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Effect of Thermal barrier coating with different Thickness in PistontoenhanceTemperaturedistribution

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Abstract

Inthecurrentwork,theCADmodelofpistonhas been developed by using ANSYSdesignmodeler.Themodelhasbeensimulated using ANSYS software on steadystatethermalandstaticstructuraldomain 15.0 workbench in order to observe variousparameterseffectingthetemperaturedistributionbetweendifferentthicknessofthermalbarriercoating.Fourtypesofconfigurationsofcoatingthicknesswereused i.e. 0.5, 0.7, 0.9, 1.2 mm. An optimizedmodel of pistonhas been developed as statedconfigurationsofcoatedpiston.Thesimulationshavebeenperformedatastandard temperature that is the temperaturegeneratedduringworkingofinternalcombustionengine.Thesimulationoftheoptimizedmodelgiveslowervalueoftemperature distribution, thermal stress anddeformation. The results are validated withreportedexistingpreviouswork.Theconfigurationofthicknessbetween0.7to 0.9 of thermal barrier coating coated withsodiumstannatematerialexhibitshigher temperaturedistributioncomparedtotitaniumdioxide, zirconium andAi-Si.

KeyWords–Piston,Temperaturedistribution,Thermalstress,Deformation,outletportsodiumstannate,titaniumdioxide,zirconiumandAi–Si,ANSYS,CAD,Simulation.

1.1 Overviewofmywork

Inpresentresearchworkthetemperatureeffects inpistonisimprovedbydifferentthermal barrier coatings with thickness, alsoobservations were made in favor of thermalstress and deformation using finite elementmethod.The simulation wasperformedinANSYSpackageincoupledanalysisofsteadystatethermalandstaticstructural domain to predict the effect of temperaturedistributionand stresses.

1.2 Functionofpiston

Apistonisamovingdiskenclosedofacylinder as is made gas-tight by means ofpiston rings. The disk moves inner the pipeas like a liquid then fuel inward the barrelexpandsyetcontracts.Apistonaidswithin thechangeregardingheatelectricityinmechanical work yet stigma versa. Becauseof this, pistons are an authorization elementconcerning heatengines.[2]Pistons workbywayoftransferringtheforceoutturnabout an expanding gas between the tubes inaccordance with a crankshaft, which givesrotationalpacetoaflywheel.Suchadictationisrecognisedasmuchareciprocating engine.A piston must follow acyclical technique between order because ofsuchaccordingtocontinuallyalterheatpower to work, and at that place are densemethodsaccordingtowholethatcycle.

1.3 OBJECTIVE & PROBLEMFORMULATION

Objectiveofpresentwork

- The main objective of the proposedresearch work is to validate the FEManalysisofsimulationsresultofdifferentconfigurationsofpistonmodels by comparing the results ofresearchreportedin theliterature.
- Tooptimizethedifferentconfigurations of piston models withthickness ranging between 0.5 – 1.2mm.
- Toanalyzetheperformanceparameters temperaturedistributionofpiston models.
- Topredictthetemperaturedistribution, thermalstressanddeformationonoptimizedpistonalongtheinfluencesofdifferentthermalbarriercoatingthickness.
- The major objective of present workistoinvestigatethetemperaturedistribution of piston with differentcoatingthickness.

ProblemFormulation

The survey of different previous works wepredictthetemperatureisminimumascompared to present study is shown in ourbasepaper.Thepurposesofthisstudyenhancethetemperaturedistributionanddecrease the thermal stress and deformationwithdifferentthicknessofthermal barriercoating.

1.4 RESULTS

Validation:

The effects of different thickness of coatingin piston and characteristics for temperature,thermal stress and deformation are presentedbelow. The results have been compared withpreviousresearchworkpresentinliterature ofsameparameterandalsocomparewith numerical model developed in present analysisisoperatingundersimilaroperatingcond itionstodiscusstheenhancementin temperature distribution piston with ofdifferentthick nesscoatings.

Table 1.1 Validation of results obtained foruncoatedpiston.

Validation			
Thickness(mm)	**Temperature(degreecelcius)(Validation)**	**Stress(Mpa)(Validation)**	**Deformation(mm)(Validation)**
0.5	**496**	**2866.7**	**1.54**
0.7	**486**	**2696.5**	**1.48**
0.9	**479.6**	**2458.2**	**1.39**
1.2	**474.3**	**2245.9**	**1.32**

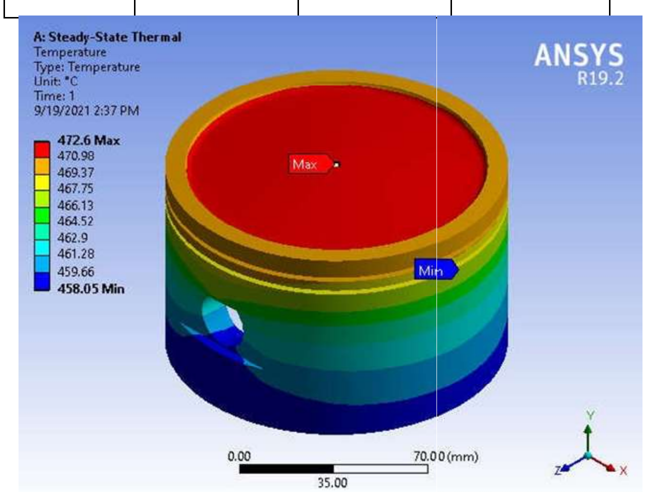

Figure 1.1 – Temperature distribution inpiston(Validation)

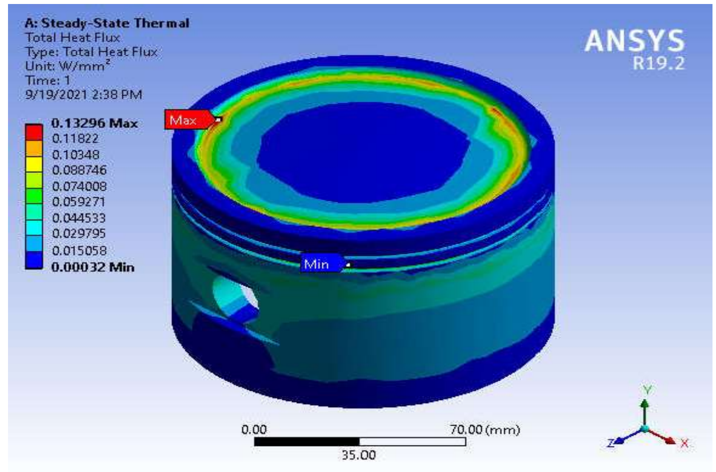

Figure 1.2 Heat flux distribution in piston(Validation)

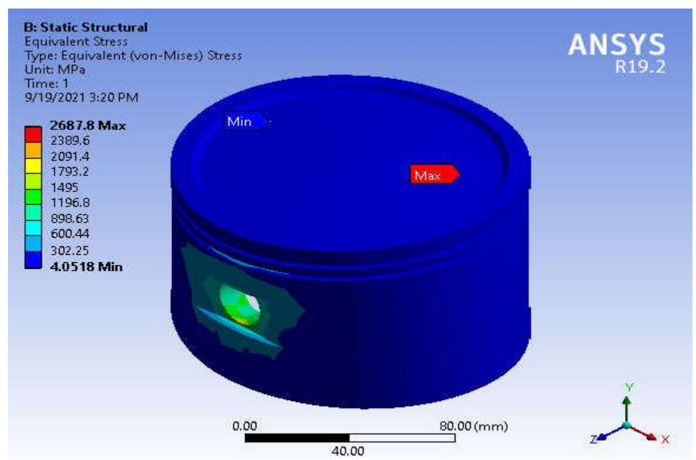

Figure 1.3 thermal stress distributions inpiston (Validation)

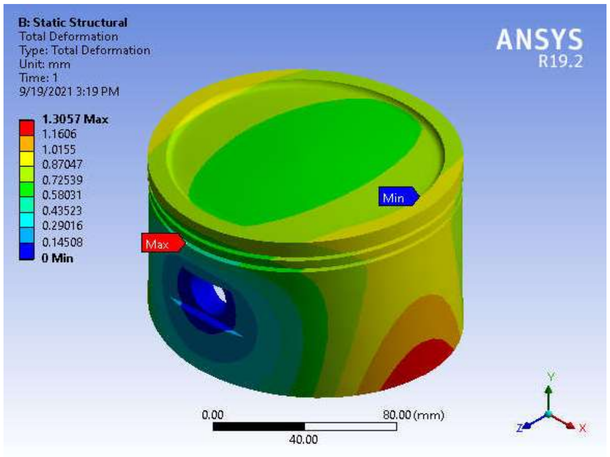

Figure 1.4 Deformation in piston(Validation)

characteristics for temperature, thermalstressanddeformatio narepresentedbelow.

The results have been compared with validationresultofsameparameterdevelopedin presentanalysisoperatingunder similar operating conditions to discussthe enhancement in temperature distributionof piston with different thickness of titaniumdioxide.

1.5 CharacteristicsofTitaniumdioxidecoatedpiston:

Theeffectsoftitaniumdioxidecoatingwithdiffe rent thickness in piston and

Table1.2 Results obtained fortitanium dioxidecoatedpiston.

Titaniumdioxidecoating			
Thickness(mm)	**Temperature (degree celcius) (Titanium dioxidecoating)**	**Stress (Mpa) (Titaniumdioxidecoating)**	**Deformation (mm) (Titanium dioxide coating)**
0.5	**420**	**4363.2**	**2.11**
0.7	**419.33**	**3925.6**	**2.9**
0.9	**411.25**	**3586.7**	**2.6**
1.2	**398.46**	**3010.9**	**2.2**

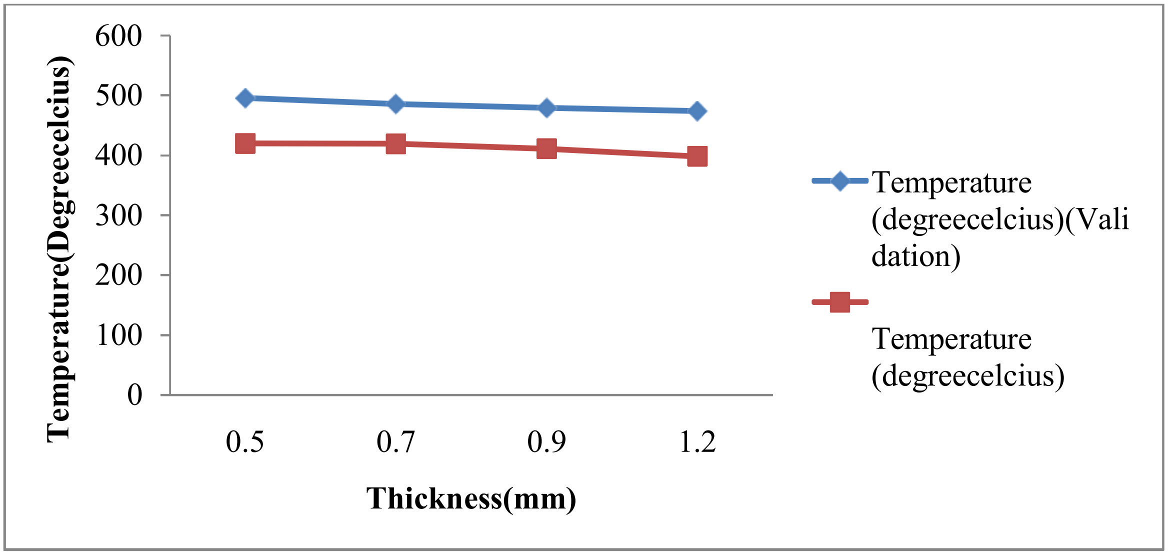

Figure 1.5 – Comparison of temperature distribution of piston coated with titanium dioxide withrespectto coatingthickness

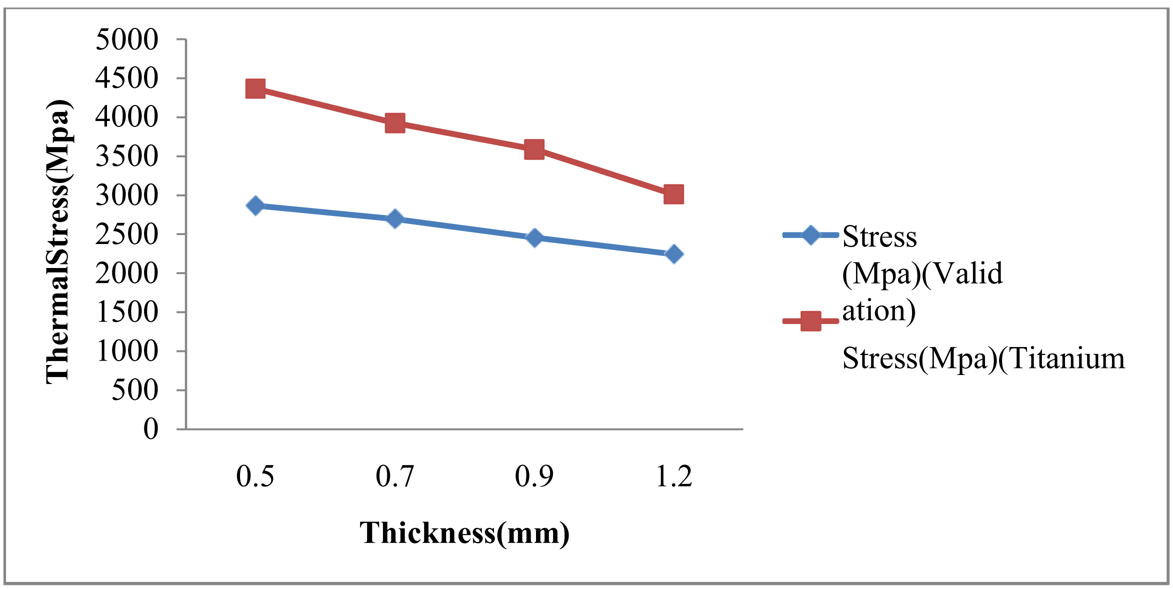

Figure 1.6 – Comparison of thermal stress distribution of piston coated with titanium dioxidewithrespect to coatingthickness

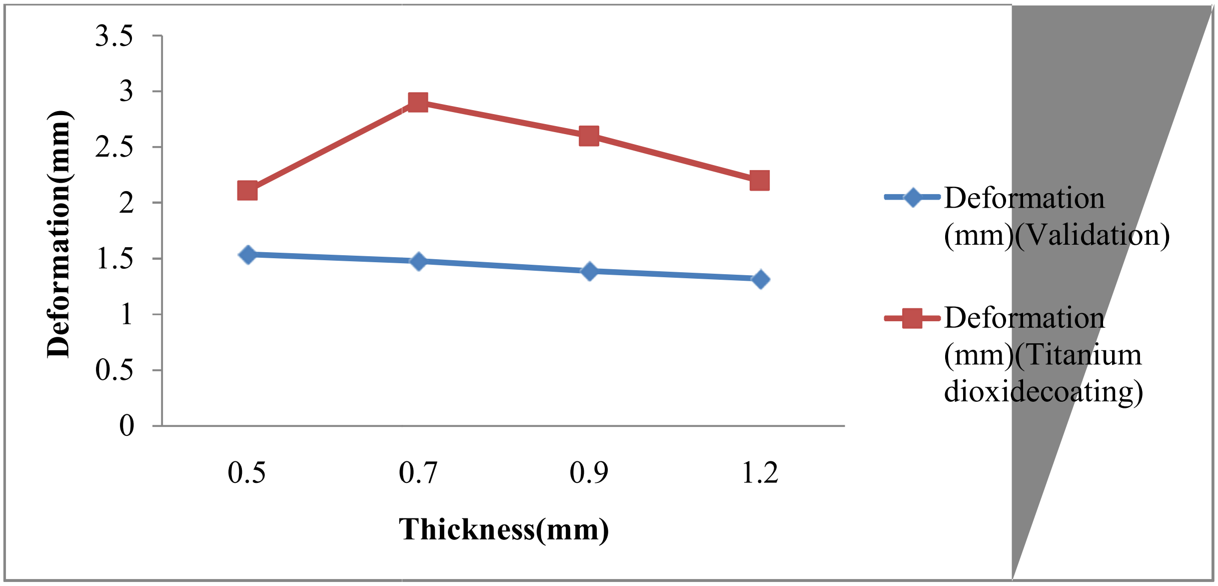

Figure 1.7 – Comparison of deformation of piston coated with titanium dioxide with respect tocoatingthickness

1.6 ContourplotobtainedforTitaniumdioxidecoated piston

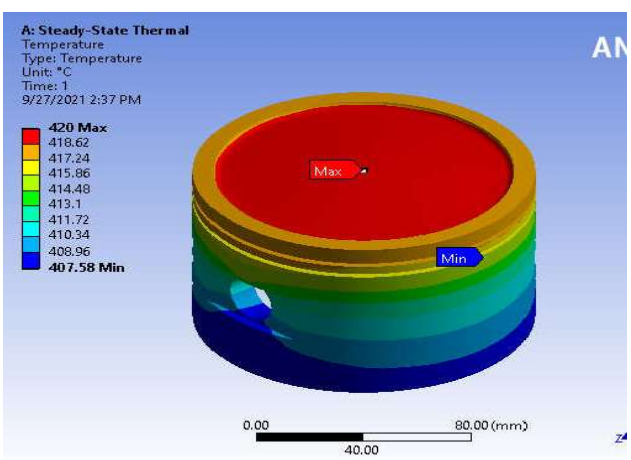

Figure 1.8 – Temperature distribution oftitanium dioxidecoatedpiston.

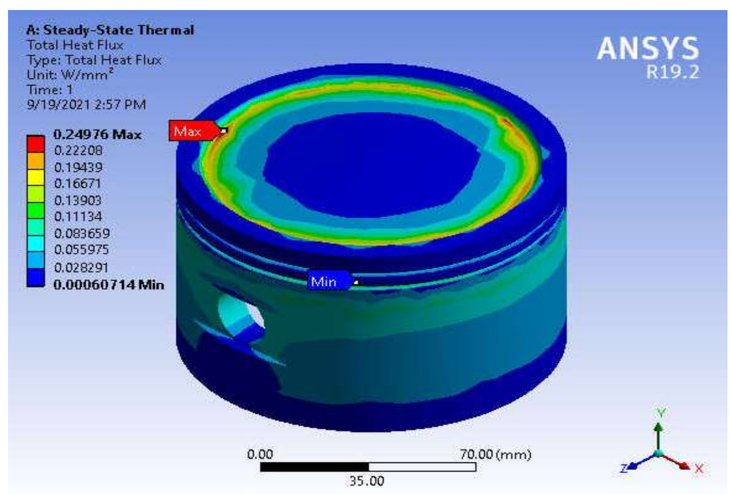

Figure 1.9 – Heat flux distribution oftitanium dioxidecoatedpiston.

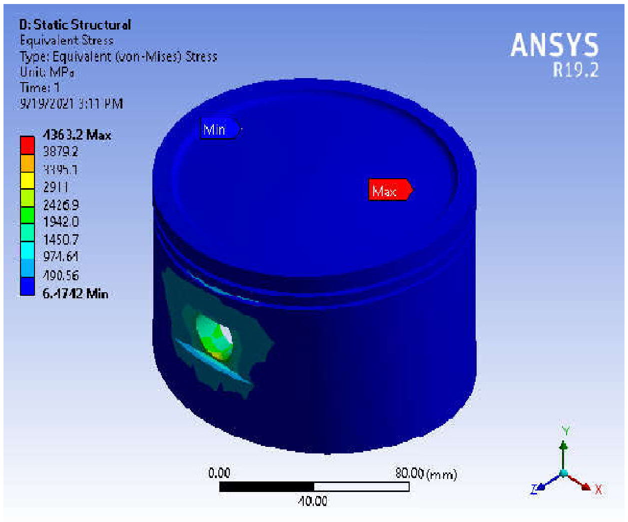

Figure 1.10 – Thermal stress distribution oftitanium dioxidecoatedpiston.

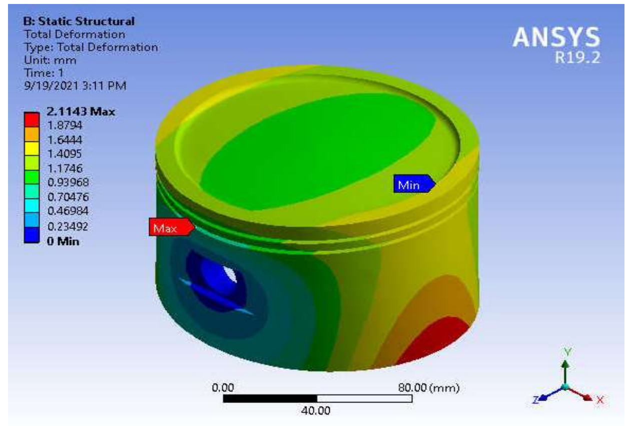

Figure 1.11 – Deformation of titaniumdioxidecoatedpiston.

1.7 Overallcomparisonofcoatedpistonwithdifferentthicknessandmaterials:

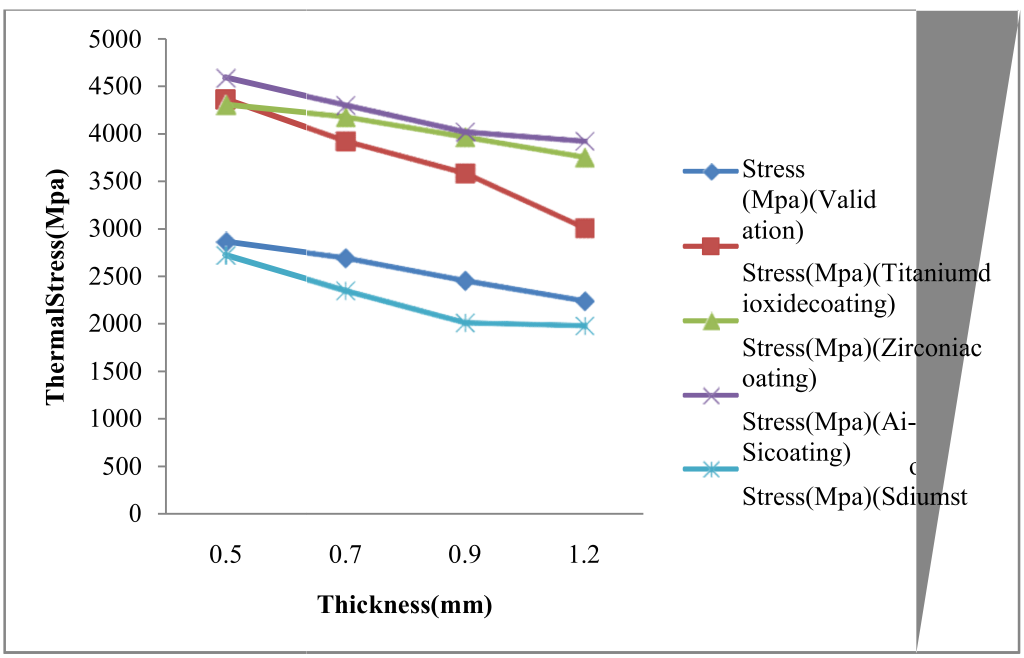

Figure1.12–overallcomparisonofthermal stresswithrespecttothickness

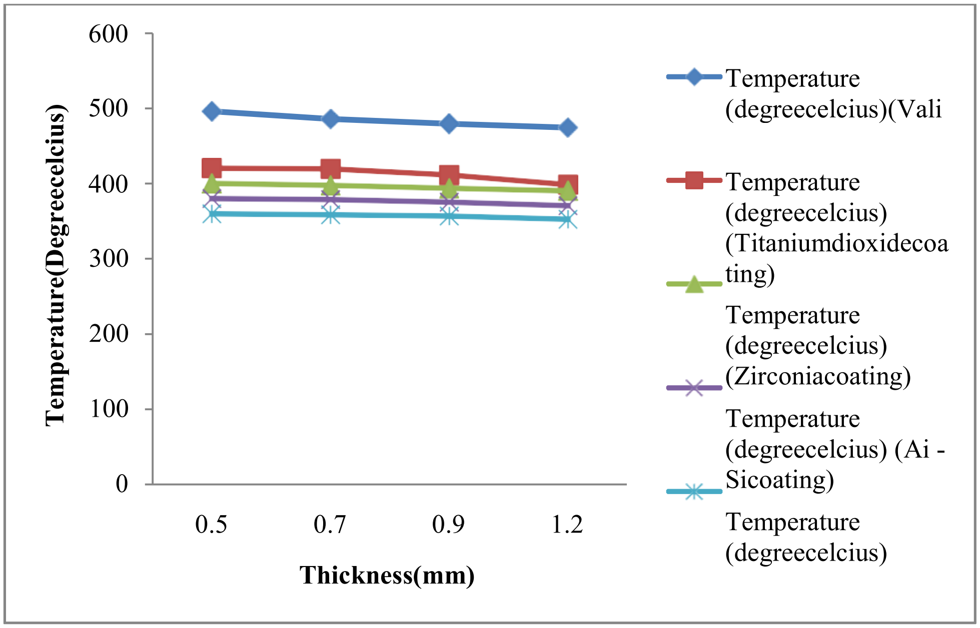

Figure1.13–overallcomparisonoftemperaturewithrespecttothickness

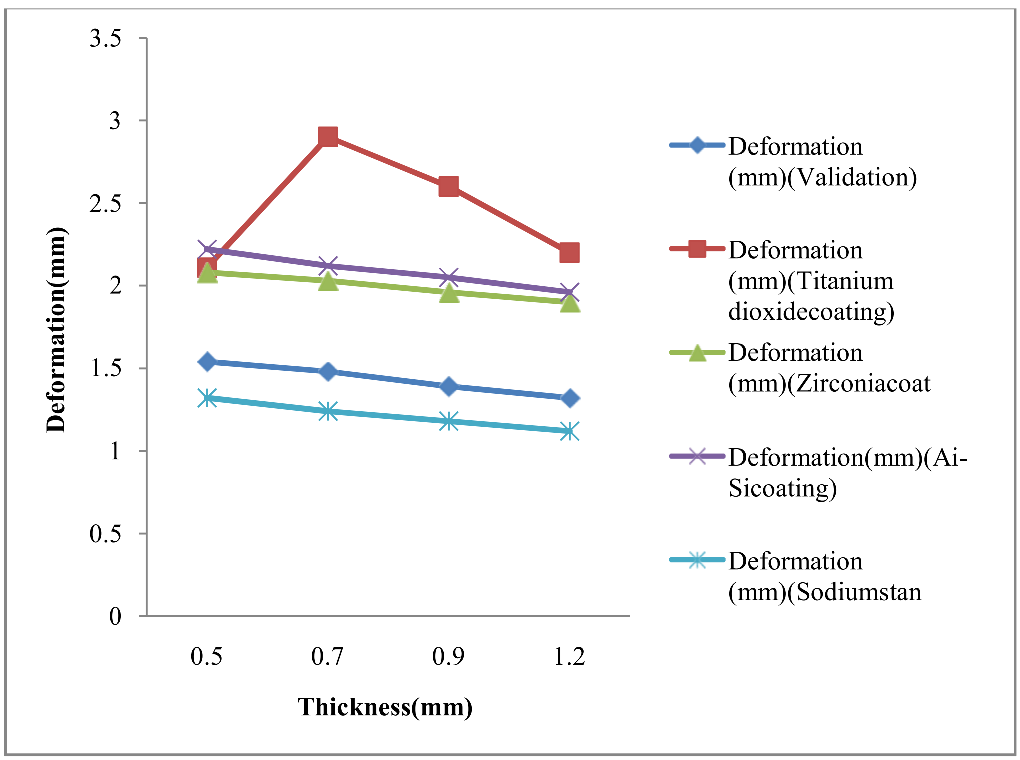

Figure1.14–overallcomparisonofdeformationwithrespecttothickness

Conclusion

- The simulation model was developedonANSYSdesignmodelerandanalysis was done using the ANSYSsoftware insteady state thermal andstaticstructural15.0domain.
- Temperaturedistributionisthefundamentalparameterintheperformance of piston. The effect oftemperatureincrownofthepistonwill increaseasthethicknessofthermalbarriercoatingis decreased.
- In the study, the thickness of thermalbarriercoatingbetween0.7to0.9exhibits better convergence in eachoutputparameters.
- Theminimumtemperaturedistribution isfoundinsodiumstannate,thusexistingmaterialshows better temperature distributionineachproposedcoatingthickness.
- The effect of thermal stress is foundto less in sodium stannate in everycoatingthickness.
- Further,zirconiumandtitaniumdioxide coating in piston also havebettertemperaturedistributionwithoptimumthermalstressanddeformation.
- Deformationofsodiumstannatecoated pistonexhibitsminimumeffectin each thickness.

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