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Design and Analysis of Piston

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ABSTRACT: The Piston is part of the engine which converts heat and pressure liberated by fuel combustion into mechanical work . The engine piston is the most complex automotive component. This articledescribes the design and analysis of pistons in different material (cast iron, gray cast iron and aluminum alloys) anddifferent conditions. Our purpose for this article is to check that which material is best for piston under different conditions. The work is used to calculate the distribution of stresses, temperature and shear stress on the pistonsurface. Mostly due to mechanical and thermal stress, piston fail. we applied temperature 720-degree Celsius on thepiston. Ansys provide a simulation solution. Design of piston is carried out using solid works and different conditionsperforminAnsys.

I. INTRODUCTION

A disc or small cylinder that fits tightly inside a tube and travels up and down against a liquid or gas, used to generatemotioninaninternalcombustionengineor toimpartmotion inapump. Apiston can beused inreci procatingengines, reciprocatingpumps,gascompressors,hydraulic cylinders,andpneumatic cylinders,amongother things.

Type of pistonhead:

1. **Flat piston head:** Flat piston has a flat top. These pistons are typically used in mass produced engines. They are easy tomanufacture andlowcostofengines.

Dish/bowl piston head: The piston has a bowl or dish shaped top. it is used to reduce compression ratio because it addsvolume to the chamber.Itcan be usedin turbochargedor superchargedenginetohelpavoiddetonation.

Dome Pistons head: These are the polar opposite of the dish pistons in concept, since they bubble in the center like astadium'sroof.Thisisachievedtomaximizetheusable surfaceareaonthepiston'stip.Lesscompressionmeans moresurface area.

Typeofpiston

Trunk piston: composite construction of these pistons consists of a thin sec.The tioned alloy steel piston crown and analuminumalloyskirt.Thesepistonsaremadeofthin,solid,andrigidmaterialsthatcanwithstandhightemperaturesandcorrosion.

Cross head piston: Piston crown, piston skirt, and piston rod (used in massive two-stroke engines) are attached to thecrosshead, which transferssidethrusttotheenginestructure.

Slipper piston: Aslipperpiston isa pistonfora petrolenginethathasbeenreduced insize andweightasmuch aspossible..Theyarereducedtothepistoncrown,supportforthepistonrings,andjustenoughofthepistonskirtremainingto leave twolands soastostopthepistonrocking in thebore.

Deflector piston: Deflector pistons are used in two-stroke engines with crankcase compression, where the gas flow withinthe cylinder must be carefully directed in order to provide efficient scavenging. With cross scavenging, the transfer (inletto the cylinder) and exhaust ports are on directly facing sides of the cylinder wall. To prevent the incoming mixturepassingstraight acrossfromoneport tothe other, thepistonhas araisedribonits crown.

Functionsofpiston:

- to transmit gas forces to the crank shaft through the connecting rod, to seal the combustion chamber against gas leakageto the crankcase - in combinationwith the piston rings - and prevent oil penetrationfrom the crankcase into thecombustion chamber.
- thechamberofcombustion.
- absorbingcombustionheatanddissipatingittothe cylinderlinerandcoolingoil.

Pistonmaterial:

Gray cast iron: It is named after the gray color of the fracture it forms, which is due to the presence of Graphite. It is usedfor housings where the stiffness of the component is more important than its tensile strength, Such as internalcombustion enginecylinderblocks.

Aluminum: Aluminumisametalthatislightweight,solid,flexible,non-corrosive,andalwaysrecyclable.Inthetransportation, manufacturing,packaging,andelectrical industries,aluminumis commonly used

Cast iron : Cast iron is an iron alloy containing 2 to 4% carbon, as well as varying percentages of silicon and manganese, aswellasamounts of sulfurand phosphorus.It'sproducedinablastfurnaceby reducing iron ore.

DesignProcedure

Designparameterforpiston:
CylinderBore (D)=110mm
PistonStroke (L)=120mm=0.12cm
PermissibleTensileStressforthematerialofthepiston=35N/mm²MaximumPressure(P) =5N/mm²
ConstantHeatSuppliedtoEngine(C)=0.05(Constant)
HigherCalorificValueoffuel(HCV)=42,000 KJ/Kg
Massofthefuelusedinkgperbrake powerper second=0.15kgIndicatedmeaneffectivepressure (pm)=0.75N/mm²
Speed(N)=200rpm
Mechanical efficiency = 80% = 0.8ThermalConductivity=46.6w/mc

ThicknessofPistonheat(th):Th=0.433*D*square root of(Pmax/ft)**Th =18mm**
Heatthroughthepiston:H=C+HCV+M+BP

$Ip=\frac{PmLAN}{60}$

$=\frac{0.75*0.73*9504*1000}{60}$

=14256
= 14.26KWBP=IP*NM
=14.26*0.8
=11.40KW
AREA(A):
$=(\pi/4)D^2$
=9503.31MM²
=9504MM²
FOURSTAKEDIESELENERGY

$n=\frac{N}{2}=\frac{2000}{2}$=1000CYCLES/MM

H=C+HCV+M+BP0.05*42,000*4.16*10^{-5}*11.40
=0.975KW

=995.90W
=996W
ThicknessofPistonHeadOnTheBasisOfHeadDisplacement:$Th=\frac{H}{12.56*k*(Tc-Te)}$

$=\frac{996}{12.56*46.6*220}$

=7.73*10^{-3}m
=7.73mm
=8mm
Takinglargeroftwovaluesgivenbyaboveequation

Th=18mmRadicalThickness:
(Pressureofgasonthecylinderwall(p_w)=0.042mpaAllowablebendingtensilestress (□t)=85mpato110mpa
=85 mpa
T1=D*squ.rootof(3pw/ft)
□1=4.23mm**T1=4.5mm**
AxialThickness:
□2=0.7t1tot1=0.7*4.5to4.5=3.15to4.5mm
□□**=4mm**
Widthofthetopland□□
=thto1.2th
=18to1.2*18
=18to21.6mm
b1=20mm
Widthofotherland□□

Widthofotherringland □2=0.75 □2to□2
=0.75*4to4
=3 to4
b2=3.5mm
Free ring(G)=3.□1To4.□1

=3*4.5to4*4.5
=13.5to18
=16mm
MaximumThicknessofBarrel□□
Radialdepthofpistonringgroove (b)b=□1+0.4
=4.5 +0.4
b=4.9mm
□3=0.03D+b+4.5
=(0.03*110)+4.9+4.5
□□=□□.□□□
Pistonwallthicknesstowardstheopenend:
□4=0.25+3+0to0.35+3

=0.25*12.7to0.35*12.7
=3.17to4.44mm
□□=4mm

Pistonpin:
□1=0.45*D
=0.45*110
=19.5mm
□0=□□□□□□□ Pressure
=20mmLoadonpinbeginspressure
= □0*□0*□1
=20*□0* 495
=990□□
MaximumloadonpistonduetogasPressure(fgmax)
=(π/4)*D^2*P
[p=maximumgaspressure=5N/MM^2]
=(π/4)*$(110)^2$*5
=47516.59N
Fgmax=□1□□□□
47516.59=990*□0
□0=47.99
Do=48mm
Insidediameter(□1)=0.6*do
=0.6*48
=28.8mm
□□= 29 mmPistondiameter
Maximum side thrust on cylinder due to gas pressure (p)**R**= μ* (π/4)D^2***P**
=4751.65N
BearingPressureonthepistonbarrel(□0)R=□0*D *404751.65=0.4*110*40
□0=107.99mm
=110mmLengthofpiston:
L=lengthof skirt(□1)+lengthof theringsection+topbarrel
=□□+[4+2+3□2]+□1
=110 +[4*4+3*3.5]+20
=156.5mm
= 156mm

Design of piston and important parameter:

Parameter	Dimension	Unit
Thicknessofpiston head(t_h)	18	mm
Radicalthickness(T1)	4.5	mm
Axialthickness(T2)	4	mm
Widthifthetopland(b1)	20	mm
Widthofotherland(b2)	3.5	mm
Inside diameter of piston(d1)	29	mm
Lengthofthepiston(L)	159	mm
Diameterofpiston(D)	110	mm

DesignOfPiston

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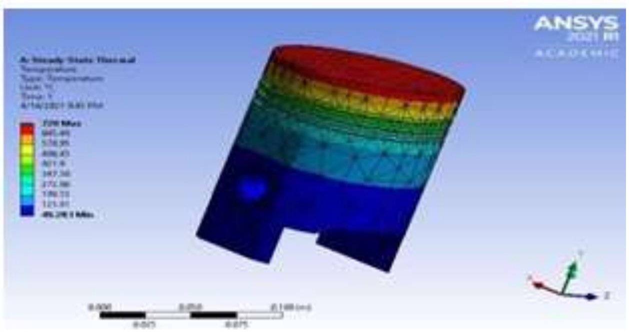
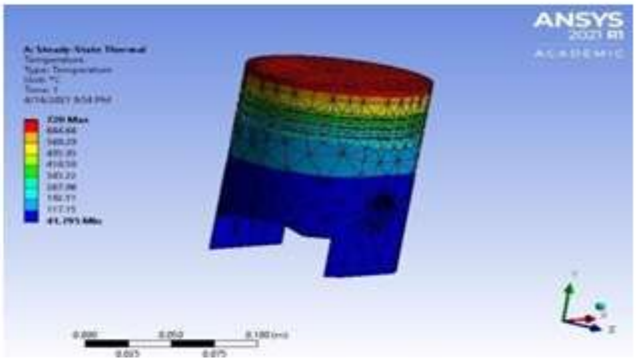
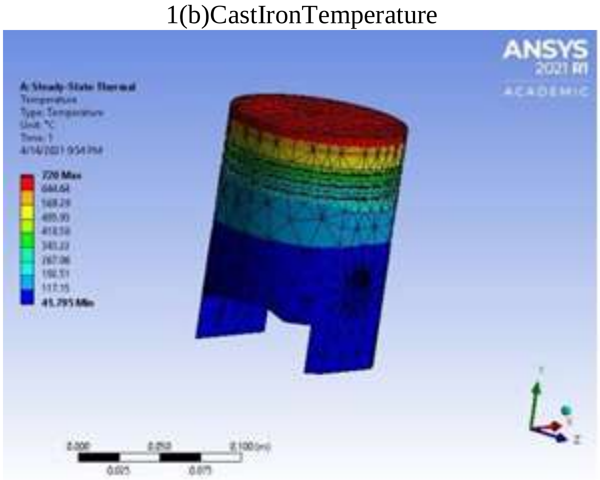


1(a)aluminumtemperature



1(b)CastIronTemperature



1(c) Gray Cast Iron Temperature

Temperature of all material for piston

No	Time(s)	Parameter	Aluminum	Cast iron	Gray cast iron
1	1	Minimum	174.34	49.283	41.795
2	1	Maximum	720	720	720
3	1	Average	416.64	295.2	206.31

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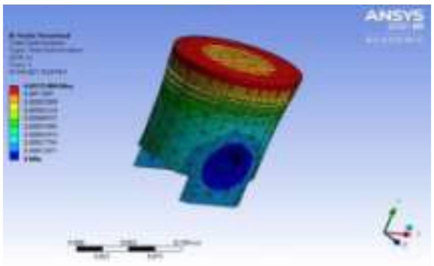
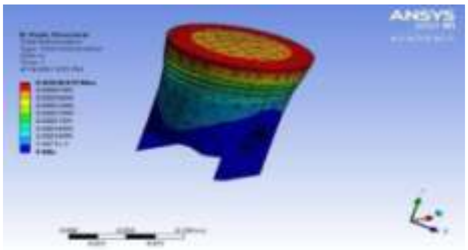
Deformation of Piston In Ansys:



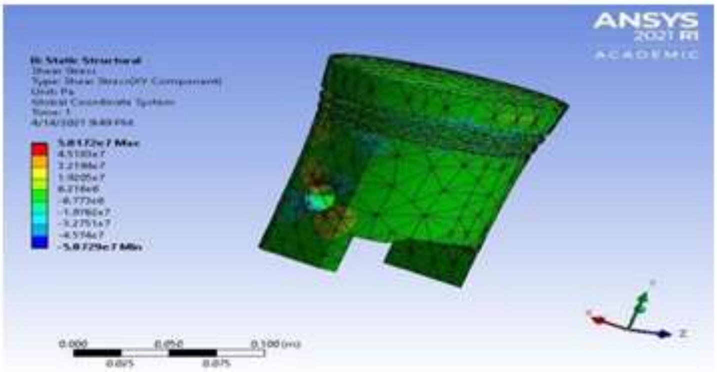
2(a)castirondeformation



2(b)Aluminiumdeformation

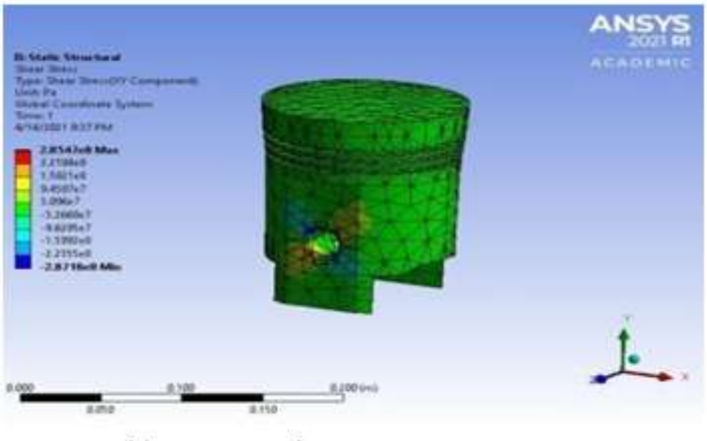
1(c)Gray cast iron deformation**Deformationtablefor allmaterial**

No	Time(s)	Parameter	Aluminum	Castiron	Gray castiron
1	1	Minimum	-2.8718e+008	-5.8729e+007	-5.5517e+007
2	1	Maximum	2.8547+008	5.8172e+007	5.6017e+007
3	1	Average	67371	41381	-73793

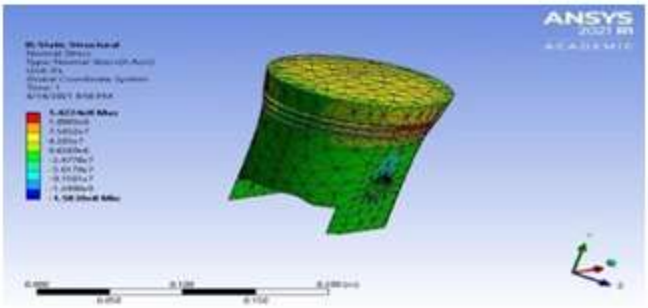


3(a)aluminumShearStress

(



3(b)CastIronShearStress



3(C)GrayCastIronShearStress

shear stress of all material for piston

No	Time(s)	Parameter	Aluminum	Castiron	Gray castiron
1	1	Minimum	0	0	0
2	1	Maximum	1.2484e-003	5.4719e-004	4.97479e-004
3	1	Average	5.3918e-004	1.8659e-004	1.0789e-004

II. CONCLUSION:

Thefundamental conceptsanddesignmethods concerned with four stroke dieselenginehavebeen studiedin this paper the results found by the use of the machine design book method are nearly equal to the actual dimensions.Hence the design for the piston made in solidworks and analysis in Ansys software for different material cast iron,aluminum and gray cast iron are studied in different conditiontotal deformation, under temperature and shear stressand comparison for this. At the end of the project we found that gray cast iron is best material for piston but it's manufacturing cost and weight of piston increase whilea luminumisthecheapestmaterialbutit'scannotwithstandhightemperature but we can usethealuminum alloytosolvesomeamount of this problem.

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