Single Cylinder Engine with Differential Gearbox

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December 07, 2021

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Description

A single-cylinder engine is a piston engine with only one cylinder, sometimes known. Motorcycles, scooters, go-karts, all-terrain vehicles, radio-controlled vehicles, portable tools, and garden machines all use this engine (such as lawnmowers, cultivators, and string trimmers). Single-cylinder engines are often simpler and more compact than multi-cylinder engines. Air cooling is frequently more effective for single cylinder engines than multi-cylinder engines due to the larger opportunity for airflow around all sides of the cylinder. When compared to liquid-cooled engines, this reduces the weight and complexity of air-cooled single-cylinder engines. Single-cylinder engines have greater levels of vibration and a more pulsing power delivery during each cycle. Because of the unequal power distribution, single-cylinder engines frequently require a larger flywheel than multi-cylinder engines, resulting in slower changes in engine speed.

The single cylinder engine produced in the project functions using a motor on its gear, which implements the work of the explosion (the work of the motor generally). The cam shaft is then connected to a worm shaft, which is in turn connected to a differential gearbox.

The job of the gearbox is to mainly reduce the speed and increase the torque. Additionally, it translates motion for one direction (the worm shaft), to two other shafts (the 2 sides of the spider gear shaft).

Note: An animation of the project is provided along with the project file to show the functionality of the assembly as to different views of each part.

Material Table:

Parts in the final Assembly	Quantity
Crank Shaft	1
Connecting rod	1
Connecting rod cover	1
Piston head	1
Piston Pin	1
Cam shaft	1
Small Gear (Engine side)	1
Large Gear (Gear Box side)	1
Shaft	1
Rocker Arm	2
Valve	2
Rod	2
Worm Shaft	1
Gearbox	1

Parts in Valve Subassembly	Quantity
Valve spring retainer	1
Retainer	1
Valve	1

Parts in Gearbox	Quantity
Main Shaft	1
Side gear	2
Spider Gear Shaft	1
Spider Gear	2
Helical Worm Gear	1
Angular contact Bearings ISO 15 ABB 0360	2
Angular contact Bearings ISO 15 ABB 4260	2
Angular contact Bearings ISO 15 ABB 8260	2
Angular contact Bearings ISO 15 ABB 4860	2
Socket set screw point	4

Motion Analysis

Simulating the motor at 650 RPM by placing a rotary motor at the crank shaft, the following displacement and velocity graphs of the piston are obtained:

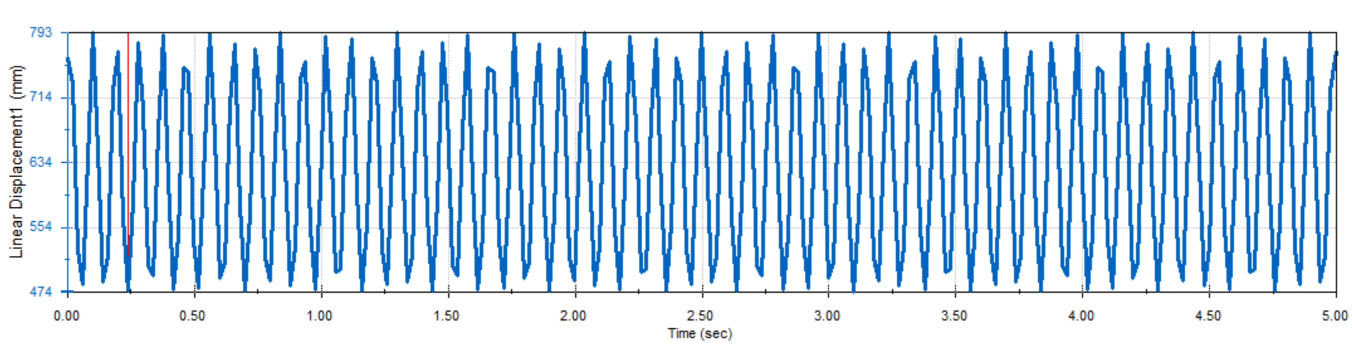


Figure 1 Displacement of the piston

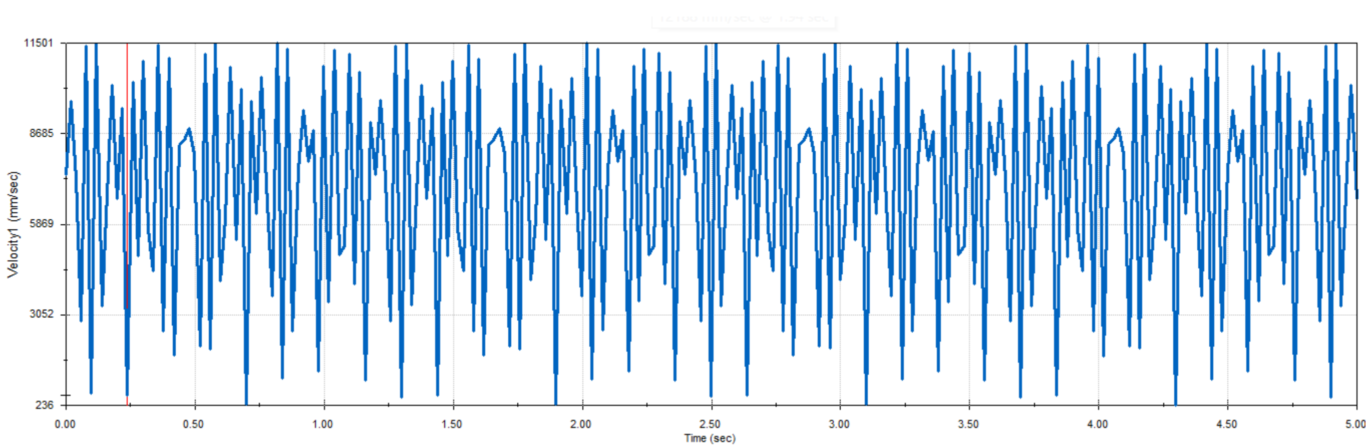


Figure 2 Velocity of the piston

Compression Ratio

Max displacement upwards = 793mm

Max displacement downwards = 474mm

Stroke=1267mm

Swept Volume = (Cylinder Diameter / 2) Squared x 3.14 x Stroke

= (240mm/2)^2*3.14*1267 = 57288672 mm^3

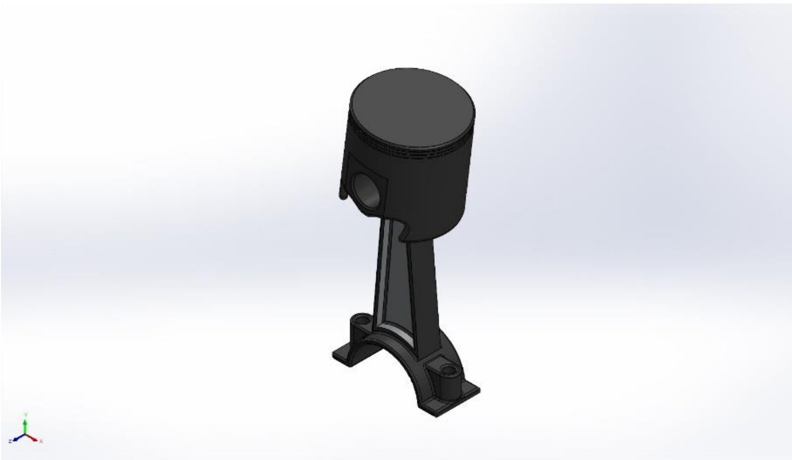
Clearance Volume = Piston Volume + Deck Volume + Gasket Volume + Combustion Chamber Volume

= 4460066 mm^3

Compression Ratio = (Swept Volume + Clearance Volume) / Clearance Volume

= 13.8448

Analysis



Simulation of Piston

Date: Wednesday, November 24, 2021
Designer: Iyad Baz
Study name: Static 1
Analysis type: Static

Description

Analysis of piston during expansion stroke

Study Results

The following analysis was done during the expansion stroke with a force that will yield a speed of 250 RPM.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	3.628e-11N/mm^2 (MPa) Node: 29068	7.893e-01N/mm^2 (Mpa) Node: 39812

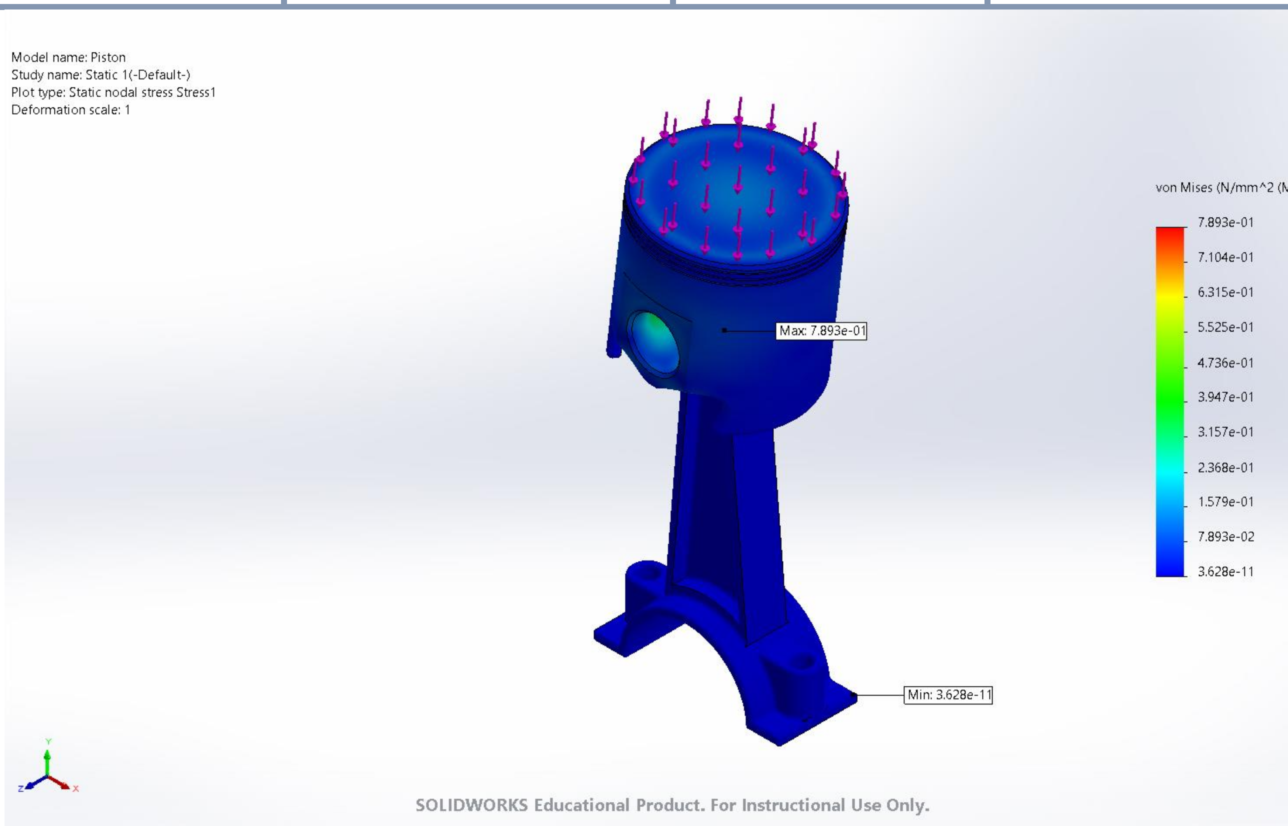


Figure 3 Stress Analysis

Piston-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 12	1.074e-03mm Node: 67247

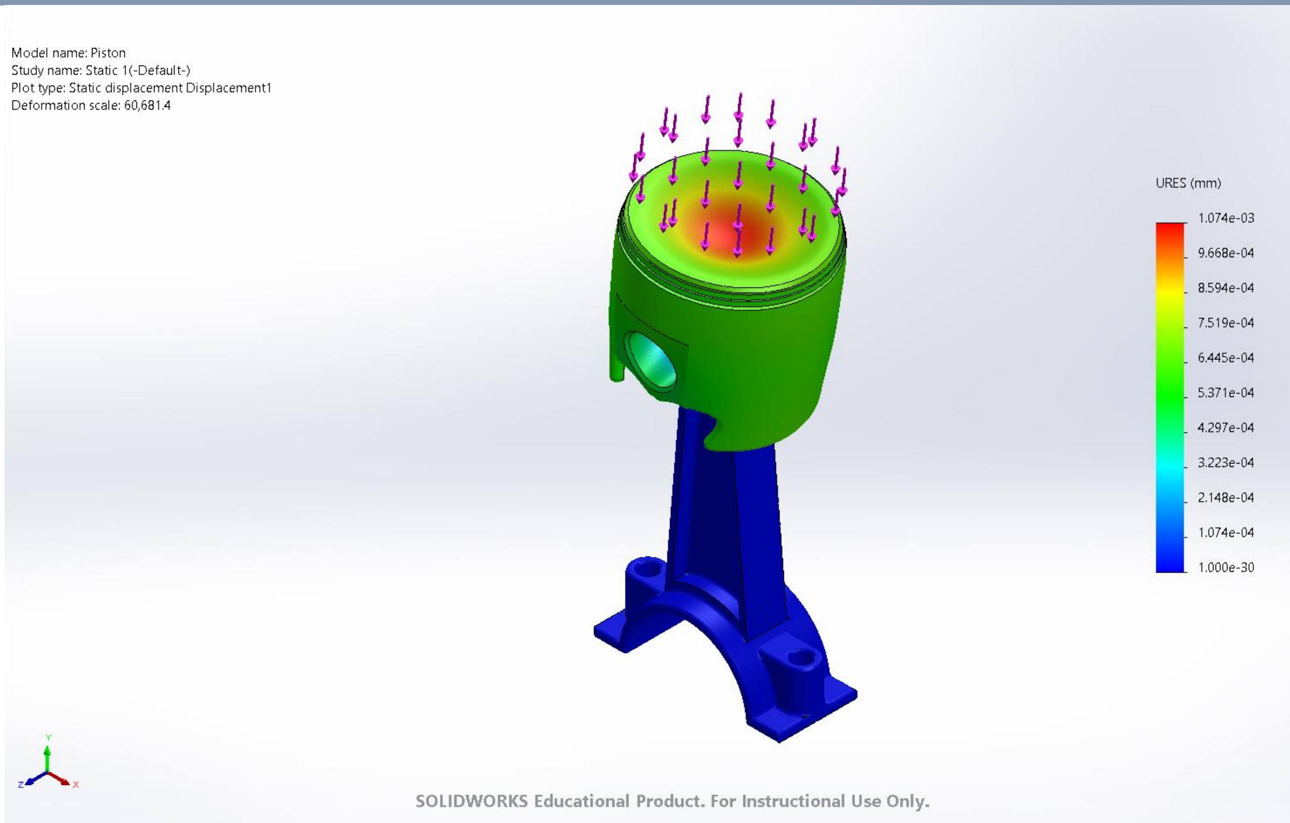


Figure 4 Displacement Analysis

Piston-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	3.733e-16	6.608e-06

		Element: 8138	Element: 23255

Figure 5 Strain Analysis

Piston-Static 1-Strain-Strain1

Name	Type	Min	Max
Factor of Safety1	Automatic	2.626e+02 Node: 39812	1.410e+13 Node: 22943

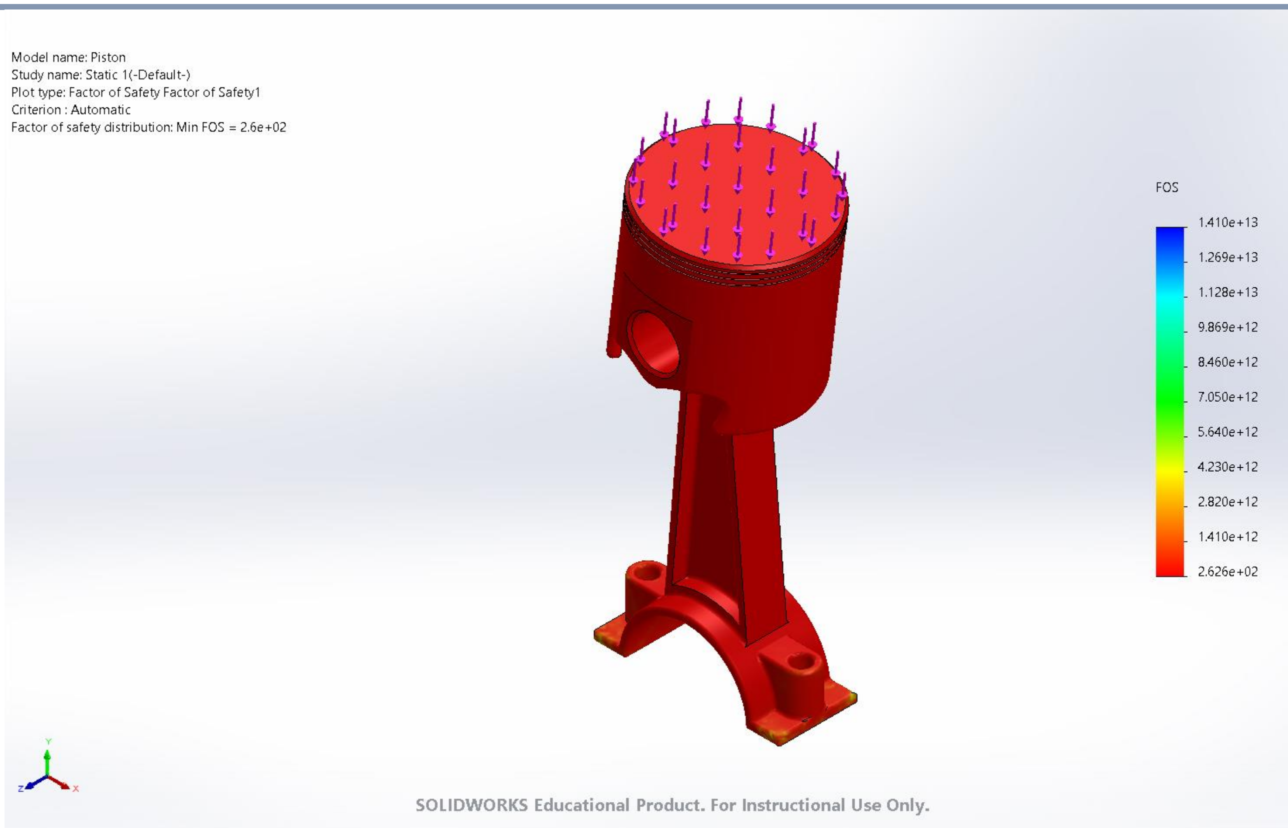


Figure 6 Factor of safety analysis

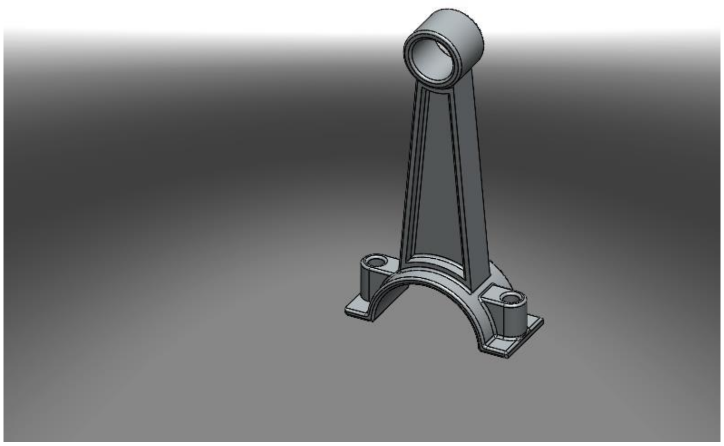
Piston-Static 1-Factor of Safety-Factor of Safety1

Sustainability Analysis

1060 Aluminum Alloy

Sustainability Report

Model Name:	Connecting Rod
Material:	1060 Alloy
Recycled content:	0.00 %
Weight:	5608.71 g
Manufacturing process:	Milled
Surface Area:	2.90E+5 mm²
Built to last:	10 years
Duration of use:	10 years



Manufacturing Region

The choice of manufacturing region determines the energy sources and technologies used in the modeled material creation and manufacturing steps of the product's life cycle.

Use Region

The use region is used to determine the energy sources consumed during the product’s use phase (if applicable) and the destination for the product at its end-of-life. Together with the manufacturing region, the use region is also used to estimate the environmental impacts associated with transporting the product from its manufacturing location to its use location.

Summary

Learn more about Life Cycle Assessment

Sustainability Report

Model Name:	Connecting Rod	Material:	1060 Alloy	Weight:	5608.71 g	Manufacturing process:
				Surface Area:	2.90E+5 mm²	Milled
		Recycled content:	0.00 %	Built to last:	10 years	
				Duration of use:	10 years	

Material	1060 Alloy	0.00 %
Material Unit Cost	2.20 USD/kg	

Manufacturing

Region:	Asia
Process:	Milled
Electricity consumption:	4.2E-4 kWh/lbs.
Natural gas consumption:	0.00 BTU/lbs.
Scrap rate:	9.9 %
Built to last:	10 years
Part is painted:	No Paint

Use

Region:	Asia
Duration of use:	10 years

Transportation

Truck distance:	1600 km
Train distance:	0.00 km
Ship distance:	6100 km
Airplane Distance:	0.00 km

End of Life

Recycled:	15 %
Incinerated:	2.0 %
Landfill:	83 %

Comments

Click here for alternative units such as 'Miles Driven in a Car'

SOLIDWORKS

Model Name:	Connecting Rod	Material:	1060 Alloy	Weight:	5608.71 g	Manufacturing process:
				Surface Area:	2.90E+5 mm²	Milled
		Recycled content:	0.00 %	Built to last:	10 years	
				Duration of use:	10 years	

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

Material:	77 kg CO_2e
Manufacturing:	2.7 kg CO_2e
Transportation:	0.537 kg CO_2e
End of Life:	0.200 kg CO_2e

80 kg CO_2e

Total Energy Consumed

Material:	960 MJ
Manufacturing:	27 MJ
Transportation:	7.2 MJ
End of Life:	0.860 MJ

990 MJ

Air Acidification

Material:	0.521 kg SO_2e
Manufacturing:	0.038 kg SO_2e
Transportation:	5.1E-3 kg SO_2e
End of Life:	4.7E-4 kg SO_2e

0.564 kg SO_2e

Water Eutrophication

Material:	0.017 kg PO_4e
Manufacturing:	1.5E-3 kg PO_4e
Transportation:	7.2E-4 kg PO_4e
End of Life:	7.0E-5 kg PO_4e

0.019 kg PO_4e

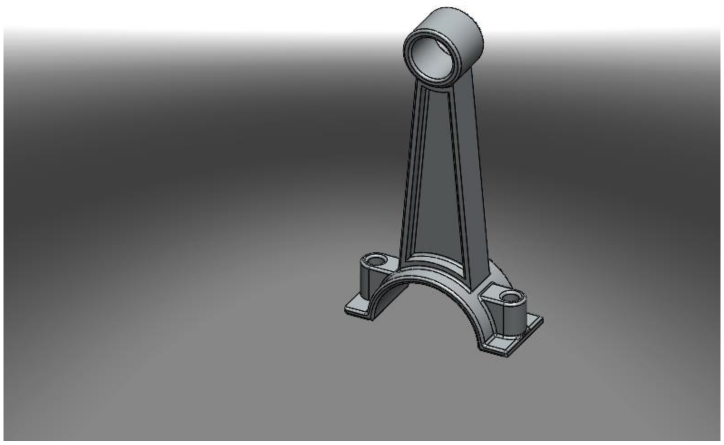
Material Financial Impact 12.30 USD

Comments

Click here for alternative units such as ‘Miles Driven in a Car’

Sustainability Report

Model Name:	Connecting Rod
Material:	1350 Alloy
Recycled content:	0.00 %
Weight:	5608.71 g
Manufacturing process:	Milled
Surface Area:	2.90E+5 mm²
Built to last:	10 years
Duration of use:	10 years



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The use region is used to determine the energy sources consumed during the product's use phase (if applicable) and the destination for the product at its end-of-life. Together with the manufacturing region, the use region is also used to estimate the environmental impacts associated with transporting the product from its manufacturing location to its use location.

Summary

Learn more about Life Cycle Assessment

Sustainability Report

Model Name:	Connecting Rod	Material:	1350 Alloy	Weight:	5608.71 g	Manufacturing process:	
				Surface Area:	2.90E+5 mm²	Milled	
		Recycled content:	0.00 %	Built to last:	10 years		
				Duration of use:	10 years		

Material 1350 Alloy 0.00 %

Material Unit Cost 2.20 USD/kg

Manufacturing

Region:	Asia
Process:	Milled
Electricity consumption:	0.00 kWh/lbs.
Natural gas consumption:	0.00 BTU/lbs.
Scrap rate:	0.00 %
Built to last:	10 years
Part is painted:	No Paint

Use

Region:	Asia
Duration of use:	10 years

Transportation

Truck distance:	1600 km
Train distance:	0.00 km
Ship distance:	6100 km
Airplane Distance:	0.00 km

End of Life

Recycled:	15 %
Incinerated:	2.0 %
Landfill:	83 %

Comments

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SOLIDWORKS

Sustainability Report

Model Name:	Connecting Rod	Material:	1350 Alloy	Weight:	5608.71 g	Manufacturing process:
				Surface Area:	2.90E+5 mm²	Milled
		Recycled content:	0.00 %	Built to last:	10 years	
				Duration of use:	10 years	

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

Material:	70 kg CO_2e
Manufacturing:	0.00 kg CO_2e
Transportation:	0.537 kg CO_2e
End of Life:	0.200 kg CO_2e

71 kg CO_2e

Total Energy Consumed

Material:	870 MJ
Manufacturing:	0.00 MJ
Transportation:	7.2 MJ
End of Life:	0.860 MJ

880 MJ

Air Acidification

Material:	0.474 kg SO_2e
Manufacturing:	0.00 kg SO_2e
Transportation:	5.1E-3 kg SO_2e
End of Life:	4.7E-4 kg SO_2e

0.480 kg SO_2e

Water Eutrophication

Material:	0.015 kg PO_4e
Manufacturing:	0.00 kg PO_4e
Transportation:	7.2E-4 kg PO_4e
End of Life:	7.0E-5 kg PO_4e

0.016 kg PO_4e

Material Financial Impact 12.20 USD

Comments

Click here for alternative units such as ‘Miles Driven in a Car’

	1060 Alloy	1350 Alloy
Cost	12.3 USD	12.2 USD
Carbon	80	71
Energy	990	880
Air	0.564	0.48
Water	0.019	0.016

Thus, it is best to use Aluminum 1350 Alloy in the manufacturing of the connecting rod.

Cost of Implementation

2 stroke engine – 1900$

https://www.alibaba.com/product-detail/2-Stroke-Engine-2-Stroke-Outboard_1600343967313.html?spm=a2700.galleryofferlist.normal_offer.d_title.31fe74b8hjv1pk&s=p

Gearbox – 165$

https://www.amazon.com/Yukon-Gear-YC-G40048044-Differential/dp/B0078UBPAE/ref=asc_df_B0078UBPAE?tag=bingshoppinga-20&linkCode=df0&hvadid=80607997944711&hvnetw=o&hvqmt=e&hvbmt=be&hvdev=c&hvlocint=&hvlocphy=&hvtargid=pla-4584207577282251&psc=1

Shaft – 514$

https://www.buyautoparts.com/blog/how-much-does-a-driveshaft-cost/

Rendered Images

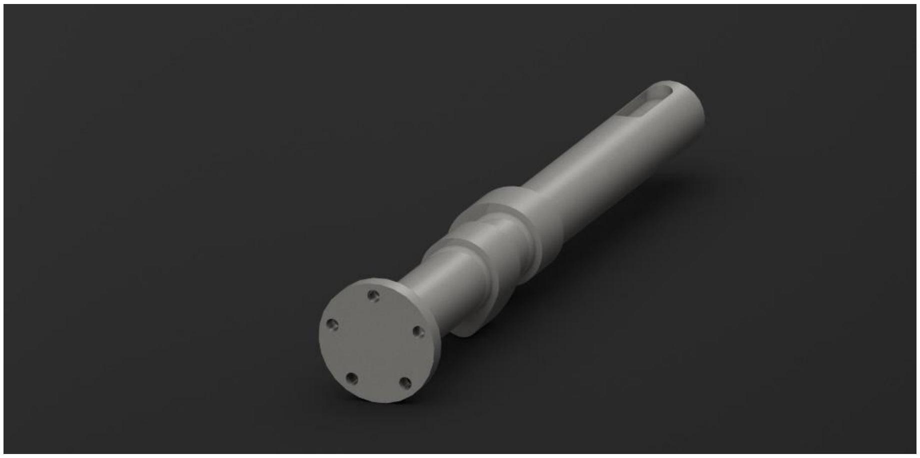

Figure 7 Cam shaft

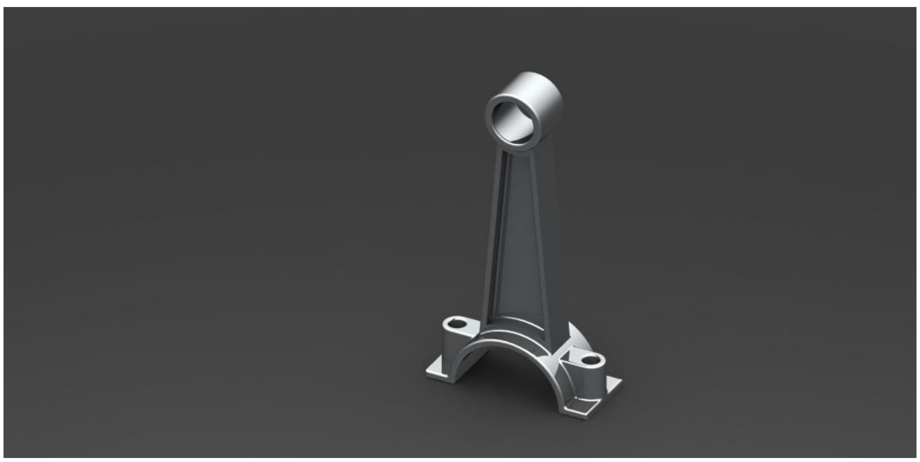

Figure 8 Connecting Rod

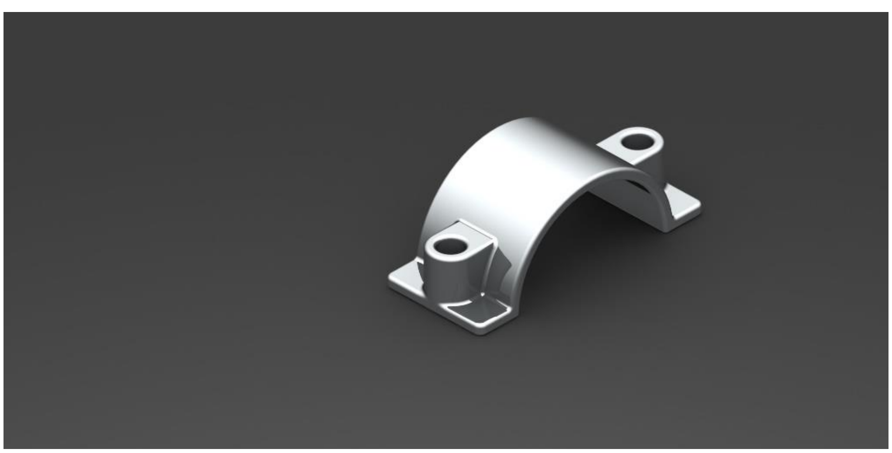

Figure 9 Connecting Rod Cover

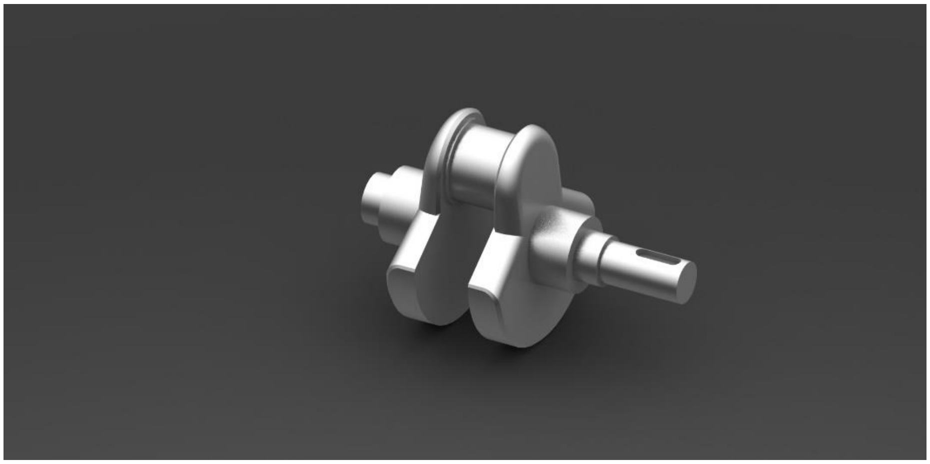

Figure 10 Crank Shaft

Figure 11 Helical Worm Gear

Figure 12 Large Engine Gear

Figure 13 Main Shaft

Figure 14 Side Gear

Figure 15 Small Engine Gear

Figure 16 Spider Gear Shaft

Figure 17 Worm Shaft

Figure 18 Piston Head

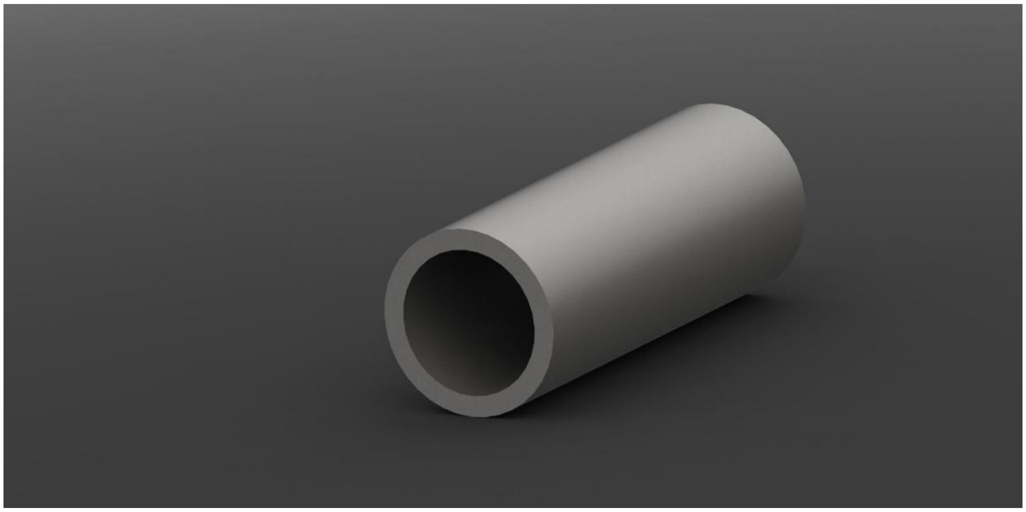

Figure 19 Piston Head

Figure 20 Rocker Arm

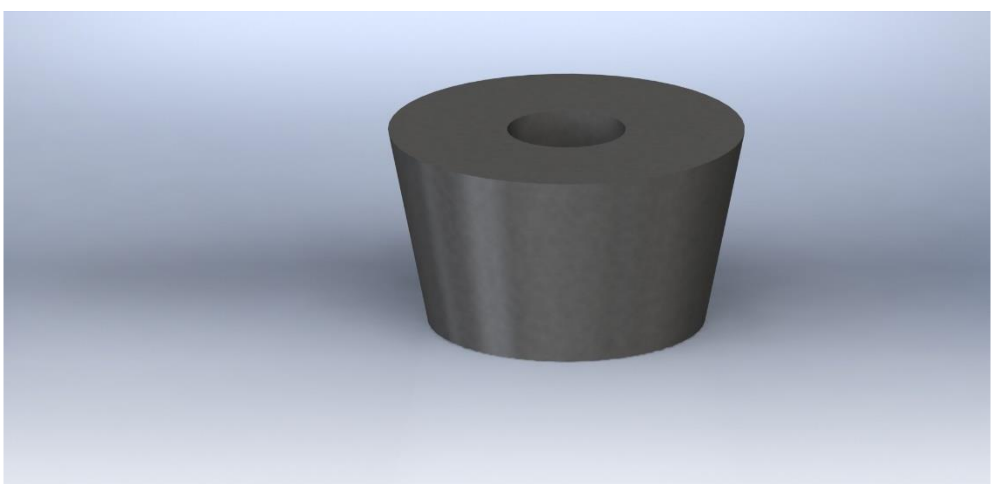

Figure 21 Valve Spring Retainer

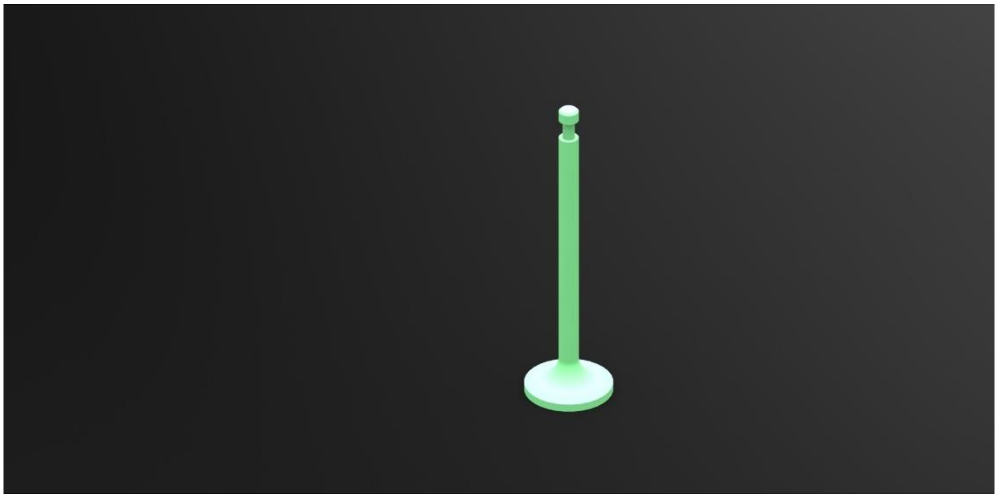

Figure 22 Valve

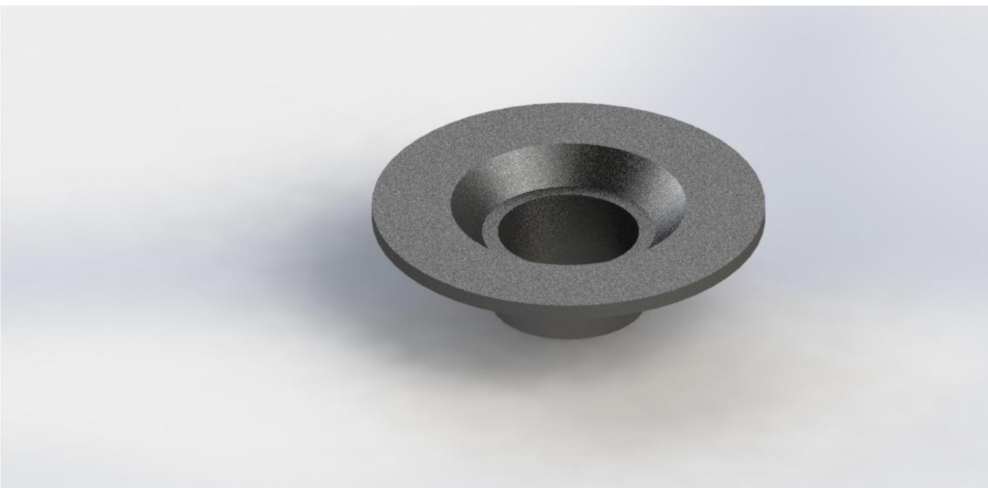

Figure 23 Retainer

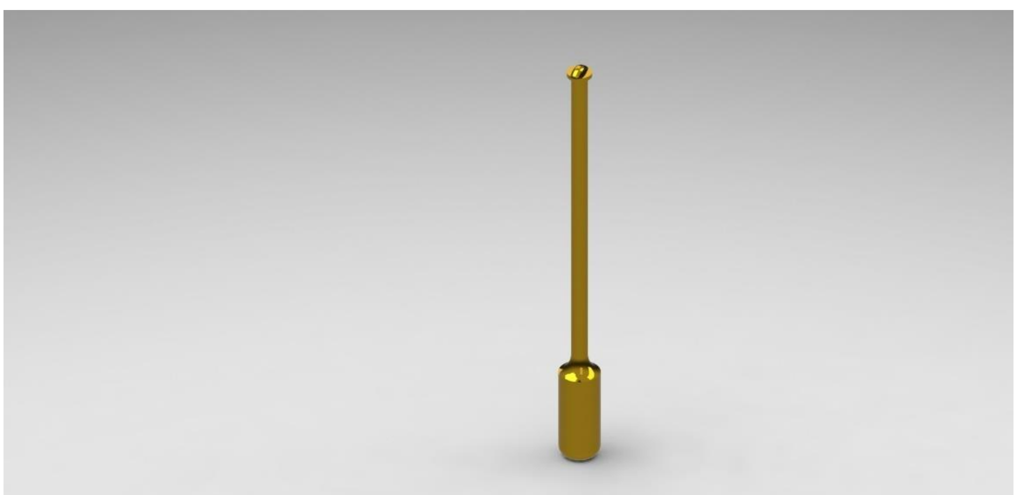

Figure 24 Rod

Figure 25 Shaft

Figure 26 Project Assembly

References

SolidWorks Tutorial â˜ º. (2017, May 31). *SolidWorks Tutorial #275: advanced differential gear box (+ speed reducer worm gear & spider gears)* [Video]. YouTube. https://www.youtube.com/watch?v=a3UcmOBPCiw

CAD CAM TUTORIAL. (2016, December 30). *Solidworks tutorial | Sketch Engine in Solidworks* [Video]. YouTube. https://www.youtube.com/watch?v=PiSMgTaHm9I