International Journal of Research and Development in Applied Science and Engineering (IJRDASE)
ISSN: 2454-6844

# *Evaluation of optimum insulation thickness for cost saving of wall design in India*

**Ahmad Raza**
Civil Engineering dept.
I.T.M., Lucknow (U.P.), India
Ahmadraza25995@gmail.com

**Vipul Aggarwal**
Civil Engineering dept.
I.T.M., Lucknow (U.P.), India

**Abstract: Thermal insulation is one of the most effective energy conservation for the cooling applications. For this reason, determination of the optimum thickness of insulation and its selection is the main subject of many engineering investigations. In this study, the optimum insulation thickness on the external walls in the cooling applications is analyzed based on two different methods used to determine annual energy consumption. One of the methods is the degree-hours method (Method 1) that is the simplest and most intuitive way of estimating the annual energy consumption of a building. The other is the method (Method 2) which using the annual equivalent full load cooling hours operation of system. In this work a Life Cycle Cost (LCC) analysis will be used to evaluate accuracy of these methods, and the results will be compared. The results will show the life cycle savings estimation in both Method and the optimum insulation thickness and payback period will respectively estimated.**

**Keywords: LCC, Thickness, Wall Design, Cost.**

## 1. Introduction:

Energy intake global is growing because of growing populace, migration to large towns and improvement in wellknown of living. To hold the usual of residing in industrialized countries and to enhance the state of affairs in growing nations, power intake can't be avoided but power may be used much more efficaciously and also more use of renewable power made. The electricity consumption is distributed among four fundamental sectors: business, building (residential/industrial), transportation and agriculture [1]. The most critical a part of the power approach of a rustic is electricity saving. Because of the restricted energy-resources and environmental pollution coming from using the fuels, power saving has become obligatory [2] Annual strength demand growth price became 6.6% between 1995 and 2004 and is projected as eight.5% among 2005 and 2015. The energy intake, which rose to 150 billion kWh in 2004, is envisaged to boom almost 4-fold by using 2020 achieving to 499 billion kWh. This requires installed capacity to increase approximately 3 fold from approximately 38,500MW in 2005 to 96,000MW through 2020 [3]. The external partitions and roof of a building are the interface among its interior and the outside environment. Buildings must be insulated according to the outdoor environmental situations and indoor thermal comfort requirements. Thermal insulation is normally set up in constructing envelope components to lessen area heating and area cooling, energy use and expenses. The value of insulation installation will increase with thickness, whilst the cost of heating and cooling decrease. Thus the value of fuel is lowest at top-quality thickness of insulation. There could be no energy savings to growth extra insulation past the financial thickness [7]. Thermal insulation materials like other natural or man-made materials exhibit temperature based properties that fluctuate with the character of the fabric and the influencing temperature variety. The effect of running temperature on the thermal overall performance of insulation substances has been the situation of many studies [8] The annual heating and cooling requirements of homes in distinct regions can be calculated from the heating degree-days of the vicinity, the overall heat trade charge of the precise constructing. The heating or cooling degree-days are decided via using longterm measured facts [9]. Cooling degree-days is an index of the electricity call for to cool buildings. This index is calculated via subtracting18 _C (65 F) from the average each day temperature, and summing best positive values over a fixed period together with a whole year. An analogous index for the electricity demand for heating is represented by means of heating diploma-days [10]. Heating diploma-days are broadly used in constructing strength management. For the construction of constructing performance strains, it is essential to have the correct constructing base temperature with the meteorological station as close as feasible to the building being monitored. Layberry [11] presented a new statistics set of degree-days calculated for seventy seven areas, weekly and month-to-month, at various constructing base temperatures from 10.5 _C to 20 _C. He calculated the statistics the use of actual hourly temperatures and compared against degree-days calculated the usage of approximate equations. Christenson et al. [12] investigated the impact of climate warming on Swiss constructing electricity demand via the degree-days technique.

## 2. Related Work:

Heat switch from opaque walls of homes may be very essential for power saving and imparting thermal comfort in exclusive climates. In **Tugce Pekdogan (2017) [10]** have a look at, insulation fashions of opaque partitions with exceptional orientations and outside, inner and sandwich materials have been numerically analyzed in terms of their time dependent thermal behaviors. The one-dimensional transient warmth conduction equation was solved through the implicit finite distinction technique for summer season and winter situations and northern, southern, eastern and western orientations. Meteorological data for cities in

Turkey with exceptional climates, i.E., Ankara, Erzurum, _Istanbul and _Izmir, were used in those calculations. When the out of doors boundary situations were described with the aid of the use of January and July monthly averages of the every day statistics; the interior air temperature become assumed to be 20 _C and 24 _C in iciness and summer. The outcomes indicated that sandwich wall insulation produced greater convenient warmth loss and warmth gain for each weather and course. The preferred deviations of the heat switch values for the specific guidelines were large in summer than in winter because of the sun radiation impact. The numerical calculations for the sandwich wall packages were performed for one-of-a-kind insulation thicknesses specifically 0.15 m and zero.25 m, and for an uninsulated wall; the outcomes were additionally compared with Turkish directive at the thermal insulation of buildings, TS825 taken as a reference circumstance. Compared with the insulation thickness calculated based on the TS825, the warmth loss and advantage values could be decreased by way of up to 65% and 80% for the worst wintry weather and summer situations. In this study, the only-dimensional temporary warmness conduction equation changed into solved through the implicit finite distinction approach with unique climates for unique orientations. The outcomes imply that the sandwich wall insulation type enables barely lower power consumption compared with outside and indoors wall insulation programs for residential usage for twenty-four-h working situations. Additionally, heat loss and gain values had been extensively decreased with thicker insulation. These effects depended on the direction of the opaque wall beneath iciness and summer season conditions within the distinct climates. On the alternative hand, since the thicker insulation covers more interior area, decision of the fabric choice of the exterior wall must be also analyzed economically. The next step of the study will be to analyze the heat transfer through the outdoors wall for one-of-a-kind running hour situations for schooling building and buying center. The effect of insulation area with specific warmness potential material utilization and unique orientations will provide treasured results in phrases of power saving below those conditions. The outcomes received in this time-based study might be useful from energy conservation and thermal comfort factors of view. They are anticipated to help reduce the capacities of heating and cooling structures and guide the selection of insulation type for building envelopes in exceptional climates. In addition, wall orientation percent given in this examine can be additionally helpful for the interior unit capability choice of the heating and cooling device.

**L. Derradji (2017) [11]** worked make a speciality of experimental and numerical take a look at of a prototype building to have a look at its thermal conduct and to examine its power overall performance with those of a classical domestic in Algeria. Yearly cooling and heating transmission masses are calculated according to the increase of the thickness of the improved polystyrene insulation for 3 one of a kind structure materials. The impact of the form of the glazing and the share of glazing inside the wall has been studied to determine the foremost thickness of the insulation. The consequences of the thermal simulation showed that the inertia related to top thermal insulation has an vital role in enhancing thermal comfort and may reach up to 70% power financial savings on heating and air conditioning. The results for cooling display that the most beneficial insulation thickness of extended polystyrene range among 1 cm and a pair of.5 cm, the strength savings vary among 0.Five and 1.Five $/m2 relying on the kind and the percentage of the window inside the wall. This work consists of first, a study on the thermal performance of a prototype constructing and 2d to decide the most excellent insulation thickness of outside walls containing home windows in the region of Algiers, Algeria. Firstly, the consequences of the iciness thermal simulation show that the indoor temperature of the prototype constructing is greater strong, varuing among 17 and 19 _C. On the opposite, the temperature of the indoor air in the classical constructing varies among 15 and 20 _C. In summer time, the indoor temperature in the constructing prototype levels among 25.5 and 27.5 _C. The indoor air temperature in the classical constructing varies among 26 and 32 _C. The effects of this have a look at display that the inertia associated with top thermal insulation can attain up to 70% power savings on heating and air conditioning. Secondly, the finest insulation thicknesses and electricity savings are decided over a constructing lifetime of 30 yr. Results for cooling show that the best insulation thickness of improved polystyrene range among 1 cm and a couple of.5 cm, the strength financial savings vary among 0.Five and 1.5 $/m2 relying on the kind and the percentage of the window inside the wall. The most appropriate insulation thickness for heating is 1 and seven cm depending on the constructing fabric and the strength supply. The heating energy financial savings range among 0.05 and 12.7 $/m2. It is determined that the highest strength financial savings are acquired with power as an electricity source, at the same time as the bottom energy is received for natural gasoline.

Owing to developing industrialization and consequent upward change in the life-style, humans are transferring faraway from traditional methods of living and fastly adopting a metropolis lifestyle, paving the manner ahead for creation of increasingly more homes. The expanded quantity of constructing in cities money owed for an ever growing call for electricity. Buildings all around the world, consume around forty% of the power generated through all of the to be had sources. When it involves assembly the cooling and heating wishes of the dwellings in huge skyscrapers, buildings particularly are notorious for devouring the lion's share of the strength provided by means of the grid. Efforts on this regard are being made to lessen the net energy intake with the aid of homes and this region of examine concerning control of power in homes has been one of the maximum appealing subjects for **Abdul Shakoor Shaikh (2018) [12]** everywhere in the international, specifically the 1st global nations, in which the wide variety of tall systems is noticeably higher than those in rest of the alternative nations. The difficult and costly piping configurations of HVAC gadget, business and chemical process plant are the primary supply of transporting warmness strength.

Therefore, enormous quantity of electricity is wasted in pipelines due to incorrect use of thermal insulation fabric and thickness. The use of thermal insulation in HVAC system is considered as energy conservation measure, as it no longer best reduces strength consumption but also abates polluting products. One of the best tools in accomplishing this goal is the use of well designed insulation with a cautious deliberation over optimizing its thickness in a value-effective, environmentally-pleasant and energy-saving angle. In this research, awareness has been positioned over experimental research of the ideal thickness of thermal insulation over ducts and pipes of various diameters, and its effect on preserving thermally secure atmosphere or trade in temperature internal a building / conduit. At the quit of experimental and mathematical research of the Optimum insulation thickness, it become concluded that internet cost of electricity for the air-conditioning system turned into calculated to be 15.Fifty three % while Conditioned Space Parameters were reduced from 24℃ to 21℃. At the quit of experimental and mathematical research of the Optimum insulation thickness, it become concluded that internet price of energy for the air-conditioning device became calculated to be 15.Fifty three % as compared to the previous studies by Natasha (2014) and Dileep 2016, whereas Conditioned Space Parameters (temperature in this example) were reduced from 24℃ to 21℃. This ultimately reduced the general prices of the air con unit and consequently as a result, the dimensions of the Air conditioned device turned into decreased.

Building Energy intake is liable for important percentage of world strength demand (40%) which is mainly fed on to hold building space cooling and heating requirement. Therefore, conservation of electricity is a critical trouble in building area. To conserve energy in buildings, an efficient HVAC device ought to be designed, and it should be operated at ideal layout parameters. In **Muhammad Haris Khan, (2018) [13]** examine, different building strength systems are studied to investigate the only power conservation machine for building application. It in particular makes a speciality of superior layout of HVAC gadget specifically its air distribution device. In air distribution machine, power loss happens because of conditioned air leakages, wrong thermal insulation thickness, terrible design of ducting layout and useless controlling of conditioned area parameters with air dealing with unit running conditions. Among above losses, great amount of electricity loss takes place due to unsuitable insulation thickness and material. In this regards, unique research had been conducted to determine greatest thermal insulation thickness and related condensation at external floor of the duct. Therefore, this examine is devoted to determining the best thermal insulation thickness material for HVAC duct. From exceptional studies, it is summarized that use of air gap, optimizing insulation at point of compression produces low in cost advantages and environmental amiable by means of the usage of existence cycle value evaluation and life cycle environmental evaluation. There are numerous studies performed lately at the economic and environmental impacts of thermal insulationmaterial at exceptional electricity source for the square, circular and oval duct. It improves the thermal performance of an HVAC system. It is investigated that insulation and dut cloth, gasoline supply, thermodynamic parameters of conditioned air, duct geometry and economic parameters (inflation and hobby price) are mainly utilized in lifestyles-cycle price evaluation to optimize thermal insulation thickness. Additionally, an air gap is currently most apropos optionally available to lessen material cost of insulation at given strength loss through the duct. However, parametric and essential analysis were performed to determine the impact of thermal insulation compression at decided on factors of an HVAC duct to keep away from related condensation of water vapor at the external surface of the duct. Therefore, ideal thermal insulation thickness not handiest produces monetary and environmental blessings but additionally reduces premature deterioration of insulation cloth over an HVAC duct.

Increasing the insulation thickness in residential buildings results in the reduction of operational CO2 emissions but concurrently will increase the embodied CO2 due to the insulation cloth. The environmentally best insulation thickness exists at a point wherein the total CO2 emissions are minimum. **Ioannis Axaopoulos, (2019) [14]** offered the most desirable insulation thickness for outside partitions of different composition and orientation, for each the heating and the cooling period. Three exceptional wall sorts and insulation substances are being offered. The dynamic thermal behavior of the outside walls simulation is primarily based on the heat conduction switch capabilities approach and the usage of the hourly climatic data to be had for the metropolis of Athens, Greece. The optimization technique makes use of a single goal characteristic approach, combining the simulation of the thermal behavior of outside partitions with an optimization set of rules. The consequences suggest that the most efficient insulation thickness varies from 11.2 to 23.4 cm and is different for each orientation, wall kind, and insulation material. In addition, the full annual CO2 emissions consistent with unit place of the wall can be decreased by means of 63.2%–72.2%, depending on the insulation material and its function on the wall. This look at determines the optimal insulation thickness for the outside partitions of a residential constructing in Athens, Greece, by means of considering its construction, orientation, and the position of the insulation on the wall. Three different wall types, 3 insulation materials, and four orientations are being evaluated inside the optimization study. The results suggest that the most excellent insulation thickness varies from 11.2 to 23.4 cm and is unique for each orientation, wall type, and insulation fabric. In addition, regardless of the wall type and the insulation cloth, the north- and the south-dealing with walls, respectively, require the best and the bottom insulation thickness. Assuming that the insulation thickness is most suitable, the once a year CO2 emissions in step with unit vicinity of the wall may be reduced with the aid of 63.2%–seventy two.2% in evaluation to uninsulated partitions, relying at the insulation cloth and its function at the wall. The wall with exterior insulation presentations the greatest reduction of CO2 emissions consistent with unit region of the wall in contrast to the alternative two wall topologies, for any orientation and most beneficial insulation thickness studied. Similarly, the use of XTR introduces the best emissions according to unit location of the wall in contrast to the two different insulation substances however additionally has the thinnest ideal thickness. With the right choice of wall kind, insulation fabric, and insulation thickness for every orientation, annual CO2 emissions can be extensively decreased, accordingly contributing to a sustainable future. However, the most advantageous insulation thickness for the minimization of CO2 emissions does no longer align with the bottom feasible electricity price. If the building design requires the minimization of the overall price, both the environmental and the monetary parameters must be studied in parallel.

## 3. Methodology:

### 3.1 The structure of the external walls

The cooling applications are applied to cool the space or room in the buildings due to hot air outside building and to absorb heat produced by people and appliances from inside building in order to provide comfortable environment. Since these applications are operated continuously all the time in the temperate countries, the energy consumption and cost for these applications are quite high. Consequently, the cooling sectors need to spend a lot of money for electricity for each cooling system every year. Any reduction in this cooling load results in reducing the electricity consumption by cooling system. Therefore, a proper insulation material with the objective of achieving the acceptable comfort for building occupants and the reduced cooling load is imperative. Insulation is made to estimate the heat gains in a building. Heat load of a building is calculated in terms of these gains. Heat gains in buildings consist of the characteristics of building (i.e., transmission and ventilation in the external walls, roof, door and windows, etc.), the characteristics of cooling system, climate conditions, outside air temperature, intensity of radiation and internal heat gains (i.e., people and appliances from inside building). In this study, the optimum insulation thickness (OIT) is calculated take account of heat losses occurred the external walls. The external walls in a building preserve external environment and its effects. At the same time, these walls are locations in which a high rate of heat gaining occurs. Here, external wall (sandwich) crosssection is shown in Fig. 1. And, the sandwich wall consists of an insulation layer in the middle of the two hollow brick layers and two plaster layers on the inside and outside surfaces.

### Method for the cooling loads:

The building envelope is affected by three heat transfer mechanisms: conduction, convection and radiation. The outer surface of wall absorbs the solar radiation and transmits it into the inner surface of building by conduction. At the same time, convective thermal transmission occurs between ambient air and the outer surface of wall, also between the inner surface of the wall and indoor air. The wall heat gain load through the building envelope may be calculated from

$$Q_w=UA(T_{(o,des)}-T)_s=UA\Delta T \qquad [1]$$

where A is surface area of wall, To, des is the design temperature of outside air, Ts is the design temperature of cooled spaces, and U is the overall heat transfer coefficient. The total resistance of wall, Rw, is equal to the summation of the surface resistances of convective heat transfer over the inside and outside surfaces of the wall and the total internal resistance of all layers of the wall as given by the following equation.

$$R_w=1/h_i+x_1/k_1+x_2/k_2+\ldots\ldots\ldots\ldots x_n/k_n+1/h_0 \qquad [2]$$

where hi and ho are convection heat transfer coefficient for inside and outside surface of cooled space, respectively.Andk1, k2, etc. arethermal conductivity of layer of wall, and x1, x2, etc. are their thicknesses. The difference between the overall heat transfer coefficients of un-insulated and insulated walls can be written as

$$\Delta U=U_{(un\text{-}ins)}-U_{ins}=1/R_w-1/(R_w+(x/k)_{ins}) \qquad [3]$$

An analysis of annual energy consumption and cost usually accompanies the design heat load calculations and plays an

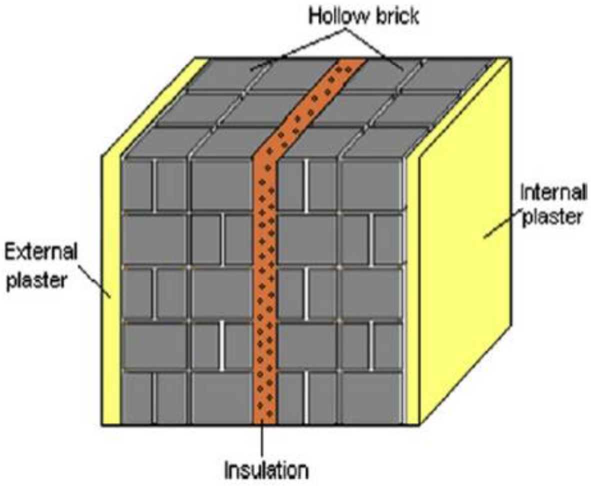

**Fig. 1. External wall cross-section.**

An analysis of annual energy consumption and cost usually accompanies the design heat load calculations and plays an important role in the selection of a cooling system. There are various methods for calculation of annual energy consumption. The simplest and most intuitive way of estimating the annual energy consumption of a building is the degree-hours method, which is a steady-state approach. The number of annual cooling degreehours (CDH) using hourly data is determined from

$$CDH=(1\,year)\sum_1^{365}(1\,day)\sum_1^{24}(T_{sa}-T_b)^* \qquad [4]$$

where Tb is the design temperature and Tsa is solar-air temperature for each hour. The * sign above the parenthesis indicates that only positive values are to be counted, and the temperature difference is to be taken to be zero when Tsa < Tb.

A cooling system is designed with respect to the indoor air temperature. Annual cooling load of cooling system should be calculated in order to estimate the total amount of energy consumption used. Total annual energy consumption of cooling system can be calculated by

$$E_{A.1} = \frac{U}{COP} CDH \qquad [5]$$

where CDH is the annual cooling degree-hours from Eq. (4), CE is cost of electricity, and COP is coefficient of performance of cooling system.

For many thermal systems, the amount of energy that must be purchased in order to operate the equipment does not change significantly from year to year. In this case, the LCC analysis can be calculated using the method presented in [23] where the LCC is considered to be the sum of two terms. The first term is proportional to the first year operating cost (F), and the second term is proportional to the first costs of the system (E).

$$\text{LCC} = P_1 F + P_2 E \qquad [6]$$

Here, it is necessary to identify the ratio of life cycle energy (P1) and the ratio of life cycle expenditures incurred to the initial investment (P2) because of the additional capital investment. P1 has relation with electricity price increase rate (d), electricity discount price rate (i), and lifetime (N) as expressed by the following

$$P_1 = \frac{1}{(d-i)}\left[1-\left(\frac{1+i}{1+d}\right)^N\right] \quad if\ i \neq d \qquad [7]$$

If the electricity price increase rate (d) is equal to discount price rate (i), P1 is calculated from

$$P_1 = \frac{N}{1+i} \quad if\ i \neq d \qquad [8]$$

P2 is the ratio of the life cycle expenditures incurred because of the additional capital investment to the initial investment. P2 is defined by

$$P_2 = 1 + P_1 M_s - \frac{Rv}{(1+d)^N} \qquad [9]$$

whereMs is the ratio of the annual maintenance and operation cost to the original first cost, Rv is the ratio of the resale value to the first cost. In this study, P2 can be taken as 1 if the maintenance and operation costs are zero. The total cost of insulation (Cins) depends on the cost of insulation material per unit volume (CI) and insulation thickness (x) can be calculated by the following equation

$$C_{ins} = C_1 x \qquad [10]$$

The total cost of the fuel can be calculated by:

$$C_f = P_1 E_{A,1} C_E \qquad [11]$$

The total cost of the insulation material and the fuel can be calculated by the following equation

$$C_t = C_f + P_2 C_{ins} \qquad [12]$$

The saving is the difference between the saved energy cost over the lifetime and the insulation payout:

$$S = C_f - P_2 C_{ins} \ or\ S = \frac{P_1 C_E \Delta U}{COP} CDH - P_2 C_1 x \qquad [13]$$

The effect of insulation thickness on the thermal transmission efficiency can be obtained by differentiating Eq. (3) and the result is as follow

$$\frac{\partial(\Delta U)}{\partial x} = \frac{R_w^2 k_{ins}}{(R_w^2 k_{ins} + R_w x)^2} \qquad [14]$$

The OIT can be determined by minimizing Eq. (13) or maximizing Eq. (12). So the differential of S or Ct with respect to x is taken and set equal to zero, then the OIT, xopt, is obtained as:

$$x_{opt} = \sqrt{\frac{P_1 k_{ins} C_E CDH}{P_2 C_1 COP}} - R_w k_{ins} \qquad [15]$$

By setting Eq. (13) to be zero, the payback period, Np, can be calculated as follow

$$N_p = \frac{P_2 C_1 COP (R_w x + R_w^2 k_{ins})(1+i)}{C_E CDH} \qquad if\ i = d \qquad [16]$$

$$N_p = \frac{In\left(1 - \frac{P_2 C_1 COP (R_w x + R_w^2 k_{ins})(d-i)}{C_E CDH}\right)}{In\left(\frac{1+i}{1+d}\right)} \qquad if\ i \neq d \qquad [17]$$

## 4. Result and Discussion:

The aim of this study is to determine optimum insulation thickness for typical exterior wall by calculating cooling/heating loads according to methods for degree-day full load cooling/heating operation in Dehradun chosen as a model city in India. Several methods have been used in many of the previous studies on optimum insulation thickness. In this study, optimized analysis is used to accurately evaluate the method, and the results are presented. It is significant to evaluate cooling/heating loads for cold store, dwelling and commercial buildings. For this reason, DD Method is used to determine cooling/heating loads. The values of monthly cooling/heating degree-degree can be calculated using a design temperature according to literature and the data. In Ref. [9], the heating and cooling/heating degree-days at various design temperatures are calculated and it is clearly indicated that cooling/heating degree-days are bigger than heating degree-days. Thus, the determination of optimum insulation thickness is supported to cooling/heating loads for gaining maximum energy saving. Moreover, it is utilized on cooling/heating applications to compare different methods in various studies. In some cases it is calculated the annual equivalent full load cooling/heating operation of temperature conditioning. The annual operating hour of air conditioner, can be accepted as 8760 (24 x 365) when it is considered all-day operation of its device in cooling/heating applications.

Fig. 4.1 shows the fuel, insulation versus insulation thickness obtained from DD Method over the lifetime of 20 years for (a) styrofoam, (b) wool and (c) combined as insulation materials. Here, increasing the insulation thickness shows increasing the insulation cost. But the fuel cost shows decreasing quickly up to intersection point of the insulation and fuel costs. The total cost is the sum of the insulation and fuel costs. The total cost decreases up to a certain value and then it starts to increase beyond this level. The value which is minimized the total cost will give the insulation thickness.

In this figure 2 it can be interpreted as the thickness of insulation material is an important part in designing of building since thick insulation material will reduce the space of building significantly. A comparison of the energy savings over lifetime versus insulation thickness for the selected insulation materials is given in Fig. 3 for DD Method represents the effect on saving of insulation thickness for insulation materials for DD Method . For rock wool, styrofoam and combined the savings are shown, respectively.

**Table 1:** The parameters used in calculations for Method 1 and Method 2

| Parameter | Data for DD Method |
|---|---|
| Cooling degree-hours (CDH) | 30180 °C-h |
| cooling system ($O_h$) | |
| Lifetime (N) | 10 years |
| Insulation | |
| Styrofoam | |
| Conductivity (kins) | 0.037 W/m K |
| Cost ($C_I$) | 8400 Rs/m$^3$ |
| Wool | |
| Conductivity (kins) | 0.040 W/m K |
| Cost ($C_I$) | 7600 Rs/m$^3$ |
| Coefficient of performance (COP) | |
| Unit cost of electricity ($C_E$) | 12$RskWh |
| Discount rate (i) | 5% |
| Electricity price increase rate(d) | 5% |
| Total heat transfer area | 1 m$^2$ |
| Inside temperature | 18 °C |
| Average annual outside temperature | 39 °C |

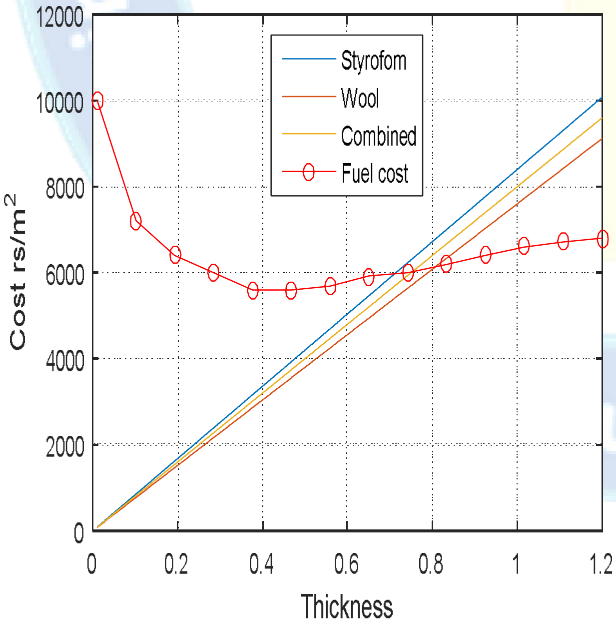

**Fig 2:Insulation and fuel cost with respect to insulation thickness.**

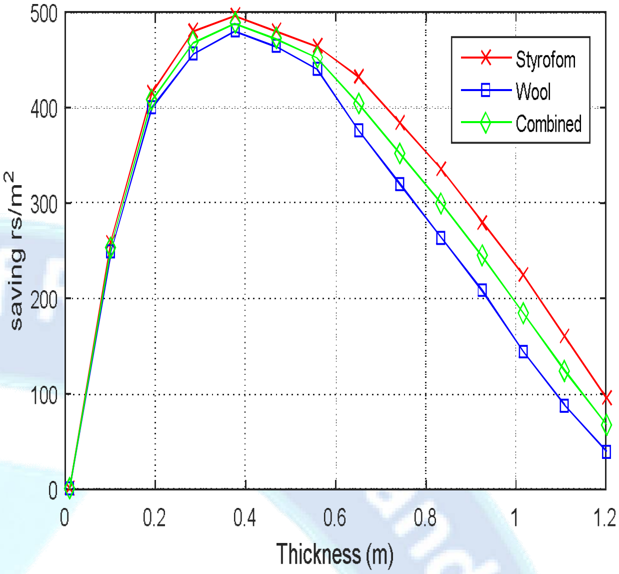

**Fig 3: Comparison of the savings on insulation thickness in both insulation materials.**

## 5. Conclusion:

A systematic approach for optimization of insulation material thickness for External walls and Roof is developed for different DD regions of India. he optimum insulation thickness, Net energy saving and Payback periods are calculated for four different Degree-Days region and two different insulation materials. The optimum result has been obtained, when LPG is used as energy sources and Expended Polystyrene as the insulating material. Energy saving is maximum at optimum insulation thickness. As seen choosing a thickness value apart from optimum thickness will increase the total cost. Therefore, optimum insulation thickness must be applied to building for economic aspect. It is observed that Net saving is highest for higher degree days and lowest for lower degree days value.

## References:

[1] Abdullah Yildiz, “Economical And Environmental Analyses Of Thermal Insulation Thickness In Buildings,” Isı Bilimi ve Tekniği Dergisi, 28, 2, 25-34, 2008 J. of Thermal Science and Technology ©2008 TIBTD Printed in Turkey ISSN 1300-3615

[2] Fr´ed´eric Kuznik, “Optimization of a Phase Change Material Wallboard for Building Use,” Preprint submitted to Elsevier Science 26 October 2007

[3] Naouel Daouas, “Analytical periodic solution for the study of thermal performance and optimum insulation thickness of building walls in Tunisia,” S1359-4311(09)00281-6 DOI: 10.1016/j.applthermaleng.2009.09.009 Reference: ATE 2888 To appear in: Applied Thermal Engineering Received Date: 9 June 2008 Accepted Date: 10 September 2009

[4] Aynur Ucar, “Determination of the energy savings and the optimum insulation thickness in the four different insulated exterior walls,” A. Ucar, F. Balo / Renewable Energy 35 (2010) 88–94

[5] Suresh B. Sadineni, “Passive building energy savings: A review of building envelope components,” Renewable and Sustainable Energy Reviews 15 (2011) 3617–3631

[6] Naouel Daouas, “A study on optimum insulation thicken ss in walls and energy savings in Tunisian buildings based on analytical calculation of cooling and heating transmission loads,” Corresponding author: Tel.: (216) 73 500 244, Fax: (216) 73 500 514 E-mail address: naou.daouas@gnet.tn

[7] D. Zhou1, “Review on thermal energy storage with phase change materials (PCMs) in building applications,” Published in: Applied Energy 92 (2012), pp. 593–605. Doi: http://dx.doi.org/10.1016/j.apenergy.2011.08.025

[8] Huijun Feng, “Constructal entransy optimizations for insulation layer of steel rolling reheating furnace wall with convective and radiative boundary conditions,” Chin. Sci. Bull. (2014) 59(20):2470–2477 csb.scichina.com DOI 10.1007/s11434-014-0248-z

[9] Mustafa Ertürk, “Optimum insulation thicknesses of pipes with respect to different insulation materials, fuels and climate zones in Turkey,” Energy 113 (2016) 991e1003

[10] Tugce Pekdogan, “Thermal performance of different exterior wall structures based on wall Orientation,” Applied Thermal Engineering 112 (2017) 15–24

[11] L. Derradji, “A study on residential energy requirement and the effect of the glazing on the optimum insulation thickness,” Applied Thermal Engineering 112 (2017) 975–985

[12] Abdul Shakoor Shaikh1, “Experimental Investigation of Optimum Insulation Thickness for Air Conditioning Duct,” ENGINEERING SCIENCE AND TECHNOLOGY INTERNATIONAL RESEARCH JOURNAL, VOL.2,NO.2. JUNE, 2018

[13] Muhammad Haris Khan1, “Optimum insulation thickness for HVAC duct: An Energy Conservation Measure,” Engineering Science And Technology International Research Journal, VOL.2, NO.3, SEPT, 2018

[14] Ioannis Axaopoulos, “Optimum external wall insulation thickness considering the annual CO2 emissions,” Journal of Building Physics 1–18 _ The Author(s) 2018 Reprints and permissions: sagepub.co.uk/journalsPermissions.nav