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Mitigation of Energy Demands in Building Sector: A Review

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Abstract: *Most of the countries are struggling to pace increasing energy demands and carbon emissions globally. Residential sector has significant role to play as it contributes a share of 27% in energy consumption and 17% in carbon emissions as per WEO 2017. Further windows play a significant role in buildings to mitigate the energy requirements and to reduce carbon footprints. At present researchers have carried out numerous modifications in windows and rare of them are tested experimentally as well, still nothing has been devised concrete. Many improvements tested or suggested as HISG, VT, DGU etc have been presented herein. The focus of this paper is to highlight the inputs across universe and their challenges in implementation. Most efficient glazing used commercially is HISG though VT window also shows remarkable results. The scope of HISG is very much limited in residential market due to its high payback period of 33.7 years. Payback period of VT is 14.34 years. Windows have the potential to save half of the energy consumption provided that it should be carefully designed and checked experimentally. Though many reviews are available in literature yet there is an urgent need to upgrade windows along with cost analysis following guidelines being framed by many governments in their respective building code time to time. In the current review the authors have emphasized on need of investigation in regards to economical windows to reduce the payback period.*
Keywords: *Payback period, Daylight, Energy savings, Heat insulation solar glass, types of glass for windows.*

I. Introduction

Developing countries are emerging and their energy consumption is also on the higher side. Residential sector is consuming about 27% energy [1]. Globally the energy consumption trend shows 14 % growth between 2000 and 2014 [1], [2]. This growth in energy consumption is mainly due to population growth, urbanization and ownership of appliances. [3]. Also CO2 emissions from residential sector are about 17 % responsible in GHG effect [4]. Global energy needs will expand at the rate of 30% from present to 2040 [1]. The global demands of electricity would estimate to be increased by 40% by 2040.(World energy Outlook, 2017). To compensate these increasing demands, new policy and reforms are demanded in the building codes such as new wind power and solar PV panels [5] are to be utilized especially in china as per international energy agency report, 2017.

In the building, its envelope plays a pivotal role in energy mitigation and energy savings. This has been evidenced from the research studies that the windows and its frame that is fenestration can lower the energy consumption by 40 to 60 percent [5], [6]. About 60% of the heat is lost though windows, the day lighting effect can be utilized in order to reduce heat loss [6]. Windows should be carefully designed so to reduce solar heat from outside to inside along with to reduce heat loss from outside to inside and VLT should be optimum [5]. Choice of glass is of prime importance to take care of mentioned issues. The fenestration should be chosen effectively that works efficient and should have low U-value .

Various researchers have performed enormous studies and evidenced that the windows can minimize the energy consumption provided to be designed properly utilizing the parameters required as per site [7], [8]. This not only helps to minimize the energy but also can greatly control the emission of CO2 gasses which is need of hour and is responsible for global warming. Many researches showed the reduction of CO2 emissions from the building and help in ecofriendly environment. This paper emphasis from the literature survey that the usage of glass can help the building to mitigate the energy demands and also ease the occupants to visual and cozy comforts [9].

II. Background

2.1 Type of Glasses

To ensure the reduction of heat loss through windows, the glass should be selected through various parameters that are as per climate, orientation of building, performance or intended function and efficiency.
To cater these needs glass industry has rolled and manufactures some of the majorly utilized glasses types are briefly discussed.

2.1.1 Annealed Glass (Normal Glass)

Annealed glass is manufactured from the process of heating and cooling (Annealing). This type of glass is very much limited in the performance and also have less strength and resistance to various factors such as human impacts, compressive strength etc. Due to its shear less price, these glasses are quite commonly used. The failure of this type is dangerous [9].

2.1.2 Heat strengthened Glass (HSG)

HSG is processed glass over annealed glass under the temperature of 650 degree in automated plants. These can bear strength from 40 – 60 MPa [10].

2.1.3 Toughened/ Tampered Glass

Toughened glass is one layer more than HSG where the strength is further increased to 143 Mpaon the surface and 66.7 Mpa on the edges [10].

2.1.4 Laminated Glass

Laminated glass is processed glass wherein two glasses of same or different thickness is bonded with a PVB layer within. This setup of two glasses and a layer is driven through heat and autoclave. This glass has advantage of being much stronger and when unfortunately laminated glass breaks, it breaks into small fragments rather than all listed above which breaks into large and nailed pieces.

2.1.5 Insulated Glazed Unit/ Double Glazed Unit

IGU/ DGU are again processed using two glass panes with gap in it. The gap can be from 18 to 22 mm which should be filled with air or inert gasses like argon, krypton etc. The glass panes can be selected from the listed above. The DGU has proved many benefits such as insulation, thermal comfort due to its leakage proof technology. In order to achieve these benefits one needs to be careful in deciding the gap between panes and also the selection of glass on inside and outside should be as per needs of climate and orientation which can be simulated using software. The testing of such product is required as to avoid situations such as conduction, convection and condensation through the glass which is sometime noticed after poor workmanship.

2.2 Energy Consumption

According to different works carried out by researchers in fenestration of buildings, the various attempts are laid in reference to it are as listed

2.2.1 Performance of Windows

More emphasis is required to windows wherein the glass can be selected according to various key parameters such as day lighting [11], climatic zones [12], orientation/ direction of building etc. Husin and Harith from Malaysia reported that based on Malaysia climate out of three glazing tested of 3 mm thickness, the higher luminance recorded is with adjustable louver with tinted glass having better properties (VLT-0.56, SHGC -0.65 and U-value - 1.25). The other two glazing are Casement with obscure glass and fixed louver with clear glass. The test is conducted from 9AM to 5PM [5].

2.2.2 DGU (Double Glazing Unit)

DGU also known as IGU is the most efficient role in mitigating the heat loss through windows [13]. A DGU having two glasses each of 4mm thickness is fitted at a gap of 20mm and the gap is having argon gas. The experiment showed that the u value for DGU is 0.89 W K/m2. This differs from the numerical value of 0.80 W K/m2. The difference is due to the fact that argon gas is assumed to be stationary in numerical analysis whereas it is dynamic in nature [14]. The triple glazing with argon filling is most cost efficient than DGU with air inside [15]. The argon gas is having low thermal conductivity as compared to other inert gasses [7], [16].

2.2.3 HISG (Heat Insulation Solar Glass)

HISG is a solution which has been tested in varied climatic zones and by many researchers. Erdem, young and Riffat (2014) suggested that with HISG in the windows, one can not only reduce heat loss but also generate power. With 0.66m2 glazing area, the HISG generates 0.40 W of electric power at a solar intensity of 850 W/m2. The average U value of this is 1.10 Wk/m2. The performance of HISG is two times better than DGU in respect of U value. The commercial viability of HISG is due to its self-cleaning ability, thermal comfort and power generation. The same has been evidenced by the U-value of HISG which is 1.1 Wk/ m2 [7] with other new and emerging glazing technologies.

2.2.4 VT window and Solar Pond Window

VT is windows with two glass panes sand-witched with tubes. The U value of VT window is 0.40 Wk/m2which is 5 times better thermal comfort than DGU filled with air [8]. Solar Pond Window is made of a single unit having 3 glass panes of 5mm with two interlayer of 5mm insulating liquid and in the center 5mm space filled with air. The results are better and can be used for the residential sector [19], [21] and commercial sector [17], [18].

On the account of stated experiments so far that can be utilized in the residential sector and commercial sector with many fold benefits. First the fenestration can help to cut down the heat loss from inside to outside and reduce the heat ingress from outside leads to thermal comfort for user and sufficient daylight at WWR 0.4 to 0.6 [5]. Secondly cooling loads on the HVAC can also be reduced considerably that results reduction of energy bills [16].

2.3 Policies

Many countries seeing this increasing energy demands has evoked building codes in stringent action on even residential sector in relate to commercial, due to this enforcement the new dwelling units can be prepared in line with the government policies which in turn benefit the nation as whole [3], [19], [23]. Still developing countries such as China and India are not able to stand on the policies framed by government due to their development at higher rate and to its urbanization. The building codes are refined with new energy saving technologies and still need many revisions to come to the level of other countries such as Germany, uk etc.In India, National building code (NBC) is reformed where the guidelines are laid in context to make the building energy efficient (BIS, National Building Code, 2016) [20].

2.4 Payback Period

Payback period is the time taken by the owner or person balances in terms of funds against the current trends fenestration. No doubt the researchers are in line with the global thoughts and assessment. Still cost becomes the important decision parameter especially for residential sector. Most of the researchers are silent on this. Usually the payback period is about 30 years. Payback period of HISG and VT is 33.70 years and 14.34 years respectively [3], [8]. Both the instruments are generating electricity right on the site. HISG is commercially used in many projects than VT. With the passage of growth in these instruments, the payback period will decrease further and steep declination in cost can be foresighted (IEA, 2017). There is an urgent need of experimentation along with their cost analysis so that the payback period can be computed.

2.5 Role Of Steel And Glass In Construction Industry

Blandini and Grasmug(2018) focused and provided revolutionary steps in the envelope of the building utilizing steel and glass to larger extent. He presented the ten projects showing the extraordinary combination of glass and steel installation with cable stayed facades and glass fin facades developed by Werner Sobek . The author highlights benefits such as light weight and aesthetics being coupled with technology. Blandini underlined that these master pieces can only get constructed collaboratively using sync and constant touch among clients, architects, planners and contractors [21].

III. Future Scope

Seeing the scope and feasibility in the area of windows, ample work is needed. The users are usually complaining about the fenestration that the actual performance of the fenestration deviates from the simulated one [14], [28]. The reason might be due to the complexity of the various parameters required to design the fenestration. After designing, testing becomes the major challenge. The key role here is of designing of windows as well as frames required for the fenestration. So far it is emphasized by researchers that the experiment required should also be focused along with computational analysis using software rendering [14].

IV. Conclusion

This paper focused towards numerous attempts made in building fenestrations. Multi-benefits like energy consumptions, implementation of policies, payback period and also role of glass and steel in construction industry has been presented.

Present challenge is to slow down the increasing demands of electricity as talked globally. To mitigate energy demands the windows should be carefully designed as per critical parameters overviewed and experiments should also be performed to satisfy the user.

Payback period plays role in defining the implementation of these different varieties of product such as HISG, VT, Solar Pond Window and DGU.

Present work needs to be upgraded in terms of experimentation and cost effectiveness in achieving thermal comfort and visual comfort. Many countries have laid down the guidelines even to residential sector [7], Still developing countries like India, china struggling to enforce guidelines effectively [3].

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