most useful since it provides an extremely clear method of showing the way the new extension will perform, when it comes to heat deficits, compared in order to how it will perform in the event that it had been meeting the actual Regulations minimums. It's right here that it's really apparent if another thing needs to be done. Generally there is really a shortfall; usually because of over double glazed, the section of which we also display in the actual Submission statement, in that case another thing will have to be carried out to replace with those extra heat deficits.

### XI. MATERIALS CHANGE

This is the place where a building can be used as the dwelling, when previously it had been not, or where it had been a whole dwelling that's now changed into flats, or where it had been numerous flats and it is been changed into a solitary dwelling.

### XII. CHANGE OF ONE'S STATUS

This is actually where there's been a formerly unheated building which is now warmed, or the place where a Material change useful has occurred which has resulted inside a change towards the energy standing, which within likelihood is nearly always. It may be where the previously exempt creating no longer happens because the power status offers changed with regard to reasons because above. How you can demonstrate compliance is actually just like that outlined above to have an extension. The distinction is which in just about all cases is that the full SAP2009 is going to be completed for that building because designed, and a different one for the actual building because designed however meeting the actual minimum needs for energy elements, managed fittings as well as controlled providers, the Notional Creating. The outcome required is how the actual creating CO<sub>2</sub> emissions are added up to or less than the Notional creating. In just about all respects the actual minimum needs as put down above with regard to extensions also obtain a material Change useful or Change of one's Status, and it's the entire CO<sub>2</sub> emissions, that is the key figures that have to be submitted in order to Building Manage. This is actually where, often creating Control request a SAP calculation with an existing creating, it's not really SAP calculation that's carried out when it comes to demonstrating the actual DER/TER, but it's a SAP computation, using the actual SAP software program, to display the CO<sub>2</sub> emissions. It is difficult to create reports with regard to submission in the SAP software program, unlike with regard to new develops, to do wouldn't make any feeling and would in all probability show fall short in most of the section from the report, this really is because the actual SAP software can there be to show compliance towards Part L1A, brand new builds, and never existing

types, albeit some having a new element for them, like a good extension.

The SAP software can be used to create the CO<sub>2</sub> emissions figures along with a separate statement, in my personal case one I've developed which will demonstrate compliance and really should be posted to Creating Control. The SAP loan calculator input documents may be used to support which report in the event that requested because they build Control.

### XIII. MANAGED SERVICES

Controlled Services would be the heating, warm water, lighting and so on. You would believe that given the actual wide range of different styles and equipment that may be installed right into a dwelling presently there would become more to this particular section, when it comes to complying using the Regulations, however in reality it's very easy. When we execute the calculations mentioned above previously above there isn't any provision to incorporate the effect from the controlled providers, except for any whole creating calculation in which the services because designed tend to be input, and the actual CO<sub>2</sub> emissions related to them are contained in the final numbers. They do have an effect, for example should you were selecting between the gas terminated boiler as well as an essential oil fired 1, the CO<sub>2</sub> emission related to gas boiler will be considerably less than those for that oil 1. If the actual building currently includes a gas provide and you decide to put a good oil central heating boiler in, the Notional Building may have a gasoline boiler, no oil 1, therefore a person would find it difficult to match the actual CO<sub>2</sub> emissions in the as designed when compared to Notional without creating for the actual excessive CO<sub>2</sub> emissions in the oil central heating boiler by paying elsewhere.

### XIV. ENERGY CONDUCTIVITY WITHIN PHYSICS

Energy conductivity may be the property of the material's capability to conduct warmth. It seems primarily within Fourier's Regulation for warmth conduction. Energy conductivity is actually measured within watts for each Kelvin-meter ( $W \cdot K^{-1} \cdot m^{-1}$ , i. e.  $W / (K \cdot m)$ ) or even in IP models ( $Btu \cdot hr^{-1} \cdot ft^{-1} \cdot F^{-1}$ , i. e.  $Btu / (hr \cdot ft \cdot F)$ ). Multiplied with a temperature distinction (in Kelvin's, K) and a place (in sq. meters, m<sup>2</sup>), and divided with a thickness (in yards, m), the actual thermal conductivity forecasts the rate of one's loss (in w, W) through a bit of material. Within the window creating industry "thermal conductivity" is expressed since the U-Factor [1], which steps the price of warmth transfer and lets you know how nicely the eye-port insulates. U-factor values are usually recorded within IP models ( $Btu / (hr \cdot ft \cdot F)$ ) as well as usually vary from 0.15 to at least 1.25. The actual lower the actual U-factor, the greater the eye-port insulates.

The actual reciprocal associated with thermal conductivity is actually thermal resistivity.

There are numerous ways in order to measure energy conductivity. All these are ideal for a limited selection of materials, with respect to the thermal properties and also the medium heat. There is really a distinction in between steady-state as well as transient methods. In common, steady-state techniques are helpful when the actual temperature from the material doesn't change as time passes. This can make the transmission analysis simple (steady condition implies continuous signals). The drawback is that the well-engineered fresh setup is generally needed. The Split Bar (various types) is the most typical device employed for consolidated rock and roll samples.

The transient techniques execute a measurement throughout the process of warming up. Their benefit is faster measurements. Transient methods are often carried away by hook probes.

### XV. MEANINGS

The reciprocal associated with thermal conductivity is actually thermal resistivity, generally measured within Kelvin-meters for each watt ( $K \cdot m \cdot W^{-1}$ ). When coping with a known quantity of material, its energy conductance and also the reciprocal home, thermal opposition, can end up being described. Regrettably, there tend to be differing meanings for these types of terms.

### XVI. CONDUCTANCE

With regard to general medical use, thermal conductance is the amount of heat which passes within unit time via a plate associated with particular region and width when its opposite encounters differs within temperature through one Kelvin. For any plate associated with thermal conductivity nited kingdom, area and the width  $L$  this really is  $kA/L$ , calculated in  $W \cdot K^{-1}$  (equivalent in order to:  $W/^\circ C$ ). Energy conductivity as well as conductance tend to be analogous in order to electrical conductivity ( $A \cdot m^{-1} \cdot V^{-1}$ ) as well as electrical conductance ( $A \cdot V^{-1}$ ).

There's also a measure referred to as heat move coefficient: the amount of heat which passes within unit period through device area of the plate associated with particular width when its opposite encounters differ within temperature through one Kelvin. The actual reciprocal is actually thermal insulance. To sum up:

- Energy conductance =  $kA/L$ , calculated in  $W \cdot K^{-1}$
- Energy resistance =  $L/(kA)$ , calculated in  $K \cdot W^{-1}$  (equivalent in order to:  $^\circ C/W$ )
- Warmth transfer coefficient =  $k/L$ , calculated in  $W \cdot K^{-1} \cdot m^{-2}$
- Thermal insulation =  $L/k$ , calculated in  $K \cdot m^2 \cdot W^{-1}$

The warmth transfer coefficient is also called thermal access

### XVII. RESISTANCE

Whenever thermal resistances happen in sequence, they tend to be additive. Then when heat moves through 2 components each having a resistance of just one  $^\circ C/W$ , the entire resistance is actually 2  $^\circ C/W$ . A typical engineering style problem involves picking a suitable sized warmth sink for any given warmth source. Employed in units associated with thermal opposition greatly simplifies the look calculation. The next formula maybe accustomed to estimate the actual performance:

- $R_{hs}$  may be the maximum energy resistance from the heat kitchen sink to background, in  $^\circ C/W$
- $\Delta T$  is the actual temperature distinction (temperature drop), within  $^\circ C$
- $P_{th}$  may be the thermal energy (heat flow), within watts
- $R_{smay}$  may be the thermal resistance from the heat supply, in  $^\circ C/W$

For instance, if an element produces 100 Watts of warmth, and includes a thermal opposition of 0.5  $^\circ C/W$ , what's the maximum energy resistance from the heat kitchen sink? Suppose the most temperature is actually 125  $^\circ C$ , and also the ambient heat is twenty five  $^\circ C$ ; then you're 100  $^\circ C$ . Heat sink's energy resistance in order to ambient should then end up being 0.5  $^\circ C/W$  or even less

### XVIII. STEADY-STATE CONDUCTION

Steady condition conduction may be the form associated with conduction that occurs when the actual temperature difference(s) generating the conduction tend to be constant, to ensure that (after a good equilibration time), the spatial submission of temps (temperature field) within the conducting object doesn't change any more. Thus, all incomplete derivatives associated with temperature regarding space might either end up being zero or even have nonzero ideals, but just about all derivatives associated with temperature from any point regarding time tend to be uniformly absolutely no. In constant state conduction, the quantity of heat getting into any region of the object is add up to amount associated with heat being released (if this weren't so, the temperature will be rising or even falling, as energy had been tapped or even trapped inside a region).

For instance, a bar might be cold from one finish and hot in the other, but following a state associated with steady condition conduction is actually reached, the spatial gradient associated with temperatures across the bar doesn't change any more, as period proceeds. Rather, the heat at any kind of given portion of the fishing rod remains continuous, and this particular temperature differs linearly within space, across the direction associated with heat move.

Low effect natural insulation items have several benefits over artificial insulation products based on crude essential oil. They possess low embodied power. They can be acquired from green resources and may be used

again, recycled and therefore are fully biodegradable. Some of the people materials in many cases are a by-product that has been thrown aside and increase landfill amount within the UK. They're easy as well as safe to set up with absolutely no irritating fibers. Natural insulation products also have hydrophilic properties that offer moisture manage, which helps you to reduce moisture, helping to produce a breathable creating, consequently enhancing building sturdiness. There is a variety of natural insulation products for example sheep's made of wool, hemp as well as wood fibers which are already utilized in building business.

The main insulation item is sheep's wool created from sheep selectively bred primarily with regard to food. It's excellent energy properties and it is a green resource from sheep maqui berry farmers in Britain, Wales as well as Scotland. It may be used with regard to roof, wall space and ground insulation. It is available in batts, or rolls of numerous thicknesses. Hemp is created from hemp fibers and may be grown within the UK. Insulation supplies vary, which range from the traditional - polystyrene as well as mineral made of wool - towards the traditional as well as novel, for example sheep's made of wool and hemp. (Source: Environmentally friendly home repairs, David Thorpe). Also, Natural sources might require very small energy to create

## XVIX. ORGANIC MATERIALS WITH REGARD TO INSULATION

1. Wool insulation consists of sheep's made of wool fibres, which are either mechanically kept together or even bonded utilizing around 12% polyester to create insulating bats as well as rolls. K-value: 0. 038-0.043W/mK. The recyclable renewable resource having a low embodied power is safe to set up and fire proof. It can be used for each thermal as well as acoustic insulation applications. People in a kind of clothing purchased it for a long time. It is actually safe in order to human wellness.

2. Wooden fibrebatts. K-value 0.038-0. 043W/mK. Easy as well as safe to set up, fire-resistant, recyclable, green, biodegradable within landfill and non-hazardous. Great for walls, roof, roofs, wood joisted flooring.

3. Cotton-base batts as well as rolls (e. grams. Inno-therm). K-value: 0. 038-0. 043W/mK. Recyclable, green, an organic, non-hazardous fiber that's safe to set up. Cotton generator scraps or even recycled 100 % cotton is combined with a mass fiber for example hemp along with a thermoplastic binder such as polyester.

4. Cellulose (loose, batt or even board) (e. grams. Warmcel, Homatherm). K-value: 0. 038-0. 043W/mK. Recyclable, green, made through finely shredded paper, safe to set up. Loose-fill is actually blown upon horizontal areas. Low embodied power: 0. 94 in order to 3. 3MJ/kg.

5. Flax batts, slabs as well as rolls. K-value: around 0. 043W/mK. Produced from plant in whose fibers tend to be bound as well as a spud starch as well as treated along with borax to create them fireplace and bug resistant. Recyclable, green, organic, non-hazardous fibers, safe to set up. Biodegradable within landfill.

6. Hemp batts. K-value: 0. 043W/mK. Recyclable, green, natural, non-hazardous. Such as wool as well as cotton batts, contains 15 percent polyester fiber to keep lift as well as stability as well as borax.

7. Coconut fiber board. K-value: 0. 043W/mK.

8. Cork panel. K-value: 0. 043-0. 050W/mK.

9. Wooden fiber panel. K-value: 0. 080W/mK. The firm insulation includes a higher (worse) U-value compared to batt type.

10. Strawboard. K-value: 0. 12-0. 13W/mK. Recycled, recyclable green agricultural waste materials - 100 percent straw.

11. Hemcrete. K-value: 0. 12-0. 13W/mK

There tend to be many products you can use to weatherize as well as insulate your home. The primary objective whenever insulating is to produce a heat-retaining cover, one which will contain as well as put in order to best make use of the heat made by the house's heating device. To accomplish this, you'll have to use various materials, each within an appropriate area. Let's discuss some various approaches and appear at exactly where they function best. Let's begin with air manage. Air is continually moving close to us. Within winter, the cooler outside atmosphere enters the house, and the actual heated within air normally rises. These would be the two types of air movement you'll want to pay probably the most attention in order to controlling -- leakage associated with cold air in the outside to the house, and lack of heated air in the house towards the outside. External cooler air enters the home any way it may. It techniques through splits around doorways or windows, through gaps in which the wood walls of the home connect towards the masonry basis, and via other areas, such because around outdoors water faucets. It will likewise radiate through cold eye-port glass. To fix air seepage, you have to close or even seal the actual gaps. Close to doors or even windows, use one of the numerous available kinds of weather-stripping. With regard to gaps in between wood as well as masonry, or even around doorway or eye-port frames, caulking may be the solution. (See individual handout upon "Caulking as well as Weatherization" with regard to hints on choosing and install the best materials for every situation.) In order to block chilly radiating through glass, include storm home windows, insulating cup, or actually plastic "shrink wrap" barriers to produce a pocket associated with trapped air to do something as insulation. The hotter air that you have paid in order to heat can also be moving indoors. It rises as much as and with the roof. To some lesser degree, it additionally moves out with the side wall space and home windows.

The first part of controlling this particular movement is to ensure the warmed air reaches where you need to use this. If you've got a furnace, the heated air moves via a system associated with pipes, known as "ducts." They are able to and perform leak, allowing heated air to get away where you will not use this, such as with the cellar. Prevent this particular air reduction by closing all joints within the ducts along with duct mp3, and through insulating ducts that go through unheated areas if the user has got a register in his furnace for that basement near it. (Most frequently, the warmth that radiates in the furnace as well as ducts is ample to comfortable a cellar). When the heat source in your house is the boiler, it is relatively simple to insulate water pipes which carry heat from this to the remainder of your property. Once you the user has made sure heat is dealing with where he/she would like it, keep that heated air where this belongs by following a caulking methods already laid out. In add-on, close doorways and switch off the warmth in abandoned rooms. Seal around something that passes in the heated floors to the attic (such since the chimney, drinking water or dirt pipes, or even wires.) Each one of these holes permits the rising heated air to move away from home. Only whenever you've done each one of these steps isn't it time to take a look at house insulation. There are many types associated with insulation, but all are made to contain heat in one's own home.

## XX. WARMTH CONDITION

Heat moves from greater temperature to some region associated with lower heat until decreases temperature difference with time and achieve temperature balance. In strong materials warmth makes substances to vibrate within fixed placement. More extreme vibration leads to molecules to break up and the actual material turn out to be liquid and finally molecules escape with the surface in a kind of fumes. Heat is actually one type of energy as well as energy has the capacity to perform function, therefore, heat is actually measured because work as well as described within the same models as function; Joule. Additionally, the quantity of heat necessary to raise the actual temperature of just one gram associated with water through  $1^{\circ}\text{C}$  (calorie) from  $15^{\circ}\text{C}$  is add up to 4. 1868 joules. Where warmth travels in one substance to a different it uses energy and also the rate where it happens is known as power. (Mitchell's, Useful Thermal Style in Structures, Peter Burberry, g. 15) Consequently: Heat is actually conveyed within three types: conduction, the radiation and convection. With this project conduction associated with heat is going to be mostly analyzed since it takes devote solid supplies (building materials). The rate where heat is actually conducted with the material is called the conductivity from the material and it is expressed because: Thermal the radiation, known because infrared is really a process whenever an item radiates its thermal energy as electromagnetic surf. Radiant power moves via air or even vacuum and doesn't heat something, but is actually absorbed through an item on its path and changed into

heat. This really is commonly experienced when utilizing a home electric heating unit where its heat is actually emitted with a glowing incandescent lamp. Convection happens in gas and fluids, where warm temperature through an item is conducted towards the air or even fluid. Atmosphere or liquid becomes hotter and much less dense, and begin travelling upwards to become replaced through cooler atmosphere or liquid. In building, this procedure occurs within wall as well as roof cavities.

- **Energy Conductivity**

Energy conductivity, nited kingdom, describes exactly how material performs heat. In additional word the amount of heat  $Q$  that's transmitted with time  $t$  via a thickness from the material by, in the direction perpendicular to some surface associated with area  $The$ , due to some temperature distinction  $T$ , below steady condition. (David Thorpe, Environmentally friendly Home Repairs, p. 21). It's typically calculated in  $W$  per meter for each degree Celsius (Kelvin to become 100% correct) abbreviated because  $W/(m^{\circ}\text{K})$ ; the low this quantity, the much better the insulator.

- **Energy Resistance**

Thermal resistance referred to as the  $R$ -value steps how nicely a material resists warmth travelling via it. This will depend of the actual thickness from the material and it is thermal conductivity nited kingdom. It is understood to be a ratio from the temperature distinction across a good insulator and also the heat circulation per device area via it.  $R$ -values receive in metric models:  $m^2$   $^{\circ}\text{C}/W$ . (SHR, g. 21) at first, Higher  $R$ -value usually indicates much better insulation properties of the material.  $R$ -values are utilized more in the USA than within the UK.

- **Energy Transmittance**

The  $U$ -value describes the entire thermal conductivity associated with composite framework e. grams. a wall comprising bricks, plaster, atmosphere gap, insulation, and so on., and is actually measured within watts for each square meter for each degree Celsius (Kelvin) and it is abbreviated because  $W/m^2^{\circ}\text{K}$ . Where  $d$  may be the materials level,  $k$  may be the thermal conductivity of the material, and  $R$  may be the thermal resistance from the material.

## XXI. IDENTIFYING THERMAL INSULATION PROPERTIES

British Standards BS 874: Component 2: Area 2. 1: 1986 describes the process of identifying thermal insulation properties method popular for dimensions on low-density insulation materials within fibrous, mobile or granular type, and along with slight modification towards the measurements upon denser, much more rigid supplies of greater conductivity, at the. g. rubberized, dense plastic material, glasses as well as masonry supplies. It is essential to point out: "The conduct of thermally inhomogeneous supplies in class



(c) (described above) may on no account be referred to in term of the thermal conductivity or even resistivity in support of the energy resistance or even conductance from the specimens underneath the conditions associated with test, i. e. in a particular example of beauty thickness, heat difference as well as plate emissivity, might be referred in order to.” [BS 874: Part 2: Section 2.1: 1986. P2].The dedication of energy conductivity by this process involves the actual measurement from the average heat gradient produced with the thickness from the test examples by recognized unidirectional warmth flux denseness under steady-state problems. The apparatus include a protected heater plate having a central calculating section as well as an additional heater dish separated in the guarded heating unit plate through an insulation material. The additional heater dish is kept at a similar temperature since the centre portion of the protected heater dish, temperature stability being monitored by way of series-connected thermocouples mounted within the surfaces. Below these problems, all the power supplied towards the centre area passes entirely with the specimen as with figure 1. The entire system is actually insulated through outside heat. The thickness from the specimen depends from the guarded hot-plate dimension, but with regard to mostly utilized 305 mm dish the minimal thickness from the test specimen will be 25 mm and also the maximum width 50 mm. With modifications which are allowed below appendix The of BS 874: Component 2: Area 2. 1: 1986 the actual thickness from the specimen could be increased in order to 75-100 mm.The regular covers protected hot-plates of both two-specimen symmetric as well as single example of beauty asymmetric style in a variety of sizes. This process is suitable for the related method, ISO/DP 8302, being developed within the International Organization for Standardization (ISO).There are many restrictions about the determination associated with thermal conductivity and also the category that's the closest in order to feather materials is referred to as: thermally inhomogeneous materials by which heat might be transmitted by mixture of solid as well as gaseous conduction as well as radiation, i. e. miscellaneous insulation supplies or techniques having split or additional structures leading to non-uniform warmth transfer via them.

## XXII. RESULTS

### • Experiment

Heat rig was set up in the laboratory in a room temperature environment, which varies between 22 and 23 Celsius degree. Feathers were weighted 500mg and put into testing compartment. Heat compartments of the heat rig had a temperature raised to 30°C and maintain it constantly controlled by thermocouple HS2 to achieve steady state condition.

### Calibration Test

In order to get valid data the heat rig needs to be calibrate and tested with a known insulation material.

The material used for a calibration test is Glass mineral wool with a water repellent additive DriTherm37 Standard Cavity slab produced by Knauf Insulation [http://www.knaufinsulation.co.uk]. Its Thermal conductivity K-value ranges from 0.035-0.037 W/mK.

DriTherm Cavity slab 37 standard

Thickness [mm]	Thermal conductivity [W/mK]	Thermal resistance [m2K/W]	Length [mm]	Width [mm]
100	0.035	1.4	300	300

Test without insulation material

Data from;

Sensor A2 control 30C

Thickness x=0.1m

Plate area A=0.3x0.3m=0.09m<sup>2</sup>

$$Q = K \cdot A \frac{(T_2 - T_1)}{x}$$

$$K = \frac{Q \cdot x}{A \cdot (T_2 - T_1)}$$

Average temperature of plates:

Sensor HC3 T<sub>1</sub>=21.9437 C

Sensor MC3 T<sub>2</sub>=30.60835 C

Average heater voltage and current:

$$Q = K \cdot A \frac{(T_2 - T_1)}{x}$$

Voltage V=1.62973

Current A=0.114081

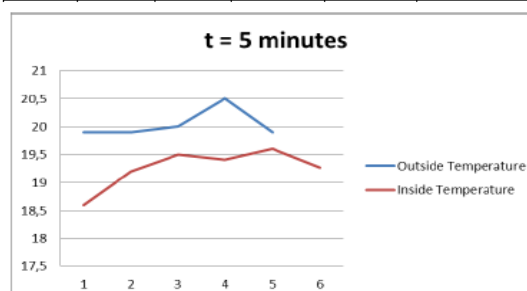
$$K = \frac{1.62973 \cdot 0.114081 \cdot 0.1}{0.09 \cdot (30.60835 - 21.9437)}$$

K = 0.023841

Insulation test with feathers

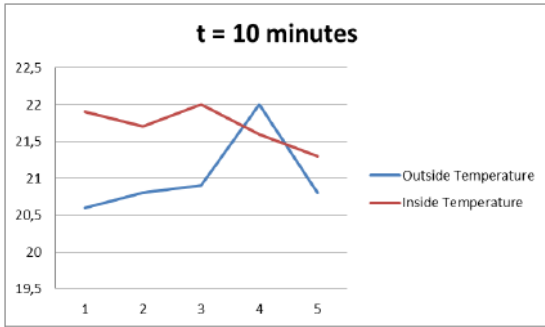
(Time = 5minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	18,6	19,9	10V	1,9V	0,268552885
2	19,2	19,9			0,1446054
3	19,5	20			0,103289571
4	19,4	20,5			0,227237057
5	19,6	19,9			0,061973743



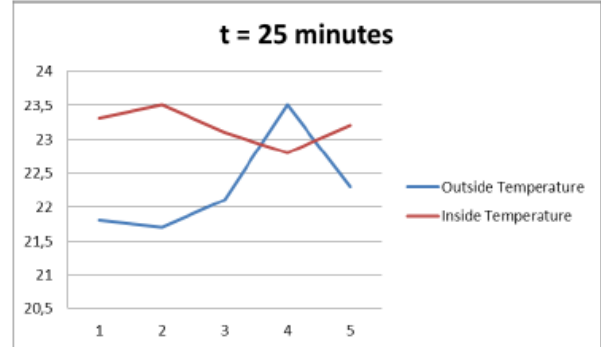
(Time = 10 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	21,9	20,6	9,5 V	1,8 A	0,268552885
2	21,7	20,8			0,185921228
3	22	20,9			0,227237057
4	21,6	22			0,082631657
5	21,3	20,8			0,103289571



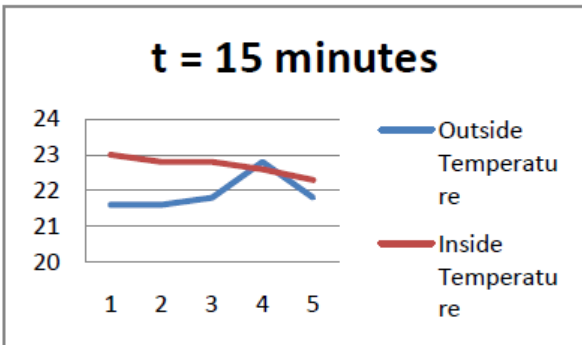
(Time = 25 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	23,3	21,8	9 V	1,75 A	0,309868714
2	23,5	21,7			0,371842456
3	23,1	22,1			0,206579142
4	22,8	23,5			0,1446054
5	23,2	22,3			0,185921228



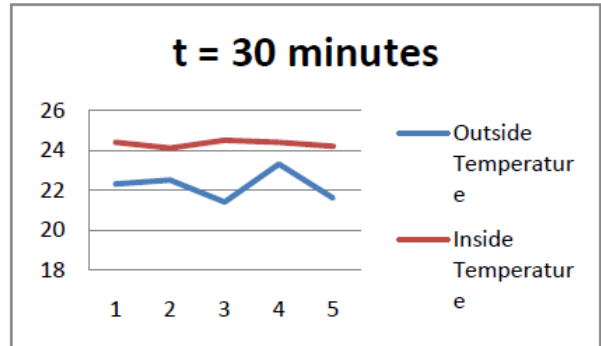
(Time = 15 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	23	21,6	9 V	1,85 A	0,289210799
2	22,8	21,6			0,247894971
3	22,8	21,8			0,206579142
4	22,6	22,8			0,041315828
5	22,3	21,8			0,103289571



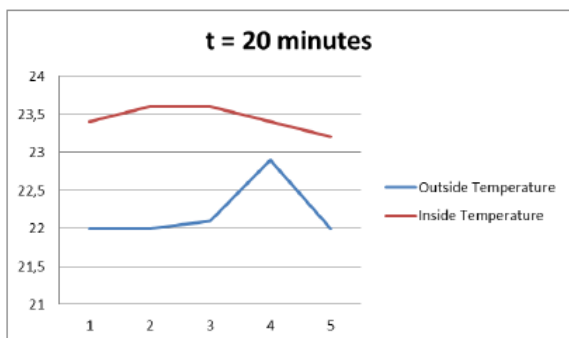
(Time = 30 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	24,4	22,3	9 V	1,75 A	0,433816199
2	24,1	22,5			0,330526628
3	24,5	21,4			0,640395341
4	24,4	23,3			0,227237057
5	24,2	21,6			0,53710577



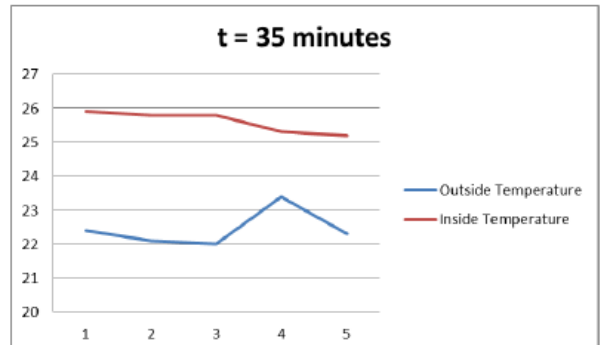
(Time = 20 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	23,4	22	9 V	1,75 A	0,289210799
2	23,6	22			0,330526628
3	23,6	22,1			0,309868714
4	23,4	22,9			0,103289571
5	23,2	22			0,247894971



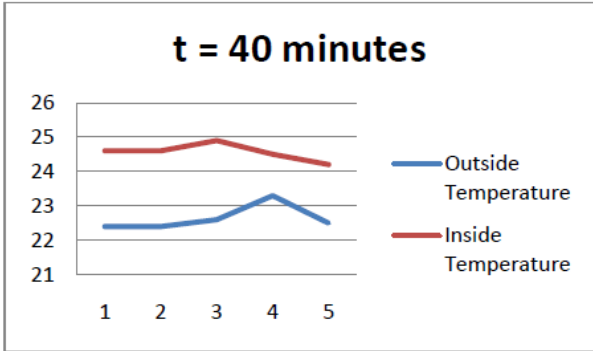
(Time = 35 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	25,9	22,4	9 V	1,75 A	0,723026998
2	25,8	22,1			0,764342827
3	25,8	22			0,785000741
4	25,3	23,4			0,39250037
5	25,2	22,3			0,599079513



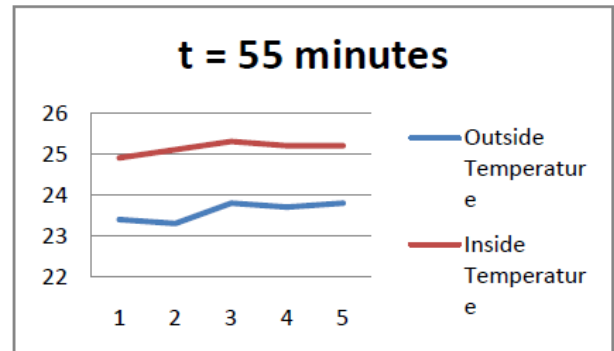
(Time = 40 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	24,6	22,4	6 V	1,29 A	0,454474113
2	24,6	22,4			0,454474113
3	24,9	22,6			0,475132027
4	24,5	23,3			0,247894971
5	24,2	22,5			0,351184542



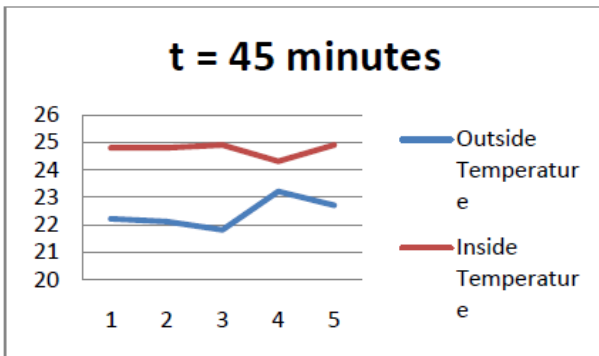
(Time = 55 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	24,9	23,4	6 V	1,2 A	0,309868714
2	25,1	23,3			0,371842456
3	25,3	23,8			0,309868714
4	25,2	23,7			0,309868714
5	25,2	23,8			0,289210799

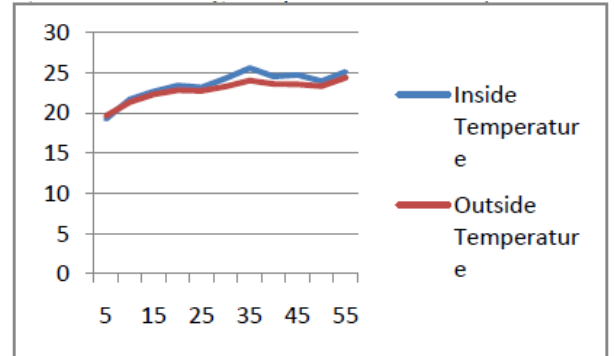


(Time = 45 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	24,8	22,2	6 V	1,29 A	0,454474113
2	24,8	22,1			0,454474113
3	24,9	21,8			0,475132027
4	24,3	23,2			0,247894971
5	24,9	22,7			0,351184542



And next, we see the average temperature over time (inside and outside)

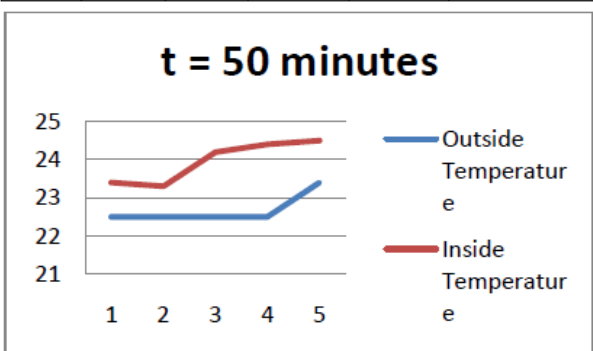


Temperature over time diagram

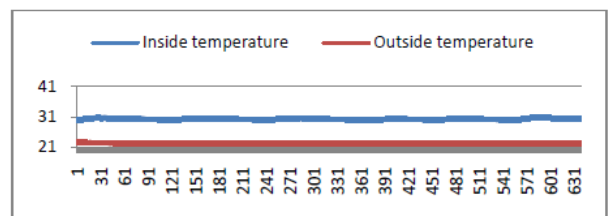
Test with Glass Wool

(Time = 50 minutes)

Data set	Temperature (Kelvin)		Heater voltage		K-value
	Inner	Outer	Voltage	Current	
1	23,4	22,5	6 V	1,29 A	0,185921228
2	23,3	22,5			0,165263314
3	24,2	22,5			0,351184542
4	24,4	22,5			0,39250037
5	24,5	23,4			0,227237057



Data set	temperature		Heater voltage		K-value
1	30.38641	21.95481	0.61322	0.043085	0.003482
2	30.22335	21.938	0.335	0.023486	0.001055
3	30.12906	21.96378	0.238812	0.017455	0.000567
4	30.14575	22.00002	0.225421	0.015916	0.000489
5	30.31461	22.01497	0.238812	0.016139	0.000516
6	30.29924	22.05929	0.709412	0.050078	0.004791



Data set	Temperature		Heater voltage		K-value
	Inside HS2	Outside MS2	Voltage V	Current A	
126-556	30.21615	21.9047	0.615592	0.043206	0.003556

Sensor A2 control 30°C

Thickness x=0.1m

Plate area A=0.3x0.3m=0.09m<sup>2</sup>

$$Q = K \cdot A \frac{(T_2 - T_1)}{x}$$

$$K = \frac{Q \cdot x}{A \cdot (T_2 - T_1)}$$

Average temperature of plates:

Sensor HC3  $T_1=21.9047C$

Sensor MC3  $T_2=30.21615C$

Average heater voltage and current:

$$Q = V \cdot A$$

Voltage  $V=0.615592$

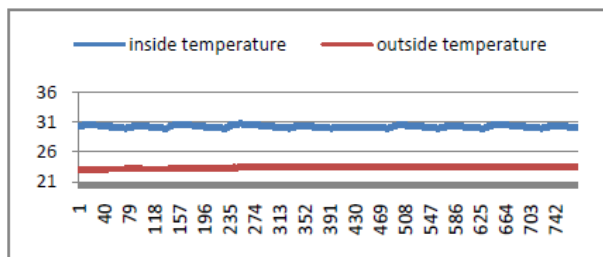
Current  $A=0.043206$

$$K = \frac{0.615592 \cdot 0.043206 \cdot 0.1}{0.09 \cdot (30.21615 - 21.9047)}$$

**K = 0.003556**

Data set	Temperature		Heater voltage		K-value
	Inside HS2	Outside MS2	Voltage V	Current A	
1	30.25023	21.88921	0.664724	0.047071	0.004158
2	30.13941	21.9077	0.610633	0.04157	0.003426
3	30.18967	21.94242	0.492245	0.03451	0.002289

TEST WITHOUT INSULATION



K-value taking the whole set of data at once

Data set	Temperature		Heater voltage		K-value
	Inside HS2	Outside MS2	Voltage V	Current A	
Average	30.23788	23.26775	1.09226	0.07693	0.013395

Sensor A2 control  $30^{\circ}C$

Thickness  $x=0.1m$

Plate area  $A=0.3x0.3m=0.09m^2$

$$Q = K \cdot A \cdot \frac{(T_2 - T_1)}{x}$$

$$K = \frac{Q \cdot x}{A \cdot (T_2 - T_1)}$$

Average temperature of plates:

Sensor HC3  $T_1=23.26775C$

Sensor MC3  $T_2=30.23788 C$

Average heater voltage and current:

$$Q = V \cdot A \quad Q = V \cdot A$$

Voltage  $V=1.09226$

Current  $A=0.07693$

$$K = \frac{1.09226 \cdot 0.07693 \cdot 0.1}{0.09 \cdot (30.23788 - 23.26775)}$$

$K = 0.013395$

Data set	Temperature		Heater voltage		K-value
	Inside HS2	Outside MS2	Voltage V	Current A	
1	30.1529	23.04954	1.292459	0.088918	0.014561
2	30.29851	23.11178	1.31087	0.09163	0.015042
3	30.37768	23.29274	1.405049	0.100243	0.017892
4	30.17193	23.33058	1.078209	0.075881	0.010763
5	30.07151	23.32309	0.280465	0.018674	0.000699
6	30.26129	23.34753	0.915949	0.064506	0.007691
7	30.16938	0.075838	1.062353	0.075838	0.010612
8	30.30137	23.325	1.295484	0.092204	0.01541

XXIII. CONCLUSION

By shielding a dwelling, a user can decrease the heat waste in houses in cold environment or climate, and decrease a heat leftover in warmer environment or climate. Consequently, insulation confines the necessity for heating or cooling adwelling. Heat waste or heat surpluses occur due to variances amid the indoor and outdoor temperature of the environment. Obviously, heat streams from a warmer to a cooler space and the temperatures will congregate to a balance, a physical occurrence that relies on phenomena like transmission (the warmth is flowing through materials) and ventilation (heat is flowing through the air). Insulation targets at decreasing the swiftness of this conjunction of temperatures so it can reduce the need for heating or cooling. Numerous methods of insulation are available like floor, roof and wall insulation which may be completed by placing insulation materials to the floor, roof or wall either on the interior or the exterior, e.g. by utilizing insulation saucers. Diverse materials for different structures entail different sorts of insulation methods. Dwellings may for instance have void walls comprised of two 'skins' detached by a void space. That space now offers some insulation but ought to be filled up with supplementary insulation materials, e.g. wool, to additionally increase the insulation results. Roof insulations for a level roof are different from insulation for a sharper roof. Floors are typically constructed of wood or concrete, each demanding precise insulation calculations. A different selection to diminish heat losses to the ground is earth insulation, for instance by inserting insulation materials on the soil in a self-styled small basement.

XXIV. RECOMMENDATIONS AND FUTURE IMPLICATIONS

More data/surveys needed on

- End-of-life developments and information of the diverse insulation materials
- Life period of the insulation materials
- CO2 reposition during utilization to be measured
- Controls linked to replacement and preservation
- Potential effects during utilization phase

We should also consider:

- Publications of comparable results
- Take a broad view of the data on the basis of relative literature
- Publications on less important performance parameters is also significant
- Production methods of insulation materials change continuously (CFP an example of this statement).

#### REFERENCES

- [1] Chapman, A. (1974). Heat transfer. New York: Macmillan.
- [2] Communities and Local Government (2010) Dwelling stock Estimates: 2010, England. Housing Statistical release.
- [3] Department of Trade and Industry. Energy Consumption in the United Kingdom. National Statistics (2001). [www.dti.gov.uk](http://www.dti.gov.uk).
- [4] Davis, Karen. (1996) *Prisoned Chickens, Poisoned Eggs*. Summertown, Tennessee: Book Publishing Company.
- [5] Ford, R. (1966). Thermal and acoustic insulation of buildings. *Ultrasonics*, 4(1), p.53.
- [6] Garnier, B. and Danes, F. (2012). Design of High Thermal Conductivity Particle Filled Polymer Using Effective Thermal Conductivity Models. *MSF*, 714, pp.21-24.
- [7] Gov.uk, (2012). Building regulation - Policy - GOV.UK. [online] Available at: <https://www.gov.uk/government/policies/providing-effective-building-regulations-so-that-new-and-altered-buildings-are-safe-accessible-and-efficient> [Accessed 28 Apr. 2015].
- [8] Malloy, J. (1969). Thermal insulation. New York: Van Nostrand-Reinhold.
- [9] Meggers, F., Baldini, L. and Leibundgut, H. (2012). An Innovative Use of Renewable Ground Heat for Insulation in Low Exergy Building Systems. *Energies*, 5(12), pp.3149-3166.
- [10] Meukam, P. and Noumowe, A. (2005). Modeling of heat and mass transfer in lateritic building envelopes. *Heat Mass Transfer*, 42(2), pp.158-167.
- [11] Raslan, R. and Davies, M. (2010). An analysis of industry capability for the implementation of a software-based compliance approach for the UK Building Regulations 2006. *Building Services Engineering Research and Technology*, 31(2), pp.141-162.
- [12] Reddy, N. and Yang, Y. (2010). Light-weight polypropylene composites reinforced with whole chicken feathers. *Journal of Applied Polymer Science*, p.NA-NA.
- [13] ROUHI, M. (1998). Feather fibers can take chicken feathers beyond feather dusters. *Chem. Eng. News*, 76(8), pp.66-68.
- [14] Schofield, S. (2010). Meeting building regulations needs. *World Pumps*, 2010(10), pp.18-19.
- [15] Smith, Page, and Daniel, Charles. (1975) *The Chicken Book*: Little, Brown
- [16] Spiga, M. and Vocale, P. (2014). Effect of Floor Geometry on Building Heat Loss via the Ground. *Heat Transfer Engineering*, 35(18), pp.1520-1527.
- [17] Tanaka, T. (1986). Characteristics of Composite Insulation: Liquid-Impregnated Insulation. *IEEE Transactions on Electrical Insulation*, EI-21(6), pp.881-888.

