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Research paper

Study on Comparison of Window-set U-value Chamber test and Simulation Modeled by Multiple Simulators

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Abstract

The This research is to offer basic data to establish process to draw more consistent and accurate simulation result value by analyzing error rate of U-Value between simulators of the same model. This study examined an error of interpretation value occurred between simulators of total 13 window-set cases, and investigated a difference between U-Value by test and U-Value by simulation. Simulation value of simulator 3 is somewhat different from that of Simulator 1 and 2, but there is no great difference of simulation value between simulators. Irrespective of simulators, test value of U-Value of most data is greater than simulation value of U-Value. Especially, in case of few windows, there is a great error between test and simulation values.

Keywords: *U-value, Window Thermal test, Thermal simulation, Simulator, Window Frame*

1. Introduction

An indication system of window-set energy consumption efficiency grade has obligatorily taken effect in South Korea since July, 2012, so a physical test of U-value and air leakage should be performed to acquire consumption efficiency grade.

However, the burden of companies about test cost and period for the physical test method grew heavier, so window-set simulation valuation method replacing some tests through simulation by rational energy utilization act and efficiency management machinery procedure (Notification No. 2012-320 of Ministry of Trade, Industry and Energy) was revised.[1] To replace test with simulation, allowable limits of error between real test value and simulation value should be within 10%. Therefore, as a result of analysis between simulators targeting various cases according to window-set simulation valuation method, it is necessary to understand error occurrence cause and type and to analyze a difference between simulation and test.

This research compares the resulting value and real thermal performance measure of window-set by performing simulation with Therm and Window software of LBNL, tools for window-set simulation, and analyzes the factor by understanding error between test value and simulation value. In addition, the research is to evaluate credibility of simulation by drawing various simulation results by types of windows. Furthermore, the research is to offer basic data to establish process to draw more consistent and accurate simulation result value by analyzing error rate of U-Value between simulators of the same model.

2. Materials and Methods

2.1 The Law Related To Use of High Efficiency Energy Apparatus

The Rules related to Public Institution Energy Use Rationalization Promotion provided that high efficiency energy apparatus certification product or first class product of energy consumption efficiency should be purchased at first on occurring new or alternative demand of energy apparatus in insulation and air tightness standards of window-set, and when there is no same product, next product should be bought.[2]

A window that borders the air, whose window area is more than 1 ㎡, and that combines frame with glass should receive energy consumption efficiency grade by fulfilling a test to make U-Value accord with a standard of KS F 2278, [3] and make air leakage accord with a standard of KS F 2292.[4]

2.2 The Building Law Related To Window-Set

A law related to window-set insulation performance require U-Value standard of window-set is below 2.40 W/㎡•K in case of bordering directly on the air, and is below 3.20 W/㎡•K in case of bordering indirectly on the air.

2.3 Test Method of Window-Set Thermal Performance

Sample standard for physical measurement test of window-set performance is 2m X 2m in case of U-Value test, and is 1.5m X 1.5m in case of air leakage. When an applicant for the test, only 2m X 2m of window-set sample can perform both U-Value and air leakage tests, and when size of really-sold window-set is smaller

than size of basic sample, it can be tested with a sample as same as size of real product.

A test according to KS F 2278 and KS F 2292 is made as a rule, but when frame material, opening type, and end window/double window are same so energy efficiency except for glass composition is not changed, it is not regarded as basic model but regarded as series certification so simulation can be used.

2.4 Domestic Window-Set U-Value Simulation Method

A valuation method of window-set U-Value makes a physical test as a rule, and when frame material, opening type, and end window/double window are as same as those of a basic model, U-Value can be tested with simulation according to the rule of ISO 15099; 2003.[5] In case of South Korea, 'Accreditation Secretariat for Window-set Simulation' in charge of business such as data information deliberation registration and guideline development related to window-set simulation by efficiency management apparatus procedure was established and has been managed, and U-Value is calculated through the definition of Edge(63.5mm of joints of frame and window pane) according to the standard of ISO 15099.[6]

Simulation valuation program is also required as the newest software following ISO 15099; 2003, and a boundary condition is designated in accordance with domestic circumstances.

An error tolerance of simulation and real experiment is decided in the rule as follows.
- It is impossible to change between grades because of simulation.
- When thermal performance is below 1.4 W/㎡K, an error tolerance is admitted until +0.14 W/㎡K. When thermal performance exceeds 1.4 W/㎡K, an authorized tolerance is admitted in a way that does not cross ±10%.

2.5 Window-Set Types Targeting Simulation

Window types supported by Window Program are total 16 types. Window-sets of 13 cases (Table 2, 3) aimed by this study are two types such as fixed window and custom dual vision horizontal. These are shown in Table 1.[7],[8]

2.6 Window-Set Modeling Method

A boundary condition for simulation was created by referring to specific procedure of window-set simulation. Property value of matter of window-set materials classified it into Frame, Glazing, and Spacer, so showed heat conductivity and emissivity by materials.

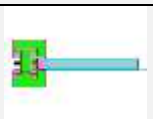
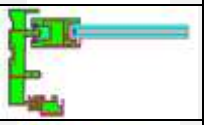
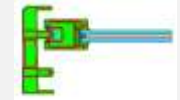
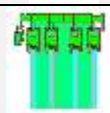
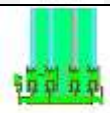
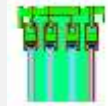
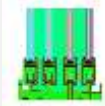
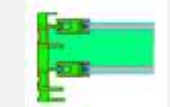
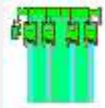
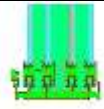
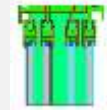
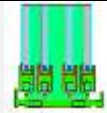
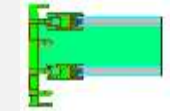
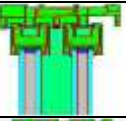
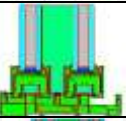
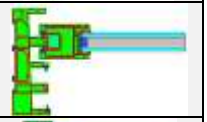
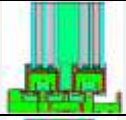
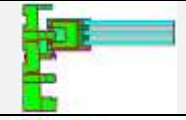
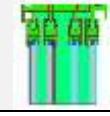
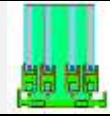
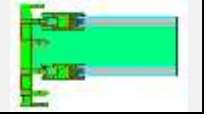
Table 1: Window-set Types supported by Window7.4

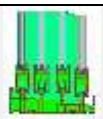
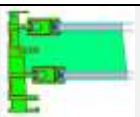
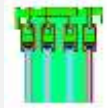
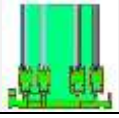
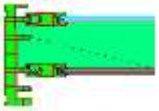
	
Fixed (picture)	Custom Dual Vision Horizontal

Table 2: Overview of thermal performance analysis target window- set configurations
*CDVH = Custom Dual Vision Horizontal

Case	Model name	Window type	Glazing composition	Frame	Spacer	U-value (W/m^2K)
1	Hs 100mm	Fixed (Picture)	24T(5TLow-e +14TAir+5TCL)	Stainless steel	Polycarbonate	1.541
2	Hs 115mm	CDVH	16T(5TLow-e +6TAir+5TCL)	PVC	PVC	2.002
3	Hs 121mm	CDVH	16T(5T Low-e +6TAir+5GN)	PVC (steel)	Aluminum	2.518
4	Hs 230mm	CDVH	22T(5TLow-e +12TAir+5TCL)	PVC	PVC	0.986
5	Hs 250mm	CDVH	22T(5TCL+6Tar +5TCL/5TLow-e+6TAr+5TGn)	PVC (steel)	Aluminum	0.761
6	Hs 235mm	CDVH	22T(5TLow-e+12TAir+5TCL)	PVC (steel)	Aluminum	0.935
7	Js-A 224mm	CDVH	22T(5T LE+12Air+5T CL)	PVC (steel)	Aluminum	2.039
8	Js-B 224mm	CDVH	22T(5T LE+12Ar+5T CL)	PVC (steel)	Aluminum	1.730
9	Js 127mm	CDVH	22T(5T LE+12Ar+5T CL)	PVC (steel)	Aluminum	1.713
10	Js 137mm	CDVH	31T(5T LE+8Ar+5T CL+8Ar+5T LE)	PVC (steel)	Rigid plastic	1.309
11	Js 224mm	CDVH	22T(5T LE+12Air+5T CL)	PVC (steel)	Aluminum	1.068
12	Js 245mm	CDVH	22T(5T LE+12Air+5T CL)	PVC (steel)	Aluminum	0.941
13	Js 260mm	CDVH	16T(5T CL+6Air+5T CL)	PVC (steel)	Aluminum	1.407

Table 3: Therm simulation models of simulation target window-sets

Case	Head	Sill	Jamb
1			
2			
3			
4			
5			
4			
7,8			
9			
10			
11			

12			
13			

3. Results and Discussion

3.1 Window-Set Simulation Analysis

Table 2 showed window-set outline of total 13 cases that are objects of thermal performance simulation. Case 1 ~ 6 are materials to compare a difference of U- Value according to a difference of modeling method between simulators, and Case 7 ~ 13 are materials to compare an error tolerance between simulation and real experiment.

Kinds of windows by case are classified into Fixed and Custom Dual Vision Horizontal, and kinds of glass are classified into Low_e, Clear, and Green. Fillers are classified into ARGON and AIR. In addition, spacer is classified into PVC synthetic resins, PVC steel reinforcing, and Polycarbonate, and frames are classified into PVC, stainless steel, and aluminium. Kinds of windows and glasses, quality of spacer and frame, and U-Value by a test by case are also as Table 2.

Modeling that drawing data by case is retrieved from Therm Program so Case 1 ~ 13 are classified into Head, Sill, Jamb is as the following Table 3.

3.2 Comparison and Analysis of U-Value Result Values between Simulators

Table 4 is that three simulators show result values of simulation from Case 1 to Case 7 with Therm and Window.
Three simulators were trained about window-set simulation method during eight months. It is judged that there is somewhat difference of modeling time and understanding of interpretation method by individual. But it is also judged that interpretation values between simulators are somewhat different but are not a great difference.

However, in case of Case 1, 2, 3, and 4, there is a huge relative error between test and simulation values, and Case 5 and 6 are within 10% of error rate, a tolerance of simulation acknowledgment value. Error rate of Case 1 ~ 4 with a window or two windows is bigger than error rate of Case 5 and 6 with four windows.

Table 5: U-value comparison of simulation and test

Case	Test (W/㎡ K)	simulation (W/㎡ K)	Relative error (%)
7	2.039	1.002	50.85
8	1.730	0.806	53.40
9	1.713	0.825	51.84
10	1.309	0.561	57.14
11	1.068	0.996	6.74
12	0.941	0.921	2.13
13	1.407	1.833	30.28

3.3 Comparison between Test U-Value and Simulation U-Value

As Table 5, relative error rate of Case 7 ~ 10 with two windows are between 50% and 60%, so error rate between test and simulation values is high, and error rate of Case 11 ~ 13 with four windows are between 21% and 30%, so their error rate between test and simulation values is smaller than that with two windows. Especially, error rate of Case 11 with four windows of Case 7 ~ 13 is 6.74%, and error rate of Case 12 with four windows of Case 7 ~

Table 4: U-value comparison of simulation result according to simulators

		Head	Sill	L-Jamb	R-Jamb	C-jamb	Test (W/㎡ K)	Simulation (W/㎡ K)	Relative error(%)
Simulator 1	Case.1	F:0.2582 E:0.1536	F:0.0593 E:0.0362	F:0.2386 E:0.1536	F:0.2974 E:0.1912	-	1.541	1.152	25.24
	Case.2	F:0.0187 E:0.0017	F:0.0527 E:0.0562	F:0.0358 E:0.0740	F:0.1572 E:0.0438	F:0.0299 E:0.0151	2.002	1.218	39.26
	Case.3	F:0.0050 E:0.0080	F:0.0049 E:0.0079	F:0.0117 E:0.0233	F:0.0114 E:0.0225	F:0.0279 E:0.0254	2.518	1.343	46.66
	Case.4	F:0.0041 E:0.0087	F:0.0055 E:0.0113	F:0.0205 E:0.0485	F:0.0084 E:0.0142	F:0.0071 E:0.0082	0.986	1.148	16.43
	Case.5	F:0.0028 E:0.0048	F:0.0003 E:0.0036	F:0.0100 E:0.0211	F:0.0129 E:0.0272	F:0.0049 E:0.0037	0.761	0.765	0.52
	Case.6	F:0.0331 E:0.0482	F:0.0179 E:0.0260	F:0.0194 E:0.0366	F:0.0445 E:0.0706	F:0.0179 E:0.0158	0.935	1.000	6.95
Simulator 2	Case.1	F:0.3002 E:0.1930	F:0.8387 E:0.3746	F:0.2938 E:0.1889	F:0.2936 E:0.1888	-	1.541	1.189	22.84
	Case.2	F:0.1877 E:0.5132	F:0.0078 E:0.0235	F:0.0037 E:0.0079	F:0.0010 E:0.0016	F:0.0043 E:0.0063	2.002	1.152	42.45
	Case.3	F:0.0309 E:0.0242	F:0.0152 E:0.0245	F:0.0135 E:0.0263	F:0.0145 0.0289	F:0.0275 E:0.0249	2.518	1.354	46.22
	Case.4	F:0.1349 E:0.3063	F:0.0020 E:0.0050	F:0.0095 E:0.0185	F:0.0094 E:0.0184	F:0.0242 E:0.0350	0.986	1.208	22.51
	Case.5	F:0.0015 E:0.0026	F:0.0007 E:0.0012	F:0.0104 E:0.0218	F:0.0135 E:0.0306	F:0.0062 E:0.0047	0.761	0.765	0.52
	Case.6	F:0.0240 E:0.0348	F:0.0307 E:0.0445	F:0.0012 E:0.0022	F:0.0015 E:0.0028	F:0.0140 E:0.0123	0.935	0.979	4.70
Simulator 3	Case.1	F:0.1682 E:0.3712	F:0.0043 E:0.0662	F:0.1282 E:0.0712	F:0.4237 E:0.2852	-	1.541	1.134	26.41
	Case.2	F:0.0169 E:0.0084	F:0.0324 E:0.0827	F:0.0477 E:0.1034	F:0.0342 E:0.0763	F:0.0722 E:0.0089	2.002	1.120	44.05
	Case.3	F:0.0178 E:0.0421	F:0.0179 E:0.0246	F:0.0174 E:0.0336	F:0.0092 E:0.0306	F:0.0523 E:0.0186	2.518	1.317	47.69
	Case.4	F:0.0241 E:0.0372	F:0.0182 E:0.0138	F:0.0407 E:0.0694	F:0.0272 E:0.0082	F:0.0193 E:0.0528	0.986	1.095	11.05
	Case.5	F:0.0072 E:0.0095	F:0.0009 E:0.0026	F:0.0087 E:0.0186	F:0.0108 E:0.0190	F:0.0039 E:0.0025	0.761	0.735	3.41
	Case.6	F:0.0291 E:0.0584	F:0.0294 E:0.0178	F:0.0227 E:0.0208	F:0.0281 E:0.0304	F:0.0113 E:0.0079	0.935	0.927	0.85

13 is 2.13%, so it is within 10% of a simulation error tolerance so can receive window-set energy consumption efficiency grade with simulation value.

4. Conclusion

This study examined an error of simulation value occurred between simulators of total 13 window-set cases, and investigated a difference between U-Value by test and U-Value by simulation.

To replace test with simulation, it should be within 10% of an error tolerance between real experimental value and simulation interpretation value. Four window-set models of 13 models are qualified for receiving energy consumption efficiency grade. Simulation value of simulator 3 is somewhat different from that of Simulator 1 and 2, but there is no great difference of simulation value between simulators. Irrespective of simulators, test value of U-Value of most data is greater than simulation value of U-Value. Especially, in case of few windows, there is a great error between test and simulation values. In case of few windows, U-Value has risen higher than that of a model with many windows. To reduce this error, it is judged that method and standard of simulation modeling of glazing should be more minutely prepared. To prepare more accurate simulation standard, further studies of glazing modeling method will be needed.

Acknowledgement

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