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Finite Element Analysis of PVC window profile &aluminium window profile with and without thermal break

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ABSTRACT
Examine a thermal analysis .Numerous analogies exist between thermal and structuralanalysis for PVC window profile &aluminium window profile with and without thermalbreak ,Finite Element Analysis, commonly called FEA, is a method of numerical analysis. FEA isused for solving problems in many engineering disciplines such as machine design,acoustics, electromagnetism, soil mechanics, fluid dynamics, and many others. Inmathematical terms, FEA is a numerical technique used for solving field problemsdescribed by a set of partial differential equations. In mechanical engineering, FEA iswidely used for solving structural, vibration, and thermal problems. However, FEA is notthe only available tool of numerical analysis. Other numerical methods include the FiniteDifference Method, the Boundary Element Method, and the Finite Volumes Method tomention just a few. However, due to its versatility and numerical efficiency, FEA has cometo dominate the engineering analysis software market, while other methods have beenrelegated to niche applications. When implemented into modern commercial software,both FEA theory and numerical problem formulation become completely transparent tousers.

I. INTRODUCTION

FEA is a powerful engineering analysis tool useful in solving many problems ranging fromvery simple to very complex. Design engineers use FEA during the product developmentprocess to analyze the designing-progress. Time constraints and limited availability ofproduct data call for many simplifications of computer models. On the other hand,specialized analysts implement FEA to solve very complex problems, such as vehicle crashdynamics, hydro forming, and air bag deployment. This book focuses on how designengineers use FEA, implemented in Solid Works Simulation, as a design tool. Therefore,we highlight the most essential characteristics of FEA as performed by design engineers asopposed to those typical for FEA preformed by analysts. FEA for Design Engineers Another design tool For design engineers, FEA is one of many design tools that are used inthe design process and include CAD, prototypes, spreadsheets, catalogs, hand calculations,
text books, etc

II. METHODOLOGY

From the perspective of FEA software, each application of FEA requires stepsPreprocessing of the FEA model, which involves defining the modelthen splitting it into finite elements
• Solving for desired results
• Post-processing for results analysis

We will follow the above three steps in this project . From the perspective of FEA methodology, we can list the following FEA steps:
• Building the mathematical model
• Building the finite element model by discretizing the mathematical model
• Solving the finite element model
• Analyzing the results

The following subsections discuss these four steps.

2.1 Building the mathematical model

The starting point to analysis with SolidWorks Simulation is a SolidWorksmodel.
Geometry of the model needs to be meshable into a correct finiteelement mesh. Thisrequirement of meshability has very importantimplications. We need to ensure that the CAD geometry will indeed mesh andthat the produced mesh will provide the data ofinterest (temperature distribution) with acceptable accuracy.it is important to mentionthat we do not always simplify the CAD modelwith the sole objective of making it meshable. Often we must simplify amodel even though it would mesh correctly, but theresulting meshwould be too large (in terms of the number of elements) and consequently, themeshing and the analysis would take too long. Geometry modifications allowfor asimpler mesh and shorter meshing and computing times.Sometimes, geometry preparation may not be required at all. Successfulmeshing dependsas much

on the quality of geometry submitted for meshingas it does on the capabilities ofthe meshing tools implemented in the FEAsoftware.Having prepared a meshable, but not yet meshed geometry, we now definematerialproperties (these can also be imported from a CAD model), loads andrestraints, andprovide information on the type of analysis that we wish toperform. This procedurecompletes the creation of the mathematical modelthe process of creating themathematical model is not FEA specific.

2.2 Building the finite element model

The mathematical model now needs to be split into finite elements in theprocess ofdiscretization, more commonly known as meshing .Geometry, loads, and restraints are alldiscretized. The discretized loads andrestraints are applied to the nodes of the finiteelement mesh.

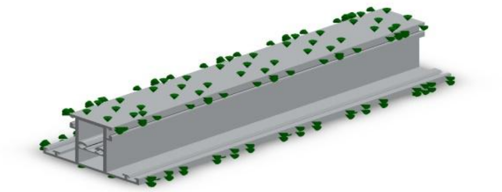
2.3 Solving the finite element model

Having created the finite element model, we now use a solver providedin SolidWorks Simulation to produce the desired data of interest.

2.4 Analyzing the results

Often the most difficult step of FEA is analyzing the results. Properinterpretation of resultsrequires that we understand all simplifications(and errors they introduce) in the firstthree steps: defining the mathematicalmodel, meshing, and solving. In the Building thefinite element modelThe mathematical model is discretized into a finite element model. Thiscompletes the pre-processing phase. The FEA model is then solved withone of thenumerical solvers available in SolidWorks Simulation .

III. STUDY 1 :ALUMINUM PROFILE WITHOUT THERMAL BREAK MODEL INFORMATION



Model name: A P without thermal break
Current Configuration: Default

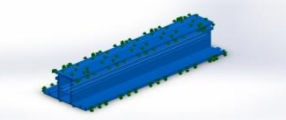
Solid Bodies			
Document Name and Reference	**Treated As**	**Volumetric Properties**	**Document Path/Date Modified**
Boss-Extrude1 	Solid Body	**Mass:0.254302 kg** **Volume:9.41858e-005 m^3** **Density:2700 kg/m^3** **Weight:2.49216 N**	**C:\Users\mo\Dropbox\research 1\New folder\A P without thermal break.SLDPRT** Sep 17 10:51:40 2012

Study Properties

Study name	A p without thermal break study
Analysis type	Thermal(Steady state)
Mesh type	Solid Mesh
Solver type	FFEPlus
Solution type	Steady state
Contact resistance defined?	No
Result folder	SolidWorks document (C:\Users\mo\Dropbox\research 1\New folder)

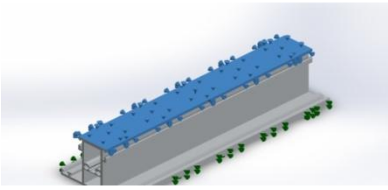
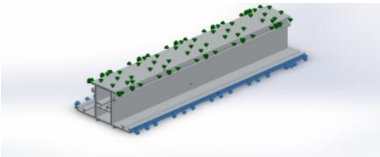
Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

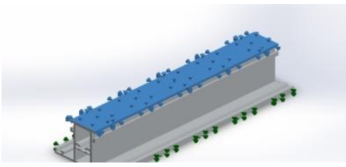
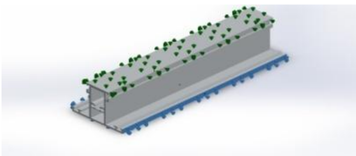
Iodel Reference	**Properties**	**Components**
	**Name:** 6063-T4 **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Thermal conductivity:** 200 W/(m.K) **Specific heat:** 900 J/(kg.K) **Mass density:** 2700 kg/m^3	olidBody 1(Boss-xtrude1)(200mm profile ithout thermal break with aterial)
Curve Data:N/A		

Thermal Loads

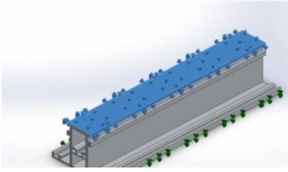
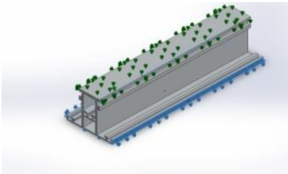
A- Outside tempreture 50 deg C - inside temp 20 deg c

Load name	Load Image	Load Details
Convection-1		**Entities:** 3 face(s) **Convection** 10 (W/m^2)/K **Time variation:** Off **Temperature** Off **Bulk Ambient** 293.15 Kelvin **Time variation:** Off
Convection-2		**Entities:** 3 face(s) **Convection** 10 (W/m^2)/K **Time variation:** Off **Temperature** Off **Bulk Ambient** 323.15 Kelvin **Time variation:** Off

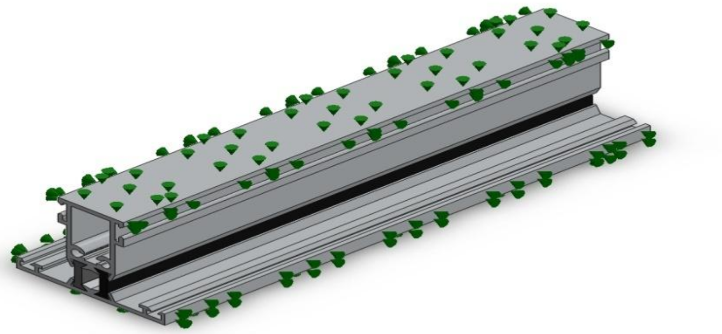
B- Outside tempreture30 deg C - inside temp 20 deg c

Load name	**Load Image**	**Load Details**
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 303.15 Kelvin

C- Outside tempreture 10 deg C - inside temp 20 deg c

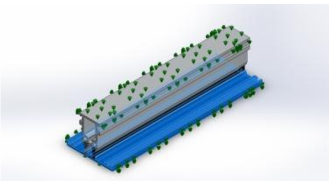
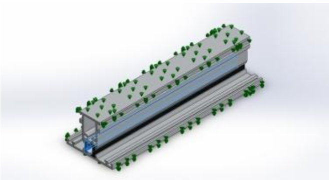
Load name	Load Image	Load Details	
Convection-1		**Entities:** **Convection Coefficient:** **Time variation:** **Temperature variation:** **Bulk Ambient Temperature:**	3 face(s) 10 (W/m^2)/K Off Off 293.15 Kelvin
Convection-2		**Entities:** **Convection Coefficient:** **Time variation:** **Temperature variation:** **Bulk Ambient Temperature:**	3 face(s) 10 (W/m^2)/K Off Off 283.15 Kelvin

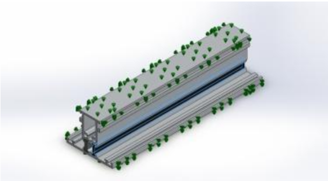
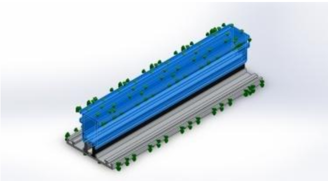
4.0 Study 2 :Aluminum profile with thermal break
Model information



Model name: A P With termal break
Current Configuration: Default

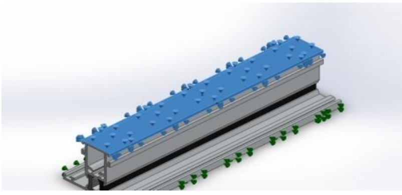
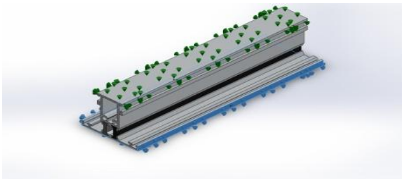
Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Boss-Extrude1 	Solid Body	**Mass:0.0989121 kg** **Volume:3.66341e-005 m^3** **Density:2700 kg/m^3** **Weight:0.969338 N**	**C:\Users\mo\Dropbox\research 1\aluminum profile\study\stady1\200mm lower profile.SLDPRT**
Boss-Extrude1 	Solid Body	**Mass:0.0110905 kg** **Volume:9.90226e-006 m^3** **Density:1120 kg/m^3** **Weight:0.108687 N**	**C:\Users\mo\Dropbox\research 1\aluminum profile\study\stady1\200mm thermal srtip.SLDPRT**

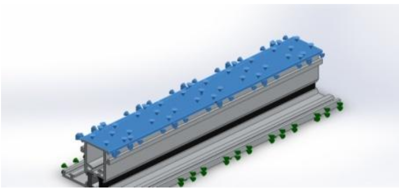
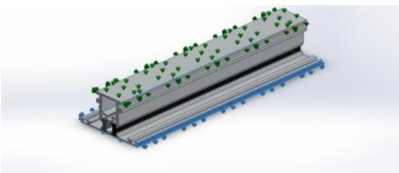
Boss-Extrude1 	Solid Body	**Mass:0.0110905 kg** **Volume:9.90226e-006 m^3** **Density:1120 kg/m^3** **Weight:0.108687 N**	**C:\Users\mo\Dropbox\research 1\aluminum profile\study\stady1\200mm thermal srtip.SLDPRT**
Boss-Extrude1 	Solid Body	**Mass:0.153047 kg** **Volume:5.66842e-005 m^3** **Density:2700 kg/m^3** **Weight:1.49986 N**	**C:\Users\mo\Dropbox\research 1\aluminum profile\study\stady1\200mm upper profile.SLDPRT**

Thermal Loads

A- Outside temperature 50 deg C - inside temp 20 deg c

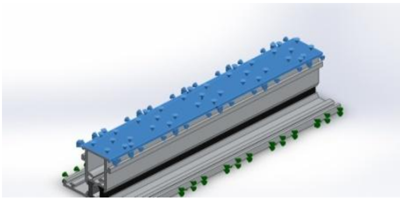
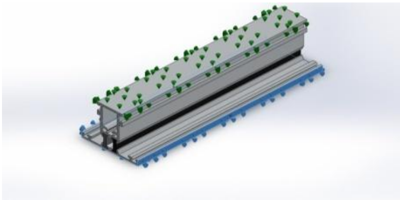
Load name	**Load Image**	**Load Details**
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 323.15 Kelvin

B- Outside temperature 30deg C - inside temp 20 deg c

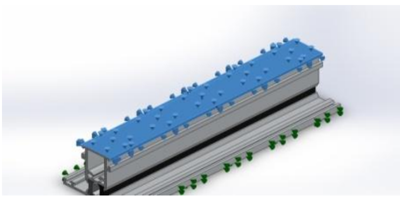
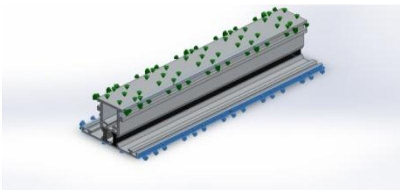
Load name	**Load Image**	**Load Details**
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 303.15 Kelvin

C- Outside temperature 10 deg C - inside temp 20 deg c

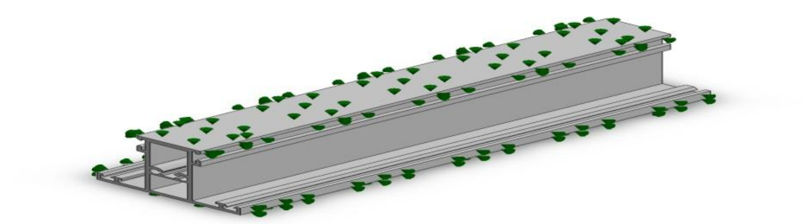
Load name	**Load Image**	**Load Details**

Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 283.15 Kelvin

D- Outside temperature -5 deg C - inside temp 20 deg c

Load name	Load Image	Load Details
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 268.15 Kelvin

5.0 Study 3 :PVC Window Profile
Model information



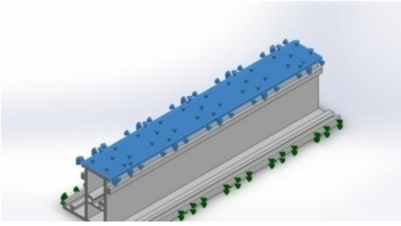
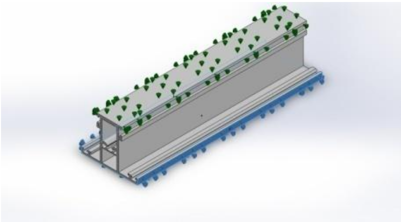
Model name: pvc profile 2
Current Configuration: Default

Solid Bodies

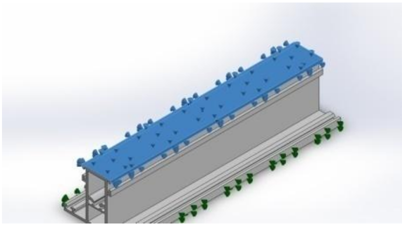
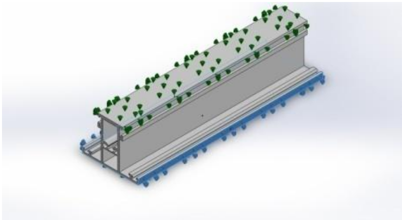
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Boss-Extrude1 	Solid Body	**Mass:0.122442 kg** **Volume:9.41858e-005 m^3** **Density:1300 kg/m^3** **Weight:1.19993 N**	**C:\Users\Eng-Al.Obaid\Desktop\research 1\backup\pvc profile 2.SLDPRT** Oct 24 11:22:40 2012

Thermal Loads

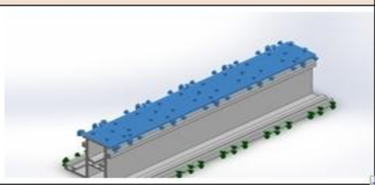
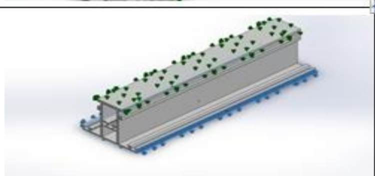
A- Outside temperature 50 deg C - inside temp 20 deg c

Load name	Load Image	Load Details
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin **Time variation:** Off
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 323.15 Kelvin **Time variation:** Off

B- Outside temperature 30 deg C - inside temp 20 deg c

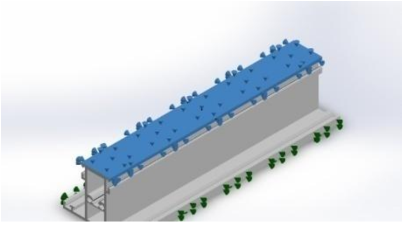
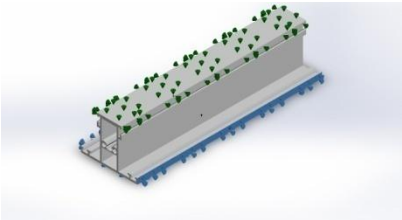
Load name	Load Image	Load Details
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin **Time variation:** Off
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 303.15 Kelvin **Time variation:** Off

C- Outside temperature 10 deg C - inside temp 20 deg c

Load name	Load Image	Load Details
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin **Time variation:** Off
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 283.15 Kelvin **Time variation:** Off

6.0 Study Results Comparison

D. Outside temperature -5 deg C - inside temp 20 deg c

Load name	Load Image	Load Details
Convection-1		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 293.15 Kelvin **Time variation:** Off
Convection-2		**Entities:** 3 face(s) **Convection Coefficient:** 10 (W/m^2)/K **Time variation:** Off **Temperature variation:** Off **Bulk Ambient Temperature:** 268.15 Kelvin **Time variation:** Off

Results : study according to out side tempreture

No	Tempreture	Temp. min/max	Window profile type		
			Aluminum profile without thermal break	aluminum profile with thermal break	pvc profile
1	50 deg Celsius	maximum tempretur Celsius	41.0116	46.3404	49.9747
		minimum tempreture Celsius	40.0116	28.3845	20.9354
2	30 deg Celsius	maximum tempretur Celsius	27.0038	28.7803	29.9898
		minimum tempreture Celsius	26.8621	22.7944	20.3137
3	10 deg Celsius	maximum tempretur Celsius	13.1379	17.2056	19.6862
		minimum tempreture Celsius	12.9961	11.2197	10.0102
4	-5 deg. Celsius	maximum tempretur Celsius	2.8448	13.0139	19.2156
		minimum tempreture Celsius	2.49038	-1.95081	-4.9745

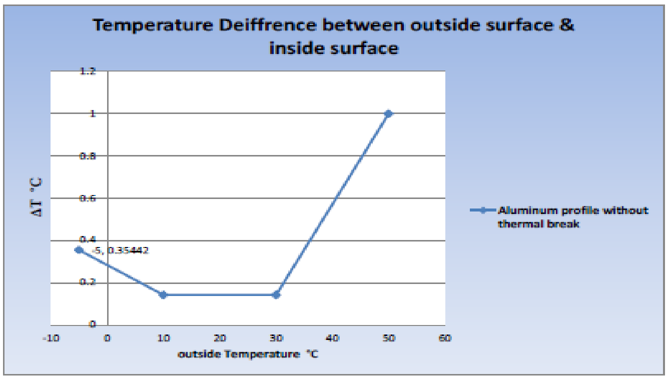
6.1 Effect of thermal Break

It is clear from our result that ,for windows aluminum profile, the effect of thermal break as thermal insulator is critical .As we apply the same outside temperature (**50deg Celsius**) on the outside surfaces for both profiles (with and without thermal break) we get minimum surface temperature of **28.3845°C**. This gives a maximum temperature difference of □**T = 18.0559 °C.** While for aluminum profile without thermal break, the minimum surface temperature becomes **40.0116 °C** and a maximum temperature difference of □**T = 1 °C** These results clearly show the positive effect of thermal break on aluminum profile.

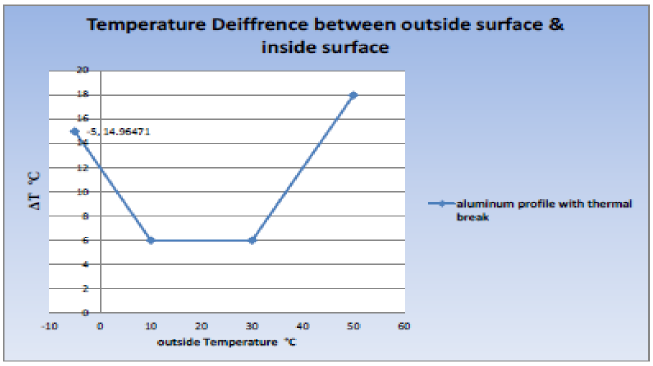
6.2 Effect of Material

From our result the effect of material type is visible as heat insulator on windows profile as we apply the same outside temperature **(50deg Celsius)** on the outside surfaces for aluminum profile with and without thermal break and a PVC profile. The maximum temperature difference in the PVC case is □**T = 29.0393 °C** while it is □**T = 18.0559 °C** for aluminum profile with thermal break, and □**T = 1 °C** for aluminum profile without thermal break. As a result, using PVC profile will enhance the insulation and help in reducing heat gain thought windows especially in hot weather.

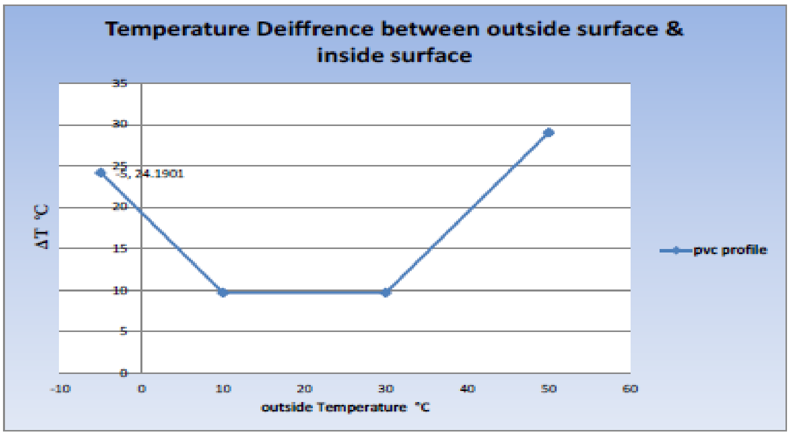
6.3Effect of Outside Temperature



By using aluminum profile without thermal break, the maximum temperature difference between profile outside surface and inside surfaces in cold or hot conditions is very small. This mean the aluminum profile without thermal break fail to insulate the inside room from the extreme drop or gain in the outside temperature.



In the case of using aluminum profile with thermal break there is big temperature difference between the profile outside surface temperature and inside surface and ΔT is higher in the hot condition than it is in the cold condition. This means the thermal break is working as a good thermal insulator in the extreme weather conditions.



In the case of using PVC there is big temperature difference between the profile outside surface temperature and inside surface and ΔT is higher in the hot condition than it is in the cold condition .This means the PVC profiles is working as a good thermal insulator in the extreme weather conditions and even better than aluminum profile with thermal break because of higher temperature differences in comparison with aluminum profile with thermal break.

VII. Conclusion

Result of the study :

The result of the study can be summarized as a design recommendation :

1- It is highly recommended to use the PVC windows profiles specially in cold and hot countries.

2- 2- All aluminum profile used in hot countries should be manufactured with thermal breaks to provide maximum heat insulation between outdoor and indoor environment.

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