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**Product Design Specification**

**EMAE 360 - Fall 2018**

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# Product Identification

Darley Havidson is our team’s attempt at making a V-Twin engine. This V-Twin engine will be used to power touring-style motorcycles, which will be used for recreational and transportation purposes. Our focus is primarily on minimizing cost, and improving efficiency, safety and reliability of this engine.

* *Product Name*
  + Darley Havidson V-Twin engine for touring motorcycles
* *Basic Functions*
  + Powers a Touring-Style Motorcycle, used for recreational and transportation purposes
* *Special Features*
  + Minimized cost, focus on efficiency, safety, and reliability
* *Key Performance Targets:*
  + Idles at 800 RPM
  + Capable of 5000 RPM continuous service
  + Produces at least 80 horsepower and 90 lb-ft of torque
* *Service Environments*
  + Our engine will be designed for United States highway use
    - Designed to withstand rain, dust, grime
    - Operate in temperatures up to 110 degrees Fahrenheit
* *User Training:*
  + The engine will be operable by anyone with a motorcycle license

# Market Identification

## Target Market and Size

The target market for the engine will be the United States, with particular focus in Florida and the surrounding areas. This requires the engine to comply with all U.S. federal regulations and standards on motorcycle engines, and any local to Florida as well. To accommodate an expected increase in unit sales the target area will be expanded to the rest of the U.S. after the company gains a foothold in the market.

As of 2016 Florida has the second highest number of registered motorcycles, with 580,002 units.13 The natural scenery, long open roads, and year long riding season creates a great atmosphere for motorcycle riders. Florida also has an older population than many other states, making it especially promising for touring motorcycles, which is the bike type that the engine will be primarily produced for. This older population of riders who enjoy long rides through scenic roads will be the main demographic targeted for sale. With these types of riders in mind, the engine will be marketed as a higher-end, smooth, and efficient rider experience. As production increases Texas will also become a target market, having the third most motorcycle registrations in the country and similar characteristics to Florida, promoting a large consumer base for motorcycles.

## Anticipated Market Demand (units per year)

With launch planned in 2020, the expected sales for the first year is 7,500. In the second year, sales are expected to increase to 12,000, with another increase to 15,000 in the third year.

## Competing Products

All engines listed in the table below are possible competitors to bikes with the engine produced by this team.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Model Name** | **Price** | **Displacement** | **Engine Type** | **Horsepower** | **Torque (lb\*ft)** |
| BMW K 1600 | $25,595 | 1649cc | I-6 | 160 | 129 |
| Tiger Explorer | $19,800 | 1215cc | Inline 3 | 91 | 85 |
| BMW R1200RT | $19,586 | 1170cc | Flat twin | 109 | 89 |
| Honda Gold Wing | $26,700 | 1833cc | Flat 6 | 125 | 130 |
| Suzuki V-Strom 1000 ABS | $12,699 | 1037cc | V-twin | 113 | 103 |
| Kawasaki Vulcan 1700 Voyager ABS | $17,399 | 1700cc | V-twin | 124 | 108 |
| Harley-Davidson Electra Glide | $24,589 | 1746cc | V-twin | 126 | 111 |

Table 1 - Competitor Data 1,2,3,4,5

## Branding Strategy

The Darley Havidson team has created the logo pictured below:



There is always need for new designs in the motorcycle industry due to the constant upgrade of technology in engine design. There is significant competition in motorcycle engine design, with competitors such as Harley Davidson Motor Company, Honda Motor Company Limited, and Yamaha Motor Company Limited. There are similar V-Twin 4-stroke engines on the market currently from these different competitors.

Key Project Deadlines

## Time to Complete

13 weeks (from start date)

8 weeks (from Conceptual Design Review)

## Fixed Project Deadlines

Week 10 Deliverables: October 31

Week 11 Deliverables: November 5

Week 12 Deliverables: November 16

Week 13 Deliverables: November 19

Week 14 Deliverables: November 30

Detail Design Review: December 7

Final Report: December 14

# Physical Description

## Design Variable Values

We have currently decided on the following variable values in the current stage of our design:

* Number of cylinders: 2
* Configuration: 45 degree V-Twin
* Total Displacement: 1778 cc
* Compression Ratio: 10:1
* Bore/Stroke Ratio: 0.97
  + Bore: 4.0625 in
  + Stroke: 4.1875 in
* Redline RPM: 5641 RPM
* Air/Fuel Ratio: 14.75
* Combustion Chamber Geometry: Pent-roof
* Cooling System: Liquid Cooled
* Number of Valves Per Cylinder: 4
* Valve Timing: Single Overhead Cam (Single OHC)
* Injection Cycle: Direct

Constraints that determine known boundaries on some design variables

Our system and derived requirements form the basis for our design variable values. Below are the relevant design requirements for our system for each design variable.

* Number of Cylinders:
  + The system shall be a V-Twin cylinder configuration.
* Configuration:
  + The system shall be a V-Twin cylinder configuration.
* Total Displacement:
  + The system shall have over 1500 cc of total displacement between all cylinders
* Compression Ratio:
  + The system shall have a compression ratio between 9:1 and 10:1
* Bore/Stroke Ratio:
  + The system shall produce at least 80 horsepower and at least 90 ft-lb of torque
  + The system shall have over 1500 cc of total displacement between all cylinders
* Redline RPM
  + The system shall have a max rpm over 5000 rpm
  + The system shall produce at least 95 horsepower and 100 ft-lb of torque
* Air/Fuel Ratio
  + The system shall produce at least 95 horsepower and 100 ft-lb of torque
  + The system shall have a combustion efficiency of at least 0.9
* Combustion Chamber Geometry
  + The system shall have a combustion efficiency of at least 0.9
  + The system shall produce at least 80 horsepower and at least 90 ft-lb of torque
* Cooling System
  + The system shall produce at least 80 horsepower and at least 90 ft-lb of torque
  + The system shall have an operating life of at least 50,000 miles
* Number of Valves Per Cylinder
  + The system shall produce at least 95 horsepower and 100 ft-lb of torque
  + The system shall have a combustion efficiency of at least 0.9
* Valve Timing
  + The system shall have a combustion efficiency of at least 0.9
* Injection Style: Direct
  + The system shall be fuel injection and spark ignition

# Financial Requirements

## Pricing Policy over Life Cycle

* Target Manufacturing Cost
  + Our target maximum manufacturing cost is $3750
* Estimated retail price
  + A 30% profit margin to our manufacturing cost gives a retail price of $4875

## Warranty

* Our engine will have a warranty of 2 years or 25,000 miles, whichever comes first

## Capital Investment Required

* Estimated cost for production line: $5 million

## Rate of Return

* Our profit per unit sold is $1125
* This means that we will have to sell 4445 units to break even
* On our estimated sales plan, this puts our break even point in the first year of production

## 

# Life Cycle Targets

## Useful Life

The engine should have a useful life of at least 50,000 miles. This is achieved by following the proper maintenance protocol outlined in the service manual. Coolant is used as lubrication instead of water, as it contains additives that help prevent the build-up of rust and corrosion and thus extend the engine’s useful life.12

## Cost of Operation and Maintenance

* Oil change - $35
* Gas (cost per gallon in Florida, average) - $2.79017
* Coolant flush - between $71 and $11516
* Replace spark plugs - cost of part: $5 - $2014, cost of labor: approx. $75/hr if done at a shop
* General maintenance - tune-up costs average of $75/hr15

## Maintenance Schedule and Location

* The engine should be maintained after every 1500 miles or 1 year, whichever comes first
* Oil changes should occur every 3000 miles using correct oil
* It is recommended to take the vehicle to a local motor vehicle shop for maintenance to ensure proper inspection and top performance

## Reliability

System should have a factor of safety of at least 6. Critical parts include piston rings, fuel line, seals and bushings, and counterweights. Issues can easily arise in these areas which would lead to engine failure. However, with correct preventative maintenance, these critical parts should not fail under normal circumstances.

## End of Life Strategy

Our motorcycle engine should be made of at least 95% recyclable material.18 The method of calculating the percentage of recyclable material should comply to the ISO 22628:2002 standard for road vehicles. Our motorcycle engine will be able to be taken to designated collection center at end of life. Customer will pay fixed fee for recycling and can pay an additional fee for transportation of motorcycle to collection center. Ferrous and non-ferrous metals will be separated and reclaimed to be used in other products. Oil remaining in the engine will be removed and packaged for reuse. Plastics and composites will be removed and taken to landfill. Our design will minimize the amount of plastics and composites used to reduce our economic footprint as much as possible.11

# Social, Political and Legal Requirements

Our motorcycle engine will be launched with focus on 50-60 year olds located in Florida. It must be in accordance with the EPA regulations for Class 3 Highway Motorcycles. There are no opportunities to patent this product.

## 

## Safety and Environmental Regulations

As mentioned above, our engine must meet EPA standards for class 3 highway motorcycles for noise, emissions, and useful life. These guidelines can be seen in the chart below:

|  |  |
| --- | --- |
| Noise | Max 78 dBA (over 35 mph) |
| Emission | 0.8 g/km HC + NOx |
| 12.0 g/km CO |
| Useful Life | 5 years |

## Standards

Our design must meet the standards as defined by the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA).

## Safety and Product Liability

Predictable unintended uses for the product, safety label guidelines, applicable company safety standards.

* Unintended uses for engine: using the engine in a vehicle other than a motorcycle, using the engine to produce power, removing the engine without following proper safety protocols.
* Safety label guidelines
  + Warning: Engine may be very hot.
  + Warning: turn off engine while fueling. Only use 87-octane gasoline with this engine. Avoid sparks, heat and open flame while refueling.
  + See owners manual for proper use and instructions for removal of engine.

## Intellectual Property

Patents related to product. A few of the patents related to our product can be seen below.

* US5205244A: this patent is for a fuel injected motorcycle engine. Specifically, relating to the minimizing the noise in the fuel injection system.
* US4321978A: this patent is for the intake system of a v-shaped cylinder arrangement.
* US6854542B2: this patent is for a Harley Davidson heat deflector on a v-twin motorcycle engine.

# Manufacturing Specifications

## Manufacturing Requirements

The components of our motorcycle engine that we will be manufacturing include the engine block, the cylinder head, the cylinder sleeves, the crankshaft, the camshaft, the pistons, the connecting rods, the valves, the intake manifold, the exhaust manifold, and the oil pan. Each component will either be die cast or forged, while a majority of them will also require an additional machining process before assembly. The engine components that will be manufactured using the method of die casting include the engine block, the cylinder head, the camshaft, the pistons, the intake manifold, the exhaust manifold, and the oil pan. The engine components that will be manufactured using the process of forging include the crankshaft, the cylinder sleeves, the connecting rods, and the valves. The engine components that will required an additional machining process after their initial manufacturing process include the engine block, the cylinder head, the crankshaft, the camshaft, the pistons, the connecting rods, the valves, the intake manifold, the exhaust manifold, and the oil pan.

KEY: DC = Die Cast F = Forged M = Machined

|  |  |  |
| --- | --- | --- |
| Part | Processes | Justification |
| Engine Block | DC + M | Large component + Intricate shape + Mass production |
| Cylinder Head | DC + M | Large component + Intricate shape + Mass production |
| Cylinder Sleeves | F | Steel Alloy + Mass Production |
| Crankshaft | F + M | Strength + Stiffness + Mass Production |
| Camshaft | DC + M | Strength + Stiffness + Mass Production |
| Pistons | DC + M | Aluminum Alloy + Mass Production |
| Connecting Rods | F | Strength + Stiffness + Mass Production |
| Valves | F + M | Strength + Stiffness + Mass Production |
| Intake Manifold | DC + M | Large component + Intricate shape + Mass production |
| Exhaust Manifold | DC + M | Large component + Intricate shape + Mass production |
| Oil Pan | DC + M | Large component + Intricate shape + Mass production |

## Suppliers

The components of our motorcycle engine that we will be purchasing include any fasteners, the spark plugs, the timing chain, the starter motor, any pumps, the oil filter, the sprockets, the alternator, the valve springs, and the coolant hoses.

→ Suppliers:

|  |  |
| --- | --- |
| **Part** | **Supplier** |
| Fasteners | Fastenal |
| Spark Plugs | Summit Racing |
| Timing Chain | Sprocket Center |
| Starter Motor | DB Electrical |
| Pumps | Sun Motorcycle Parts |
| Oil Filter | K&N Engineering |
| Sprockets | Sprocket Center |
| Alternator | DB Electrical |
| Valve Springs | Peterson Springs |
| Coolant Hoses | Gates Corporation |

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# References

1 Triumph Motorcycles, Triumph Motorcycles. [Online]. Available: https://www.triumphmotorcycles.co.uk/motorcycles/adventure-and-touring/tiger/2018/tiger-explorer. [Accessed: 10-Oct-2018].

2 “Category:Touring motorcycles,” Wikipedia, 24-Sep-2014. [Online]. Available: https://en.wikipedia.org/wiki/Category:Touring\_motorcycles. [Accessed: 10-Oct-2018].

3 “The 12 Best Touring Motorcycles for the Wide Open Road,” BookMotorcycleTours.com. [Online]. Available: https://www.bookmotorcycletours.com/news/best-touring-motorcycles. [Accessed: 10-Oct-2018].

4 “V-Strom 1000 ABS,” Suzuki Cycles - Product Lines - Cycles. [Online]. Available: http://www.suzukicycles.com/Product Lines/Cycles/Products/V-Strom 1000/2016/DL1000A.aspx. [Accessed: 10-Oct-2018].

5 “2019 Electra Glide Ultra Classic Motorcycle,” Harley-Davidson USA. [Online]. Available: https://www.harley-davidson.com/us/en/motorcycles/2019/touring/electra-glide-ultra-classic.html. [Accessed: 10-Oct-2018].

6 “US5205244A - Air intake system for fuel injection type motorcycle engine,” Google Patents. [Online]. Available: https://patents.google.com/patent/US5205244A/en?oq=US5205244A. [Accessed: 10-Oct-2018].

7 “US4321978A - Intake system for motorcycle engines having V-shaped cylinder arrangement,” Google Patents. [Online]. Available: https://patents.google.com/patent/US4321978A/en?oq=US4321978A. [Accessed: 10-Oct-2018].

8 Google Patents. [Online]. Available: https://patents.google.com/?q=motorcycle engine&oq=motorcycle engine. [Accessed: 10-Oct-2018].

9 T. Moor, “How Much Does an Oil Change Cost?,” Angie's List | Join for FREE to see 10 Million Verified Reviews, 11-Oct-2016. [Online]. Available: https://www.angieslist.com/articles/how-much-does-oil-change-cost.htm. [Accessed: 10-Oct-2018].

10 A. Tsuji, Y. Nelson, A. Kean, and S. Vigil, “Recyclability Index for Automobiles .” [Online]. Available: https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1024&context=cenv\_fac. [Accessed: 10-Oct-2018].

11 “Motorcycle Recycling System to Be Introduced,” News from JAMA Asia. [Online]. Available: http://www.jama-english.jp/release/release/2004/040705.html. [Accessed: 10-Oct-2018].

12 J. Angelina and G. Cote, “Motorcycle Mileage: What Is Considered High Miles On A Bike?,” BestBeginnerMotorcycles, 16-May-2017. [Online]. Available: https://www.bestbeginnermotorcycles.com/considered-high-miles-motorcycle/#tab-con-7. [Accessed: 10-Oct-2018].

13 “Private and commercial U.S. vehicle registrations by state 2016 | Statistic,” Statista. [Online]. Available: https://www.statista.com/statistics/191011/registered-private-and-commercial-us-motor-vehicles-by-state-2009/. [Accessed: 10-Oct-2018].

14 “Shop for your Bike,” Harley-Davidson USA. [Online]. Available: https://www.harley-davidson.com/shop/motorcycle-spark-plugs. [Accessed: 10-Oct-2018].

15 “Spring Bike Tuneups: Costs? Do You Need One?,” Dave's Cheap Bikes Blog, 11-Sep-2017. [Online]. Available: http://www.davescheapbikes.com/spring-bike-tuneups-costs-need-one/. [Accessed: 10-Oct-2018].

16 “The Complete Coolant Flush Cost Guide,” Auto Service Costs. [Online]. Available: https://autoservicecosts.com/coolant-flush-cost/. [Accessed: 10-Oct-2018].

17 “US Average Gas Prices by State,” GasBuddy. [Online]. Available: https://www.gasbuddy.com/USA. [Accessed: 10-Oct-2018].

18 “2018 NORTH AMERICAN ENVIRONMENTAL REPORT.” Honda.