

Web 2.0 Hub Motor Manufacturing Document.
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The motor is an axial-gap brushless DC motor with two stators and one rotor disc. This description might not line up with the illustrations in the CDR presentation due to the rapid development of the system; calculations and discussions have led to further improved designs that couldn't be CADED in time.

The motor consists of the rotor disc attached to the axle by two steel cylinders which are welded in place. This axle sits on two conical automobile bearings which hold it in place between the two halves of the polycarbonate safety shell. The safety shell has holes for ventilation, and it doubles as the mount for the stator coils, which are embedded within it. It is held in place around the rotor disc by six steel arms, which in turn are retained by retaining rings and small bolts. The power cables are fed through the polycarbonate shell, and the Hall sensor feeds are run along the outside through a small hole at the very edge.

Sections to be manufactured include

1. The Rotor Disc

The steel plate should be the appropriate size as ordered. A 1-1/4" hole is milled through the center. Six evenly-spaced 1/4" holes are milled in the plate 1-5/8" from the center. The plate is coated with a thin layer of epoxy. Then the magnets are arranged radially with alternating polarity against the epoxy layer, with another thin layer of epoxy on every surface between magnets. Once the epoxy has cured, the process of adding magnets is repeated on the opposite side of the steel disc, with flux carried through the disc (i.e. no magnetic poles oppose through the disc).

2. The Driveshaft

The steel rod is cut to 7" in length. Six evenly-spaced 1/4" holes are milled through each of the steel cylinders. The first steel cylinder (3/8" thickness) is placed 2/3" from the end of the rod and welded in place. The rotor disc is then fitted onto the steel rod against the steel cylinder, and the six 1/4" bolts are placed through the holes in the cylinder and the disc. The second steel cylinder is then fitted onto the steel rod (axle), meshed with the bolts and pressed flush with the rotor disc. This second cylinder is

then welded into place. The retaining nuts are fixed to the ends of the bolts with lock-tite and tightened. The tapered bearings are then attached to the axle on either side of the cylinders, facing outwards.

3. The Coils

The stranded wire is laminated. It is then wound to shape on the winding machine. (18 coils are needed.) The recessions in the polycarbonate frame are half-filled with epoxy and the coils fitted solidly into place so that they protrude two millimeters above the surface of the polycarbonate.

4. The Shell

The steel frame is waterjetted from stock in six arms. The ends of each arm are rounded along the shortest axis so that their end surfaces fit radially with one another; a notch is cut into either side of the arms at both ends and a 3/16" hole milled and tapped between the notches. Two steel rings, one of outer diameter 4" and inner diameter 3-3/8" and one of outer diameter 2" and inner diameter 1-1/4" are waterjetted from stock. Six evenly spaced radial notches for the arms are cut into each ring. A hole 3/16" diameter is milled and tapped in each notch. The remaining five-inch piece of steel rod is keyed to fit into the AHPV suspension arm. The two halves of the polycarbonate shell with coil and frame grooves are milled out from stock. Four ridges are welded to the outside of each of the bearing rings, and the rings are embedded within the shell halves.

5. Electronics

The Hall Effect sensors are placed on the shell at a radius of five inches in between the radial segments of two coils and are placed every other coil thereafter around the frame. They are secured in place by epoxy, and their signal wires run to the outside of the motor. The power cables run through the shell through the cable hole and run in a circle at a radius of two inches to provide power to the coils. The cables also run along a groove to one side of the shell to provide power to the far stator.

To assemble the subsystems:

The axle with bearings is placed into the suspension-arm half of the motor so that the rotor surface and

stator coils are separated by a millimeter of air. Next the second half of the shell is placed on top so that the axle protrudes through the hole in the middle. The rotor bearings should be snugly seated. The polycarbonate shell halves should be aligned and fitted together. The steel arms are placed radially around the two halves, and the two retaining rings are fitted into place to hold the arms. All twelve bolts are inserted and the suspension-arm bar is inserted and bolted into place.

Assembly is paid at \$40/hr; Engineering is paid at \$75/hr; Machining is paid at \$50/hr.

Section	Rate	Qty	Total Cost
Design and Engineering			0
Engineer	\$75*	40**	3000
CAD workstation	\$55	10	550
Simulation workstation	\$55	30	1650
Rotor Disc			
Magnets	\$30	32	960
Disc	\$35	1	35
Epoxy	\$10	1	10
Assembly	\$40	4	160
Driveshaft			
Steel Rod	\$33	1	33
Bearings	\$65	1	65
Steel Cylinders	\$15	2	30
Bolts	\$15	1	15
Machining	\$50	2	100
Assembly	\$40	2	80
Coils			
Copper wire	\$12	36	432
Winding machine	\$75	3	225
Lamination	\$40	4	160
Epoxy	\$10	3	30
Assembly	\$40	5	200
Shell			
Polycarbonate	\$500	2	1000
Steel	\$150	1	150
Waterjetting	\$75	2	150
Other Machining	\$50	2	100

Assembly	\$40	4	160
Electronics			
Hall Sensors	\$2	9	18
Wiring and regulation	\$40	1	40
Assembly	\$40	1	40
Total Cost			9393

*Actually much less.

**Actually much more.