Deliverable 6

Engineering of Systems 1

Darrin Berrigan

Jacob Klaus

Nick Morris

Jared Raphael

4/27/15

Component #	Component Name	Category	Justification for catagory	Inhouse/Purchased	Weight of Component	Cost of component	Catalogue Hyperlink	Qty	Qty*Cost	Relative Cost
710 - 003	Spring	Analogy	Simple and standard component bought in a catalog	Purchased		$0.010	http://www.alibaba.com/showroom/spring-steel-price.html	1.00	$0.01	0.03%
710 - 005	Retainer	Analogy	Simple and standard component bought in a catalog	Purchased		$0.030	http://fairwayfasteners.com/washers	1.00	$0.03	0.10%
720 - 001	D-Handle bolt	Analogy	Simple and standard component bought in a catalog	Purchased		$0.127	http://www.nutsandbolts.com/bolts-hex-head-cap-screwsbolts-grade-8-coarse-c-31_158.html?page=1&sort=20a	1.00	$0.13	0.43%
720 - 002	D-Handle washer	Analogy	Simple and standard component bought in a catalog	Purchased		$0.004	http://www.nutsandbolts.com/washers-flat-washers-uss-coarse-zinc-c-41_236.html	1.00	$0.00	0.01%
720 - 003	D-Handle wingnut	Analogy	Simple and standard component bought in a catalog	Purchased		$0.167	http://www.nutsandbolts.com/nuts-wing-nuts-c-35_213.html	1.00	$0.17	0.56%
730 - 003	Shield Bolt	Analogy	Simple and standard component bought in a catalog	Purchased		$0.118	http://www.nutsandbolts.com/bolts-hex-head-cap-screwsbolts-grade-8-coarse-c-31_158.html?page=1&sort=20a	1.00	$0.12	0.39%
730 - 004	Shield Wingnut	Analogy	Simple and standard component bought in a catalog	Purchased		$0.167	http://www.nutsandbolts.com/nuts-wing-nuts-c-35_213.html	1.00	$0.17	0.56%
730 - 005	Blade Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.043	http://www.nutsandbolts.com/machine-screws-phillips-flat-head-machine-screws-c-37_468_214.html	2.00	$0.09	0.29%
730 - 006	Blade Nut	Analogy	Simple and standard component bought in a catalog	Purchased		$0.028	http://www.nutsandbolts.com/nuts-machine-screw-nuts-coarse-c-35_194.html	2.00	$0.06	0.19%
730 - 007	Shield Washer	Analogy	Simple and standard component bought in a catalog	Purchased		$0.008	http://www.nutsandbolts.com/washers-flat-washers-sae-fine-zinc-c-41_235.html	1.00	$0.01	0.03%
740 - 002	Switch	Analogy	Simple and standard component bought in a catalog	Purchased		$0.076	http://www.parts-express.com/spst-miniature-rocker-switch--060-670	1.00	$0.08	0.26%
740 - 003	Housing Screws	Analogy	Simple and standard component bought in a catalog	Purchased		$0.086	http://www.nutsandbolts.com/machine-screws-phillips-flat-head-machine-screws-c-37_468_214.html	5.00	$0.43	1.44%
740 - 004	Housing Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.086	http://www.nutsandbolts.com/machine-screws-phillips-flat-head-machine-screws-c-37_468_214.html	1.00	$0.09	0.29%
740 - 005	Throttle Trigger Spring	Analogy	Simple and standard component bought in a catalog	Purchased		$0.005	http://www.alibaba.com/showroom/spring-steel-price.html	1.00	$0.01	0.02%
740 - 008	Split Lume	Analogy	Simple and standard component bought in a catalog	Purchased		$0.360	http://ecustomhitch.com/i-6837457-curt-59826-convoluted-slit-loom-black-qty-per-foot.html?gclid=CN3h0fyR_sQCFfRr7Aod6RYAaQ	1.00	$0.36	1.21%
740 - 009	Zip ties	Analogy	Simple and standard component bought in a catalog	Purchased		$0.020	http://www.delcity.net/store/Standard-Cable-Ties/p_802443	2.00	$0.04	0.13%
750 - 002	Clamp Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.046	http://fairwayfasteners.com/hex-head-lag-screw-9333	1.00	$0.05	0.16%
750 - 003	Cover Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.036	http://fairwayfasteners.com/hex-head-lag-screw-9333	3.00	$0.11	0.36%
750 - 004	Anti Rotation Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.036	http://fairwayfasteners.com/hex-head-lag-screw-9333	1.00	$0.04	0.12%
750 - 005	Clamp Nut	Analogy	Simple and standard component bought in a catalog	Purchased		$0.033	http://fairwayfasteners.com/nuts/hex-2-way-locknut	1.00	$0.03	0.11%
760 - 002	Cover Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.016	http://fairwayfasteners.com/screws/combination-pan-head-self-tapping-screw-9325	1.00	$0.02	0.05%
760 - 003	Housing Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.013	http://fairwayfasteners.com/screws/combination-pan-head-self-tapping-screw-9325	2.00	$0.03	0.09%
770 - 002	Tank Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.016	http://fairwayfasteners.com/screws/combination-pan-head-self-tapping-screw-9325	2.00	$0.03	0.11%
780 - 003	Air Cleaner Bolts	Analogy	Simple and standard component bought in a catalog	Purchased		$0.107	http://fairwayfasteners.com/bolts/grade-2-carriage-bolt	2.00	$0.21	0.72%
785 - 001	Insulator Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.016	http://fairwayfasteners.com/screws/combination-pan-head-self-tapping-screw-9325	2.00	$0.03	0.11%
785 - 002	Washers	Analogy	Simple and standard component bought in a catalog	Purchased		$0.016	http://fairwayfasteners.com/washers/uss-flat-washer	2.00	$0.03	0.10%
785 - 003	Lock Washers	Analogy	Simple and standard component bought in a catalog	Purchased		$0.027	http://fairwayfasteners.com/washers	2.00	$0.05	0.18%
790 - 006	Small Black Washer	Analogy	Simple and standard component bought in a catalog	Purchased		$0.026	http://fairwayfasteners.com/washers/uss-flat-washer	1.00	$0.03	0.09%
794 - 002	Starter Housing Screw	Analogy	Simple and standard component bought in a catalog	Purchased		$0.053	http://www.fastenersplus.com/products/screws/machine-screws/12-24-x-1-2-steel-undercut-machine-screw-zinc-pkg-100.html	3.00	$0.16	0.53%
797 - 002	Muffler Screws	Analogy	Simple and standard component bought in a catalog	Purchased		$0.062	http://www.fastenersplus.com/1-4-20-x-3-4-steel-slotted-flat-machine-screw-zinc-pkg-100.html?utm_source=google_shopping&gclid=CPP7uPe1_sQCFdgdgQodLpg	2.00	$0.12	0.42%
790 - 005	Large Washer	Analogy	Simple and standard component bought in a catalog	Purchased		$0.050	http://www.fastenersplus.com/3-8-steel-sae-flat-washer-zinc.html	1.00	$0.05	0.17%
710 - 001	Bump Head Knob	Mechanical	Complex component made specifally for our product	Inhouse	0.028	$0.27		1.00	$0.27	0.89%
710 - 002	Inner Reel	Mechanical	Complex component made specifally for our product	Inhouse	0.054	$0.50		1.00	$0.50	1.67%
710 - 004	Outer Spool	Mechanical	Complex component made specifally for our product	Inhouse	0.068	$0.62		1.00	$0.62	2.09%
720 - 004	D-Handle	Mechanical	Complex component made specifally for our product	Inhouse	0.083	$0.75		1.00	$0.75	2.53%
730 - 001	Shield	Mechanical	Complex component made specifally for our product	Inhouse	0.150	$2.16		1.00	$2.16	7.25%
730 - 002	Blade	Mechanical	Complex component made specifally for our product	Inhouse	0.005	$0.04		1.00	$0.04	0.12%
740 - 001	Throttle Housing	Mechanical	Complex component made specifally for our product	Inhouse	0.083	$0.75		2.00	$1.51	5.07%
740 - 006	Throttle Trigger	Mechanical	Complex component made specifally for our product	Inhouse	0.005	$0.06		1.00	$0.06	0.21%
740 - 007	Throttle Cable	Mechanical	Complex component made specifally for our product	Inhouse	0.034	$0.14		1.00	$0.14	0.48%
750 - 001	Clutch Cover	Mechanical	Complex component made specifally for our product	Inhouse	0.094	$0.85		1.00	$0.85	2.86%
760 - 001	Rear Cover	Mechanical	Complex component made specifally for our product	Inhouse	0.145	$1.31		1.00	$1.31	4.38%
770 - 001	Fuel Tank Clip	Mechanical	Complex component made specifally for our product	Inhouse	0.004	$0.03		2.00	$0.06	0.21%
770 - 003	Fuel Tank	Mechanical	Complex component made specifally for our product	Inhouse	0.134	$1.21		1.00	$1.21	4.05%
770 - 004	Fuel Cap	Mechanical	Complex component made specifally for our product	Inhouse	0.023	$0.22		1.00	$0.22	0.74%
780 - 001	Air Cleaner Cover	Mechanical	Complex component made specifally for our product	Inhouse	0.063	$0.58		1.00	$0.58	1.94%
780 - 002	Air Cleaner Filter	Mechanical	Complex component made specifally for our product	Inhouse	0.001	$0.03		1.00	$0.03	0.09%
780 - 004	Intake Manifold	Mechanical	Complex component made specifally for our product	Inhouse	0.023	$0.22		1.00	$0.22	0.74%
785 - 005	Insulator	Mechanical	Complex component made specifally for our product	Inhouse	0.041	$0.38		1.00	$0.38	1.28%
785 - 006	Insulator Spacers	Mechanical	Complex component made specifally for our product	Inhouse	0.003	$0.03		2.00	$0.06	0.19%
790 - 001	Clutch Housing	Mechanical	Complex component made specifally for our product	Inhouse	0.084	$0.40		1.00	$0.40	1.33%
790 - 002	Clutch Friction Weights	Mechanical	Complex component made specifally for our product	Inhouse	0.059	$0.23		2.00	$0.47	1.57%
790 - 004	Center Clutch Mount	Mechanical	Complex component made specifally for our product	Inhouse	0.021	$0.09		1.00	$0.09	0.32%
791 - 001	Flexible Drive Shaft	Mechanical	Complex component made specifally for our product	Inhouse	1.017	$3.75		1.00	$3.75	12.58%
792 - 001	Carburator	Mechanical	Complex component made specifally for our product	Inhouse	0.106	$0.41		1.00	$0.41	1.36%
794 - 001	Starter Housing	Mechanical	Complex component made specifally for our product	Inhouse	0.496	$4.43		1.00	$4.43	14.85%

795 - 001	Cutting String Piece 1	Mechanical	Complex component made specifally for our product	Inhouse	.005kg/m	$0.11		1.00	$0.11	0.36%
795 - 002	Cutting String Piece 2	Mechanical	Complex component made specifally for our product	Inhouse	.005kg/m	$0.11		1.00	$0.11	0.36%
796 - 001	Piston	Mechanical	Complex component made specifally for our product	Inhouse	0.068	$0.27		1.00	$0.27	0.89%
796 - 002	Engine	Mechanical	Complex component made specifally for our product	Inhouse	0.966	$3.56		1.00	$3.56	11.95%
796 - 003	Spacer	Mechanical	Complex component made specifally for our product	Inhouse	0.012	$0.06		1.00	$0.06	0.20%
797 - 001	Muffler	Mechanical	Complex component made specifally for our product	Inhouse	0.633	$2.34		1.00	$2.34	7.85%
785 - 004	Carburator O-ring	Mechanical	Complex component made specifally for our product	Inhouse	0.001	$0.03		1.00	$0.03	0.09%
785 - 007	Insulator O-ring	Mechanical	Complex component made specifally for our product	Inhouse	0.001	$0.03		1.00	$0.03	0.09%
790 - 003	Clutch Springs	Mechanical	Complex component made specifally for our product	Inhouse	0.003	$0.03		2.00	$0.06	0.19%

Shield		
wall thickness	3.175	mm
mat'l thermal diffusivity	0.12	mm^2/s
# cavities	10	
setup time	1	hr
tonage	25	tons
Processing Time =	8.90	seconds
Injecton Molding Processing Cost =	$31.50	per hour

Assumptions:
1) plastic is ABS
2) 25-125 ton press
3) 1 hour of setup per run

Part Name	Sheild		Process	Injection Molding		Tonnage	25
Material	ABS		Model Complexity	Medium		Processing Cost ($/hr)	$31.50
Grams	150		Estimated Mold $/Cavity	11,000		Processing Time (hr/unit)	0.00247236689
Qty	1		Tool Cost Increase Factor	3		Projected Area (cm^2)	431.853975
Material Cost/kg	2.4		Life-Time Production Volumes	1,000,000		Number of Cavities	10
Scrap	1.2		Cycles/Run	10,000		Nominal Thickness (cm)	317.5
			Number of Set-Ups	25		Thermal Diffusivity (cm^2/s)	0.0012
			Mold Lifetime	200,000		Set-Up Time (hr)	1
			Number of Mold Replacement	5		Set-Up $/unit	0.0001
Material Cost ($/unit)	$0.43		Tooling Cost ($/unit)	$1.65		Processing Cost ($/unit)	$0.08
			Total $/unit	**$2.16**			

Analysis and Discussion:

1.1

The categorization process was straight forward for many of the components involved with the weedwacker. All of the components that we listed as analogy were something that we found could be purchased from a supplier online and were commonly used components. This included all of our screws and bolts which were standard sizes or could be found with a quick internet search. The washers and nuts were more components that we categorized as analogy-based due to the standard sizes of them. The other components that we categorized as analogy-based were zip ties, split lumes, lead wires, and the switch because they are all simple components that can be bought from a catalog. One difficulty we encountered in the categorization process was assigning a category for lead wires. We did not consider the lead wires as part of the electronic assembly, even though it deals with electricity, because it fits better into the analogy-based category since it is a simple wire. The rest of our components we categorized as mechanical sinced they are components that need to be made for the weedwacker specifically. Most of these components were straightforward to decide as mechanical but there were a few that we were unsure of initially. The components that we were unsure of included the carburetor O-ring, the insulator O-ring, and the clutch springs. The three of these we thought could be something that might be buyable from a catalog but in the end we decided that they would be mechanical because they were too specialized for our product to simply buy them in a catalog. Other than those three components we had complete agreement as a group to what category all the parts belonged to.

1.2

For the costing components of this project, we went through and found prices online for all of our analogy-based components. The online links used to support each decision are included in the table under Catalogue Hyperlink. We tried to find packages of about 100 and then divided to get a per unit price. By using this approach of dividing out wholesale packages, the cost of component resulted in a more realistic cost than a price. For the mechanical components, we weighed each part and applied the costing formulas provided. All mechanical components were treated as either steel or plastic for the cost formula. However there was one component, the bump knob, that included metal and plastic components in it and it was treated as plastic due to weight majority in favor of plastic. Another component, Starter Housing Assembly, included multi-filament material which was treated as plastic because plastic was the most expensive coefficient in the cost equation. For the purpose of this assignment, all mechanical components were assumed to be made in-house, though the team is aware that it might be in the best interest of the company to outsource some of these mechanical components. For the injection molded part, we chose to do a level 2 analysis on the Shield. We used the outline given in the lecture and found accurate information that was available online for each category. As mentioned previously, our product did not contain any electronic assemblies so there was no need to calculate cost for electrical components such as electronic PCB's.

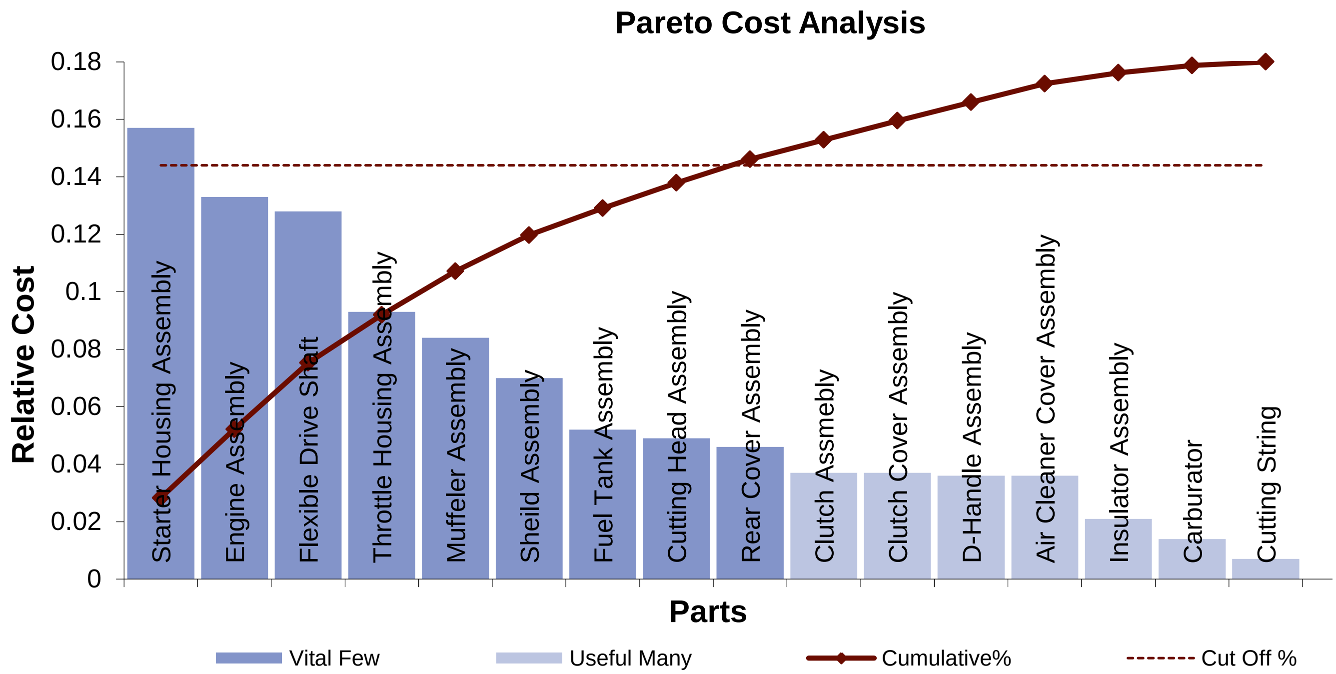
1.3

The total cost of each component was calculated based on it's unit cost and quantity from the categorization/costing process and the BOM. The relative cost of each component was calculated based on the total component cost over the overall cost of every component. The relative cost of each component was then grouped and summed together under the corresponding parts selected in the phase II QFD analysis. This allowed us to determine the relative cost of each part in comparison to its importance as calculated in the phase II QFD analysis.

Parts	Component #	Relative Cost
Cutting Head Assembly	710 - 001	0.91%
	710 - 002	1.70%
	710 - 003	0.03%
	710 - 004	2.13%
	710 - 005	0.10%
D-Handle Assembly	720 - 001	0.43%
	720 - 002	0.01%
	720 - 003	0.57%
	720 - 004	2.59%
Shield Assembly	730 - 001	5.34%
	730 - 002	0.12%
	730 - 003	0.40%
	730 - 004	0.57%
	730 - 005	0.29%
	730 - 006	0.19%
	730 - 007	0.03%
Throttle Housing Assembly	740 - 001	5.17%
	740 - 002	0.26%
	740 - 003	1.47%
	740 - 004	0.29%
	740 - 005	0.02%
	740 - 006	0.21%
	740 - 007	0.49%
	740 - 008	1.23%
	740 - 009	0.13%
Clutch Cover Assembly	750 - 001	2.92%
	750 - 002	0.16%
	750 - 003	0.37%
	750 - 004	0.12%
	750 - 005	0.11%
Rear Cover Assembly	760 - 001	4.47%
	760 - 002	0.0005
	760 - 003	0.09%
Fuel Tank Assembly	770 - 001	0.22%
	770 - 002	0.11%
	770 - 003	4.14%
	770 - 004	0.76%
Air Cleaner Assembly	780 - 001	1.98%
	780 - 002	0.09%
	780 - 003	0.73%
	780 - 004	0.76%
Insulator Assembly	785 - 001	0.11%
	785 - 002	0.11%
	785 - 003	0.18%
	785 - 004	0.09%

Part	Importance	Cost/Worth	Cost
Cutting Head Assembly	11.90%	0.41	$1.42
Engine Assembly	26.34%	0.51	$3.89
Flexible Drive Shaft	16.76%	0.77	$3.75
Fuel Tank Assembly	1.77%	2.95	$1.53
Clutch Assmebly	8.19%	0.46	$1.09
Sheild Assembly	4.13%	1.68	$2.03
Muffeler Assembly	4.87%	1.73	$2.46
Starter Housing Assembly	6.00%	2.62	$4.58
D-Handle Assembly	5.65%	0.64	$1.05
Throttle Housing Assembly	1.92%	4.83	$2.71
Rear Cover Assembly	1.62%	2.85	$1.35
Air Cleaner Cover Assembl	1.51%	2.36	$1.04
Insulator Assembly	3.04%	0.68	$0.61
Clutch Cover Assembly	0.89%	4.13	$1.07
Carburator	2.86%	0.49	$0.41
Cutting String	2.55%	0.28	$0.21

	785 - 005	1.31%					
	785 - 006	0.19%					
	785 - 007	0.09%					
	790 - 001	1.36%					
	790 - 002	1.60%					
	790 - 003	0.19%					
	790 - 004	0.32%					
	790 - 005	0.17%					
Clutch Assembly	790 - 006	0.09%					
Flexible Drive Shaft	791 - 001	12.84%					
Carburator	792 - 001	1.39%					
Starter Housing Assembly	794 - 001	15.16%					
	794 - 002	0.54%					
	795 - 001	0.36%					
Cutting String	795 - 002	0.36%					
	796 - 001	0.91%					
	796 - 002	12.20%					
Engine Assembly	796 - 003	0.21%					
	797 - 001	8.01%					
Muffler Assembly	797 - 002	0.43%					

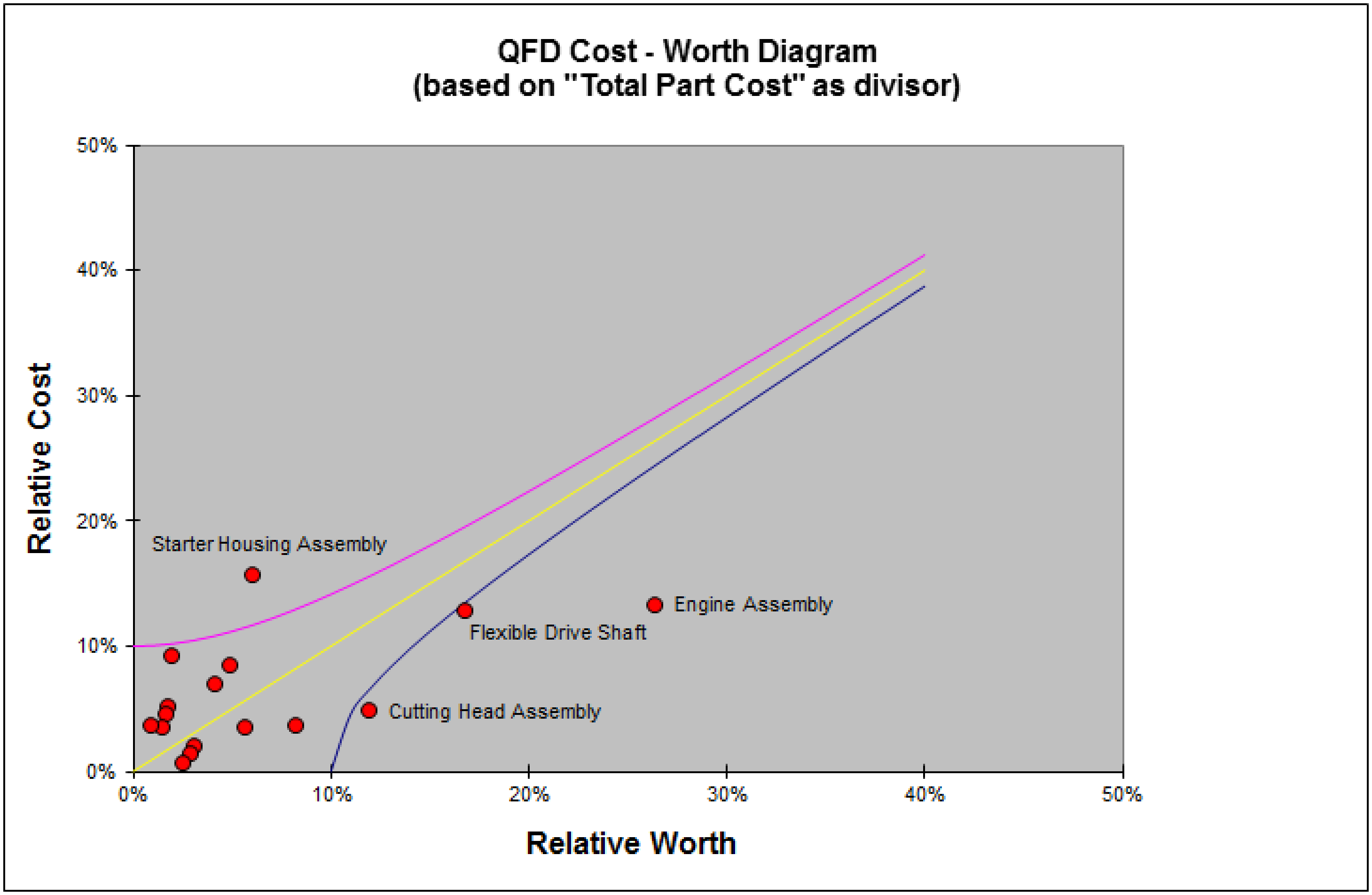


The first 9 Parts cover 81.2 % of the Total Relative Cost

Cumulative Percentage Cutoff: 80%

#	Parts	Relative Cost	Cumulative%
1	Starter Housing Assembly	0.157	15.7%
2	Engine Assembly	0.133	29.0%
3	Flexible Drive Shaft	0.128	41.8%
4	Throttle Housing Assembly	0.093	51.1%
5	Muffeler Assembly	0.084	59.5%
6	Sheild Assembly	0.07	66.5%
7	Fuel Tank Assembly	0.052	71.7%
8	Cutting Head Assembly	0.049	76.6%
9	Rear Cover Assembly	0.046	81.2%
10	Clutch Assmebly	0.037	84.9%
11	Clutch Cover Assembly	0.037	88.6%
12	D-Handle Assembly	0.036	92.2%
13	Air Cleaner Cover Assembly	0.036	95.8%
14	Insulator Assembly	0.021	97.9%
15	Carburator	0.014	99.3%

Part #	Part	Part Cost	Part Relative Worth *	Part Relative Cost	Cost / Worth	
			* *From QFD Phase II*			
1	*Cutting Head Assembly*	*$1.42*	*12%*	4.9%	0.41	0.04
2	*Engine Assembly*	*$3.89*	*26%*	13.3%	0.51	0.13
3	*Flexible Drive Shaft*	*$3.75*	*17%*	12.8%	0.77	0.12
4	*Fuel Tank Assembly*	*$1.53*	*2%*	5.2%	2.96	0.05
5	*Clutch Assmebly*	*$1.09*	*8%*	3.7%	0.46	0.03
6	*Sheild Assembly*	*$2.03*	*4%*	7.0%	1.68	0.06
7	*Muffeler Assembly*	*$2.46*	*5%*	8.4%	1.73	0.08
8	*Starter Housing Assembly*	*$4.58*	*6%*	15.7%	2.61	0.15
9	*D-Handle Assembly*	*$1.05*	*6%*	3.6%	0.64	0.03
10	*Throttle Housing Assembly*	*$2.71*	*2%*	9.3%	4.84	0.09
11	*Rear Cover Assembly*	*$1.35*	*2%*	4.6%	2.86	0.04
12	*Air Cleaner Cover Assembly*	*$1.04*	*2%*	3.6%	2.36	0.03
13	*Insulator Assembly*	*$0.61*	*3%*	2.1%	0.69	0.02
15	*Clutch Cover Assembly*	*$1.07*	*1%*	3.7%	4.11	0.03
15	*Carburator*	*$0.41*	*3%*	1.4%	0.49	0.01
16	*Cutting String*	*$0.21*	*3%*	0.7%	0.28	0.00
	Total Part Cost	$29.20	100%	1.00		



2.1

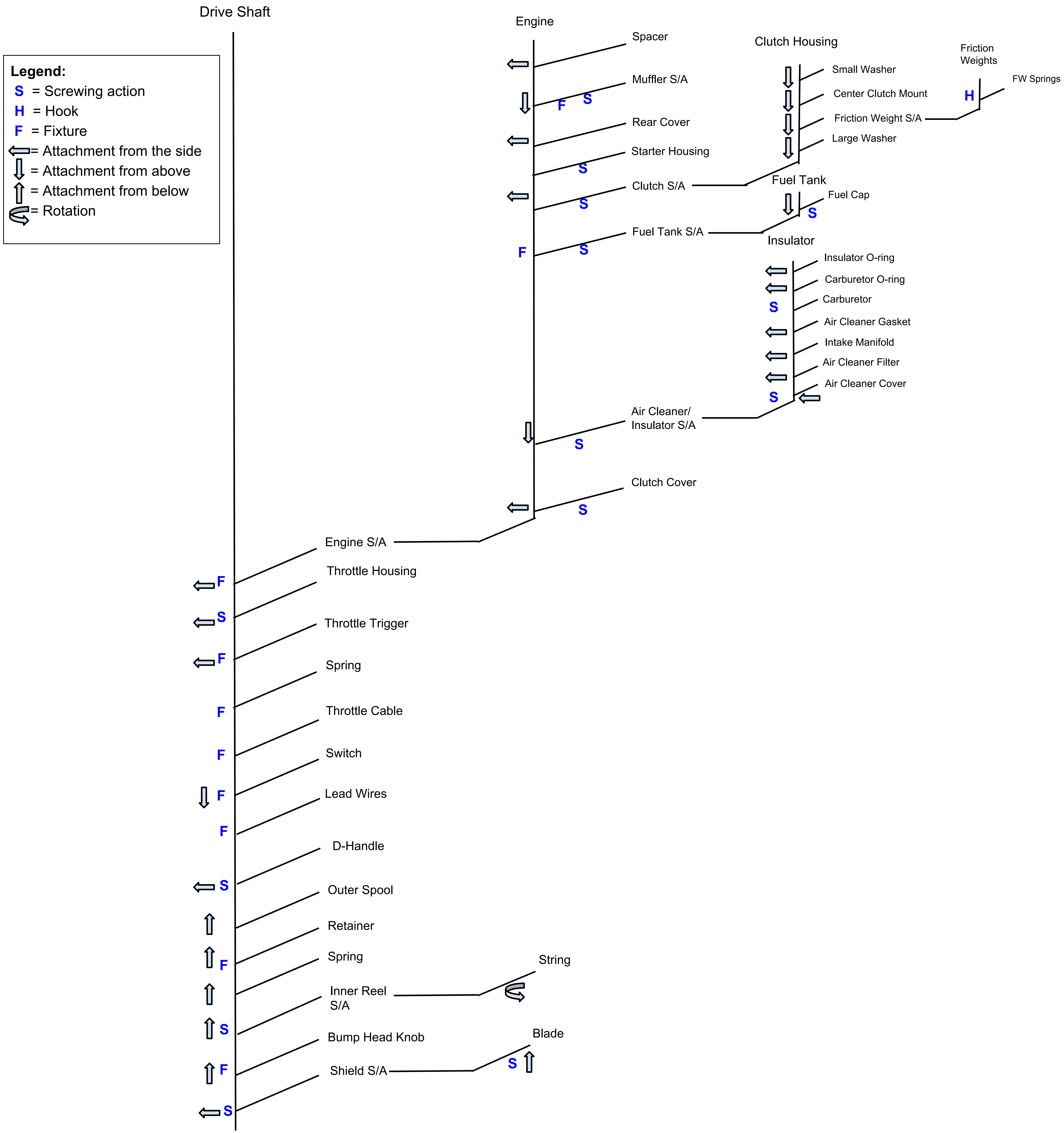
In order to complete our cost worth analysis we needed to add the rest of our parts to our phase II QFD to give us the worth of each assembly. The reason that these parts weren't initially included in our QFD was because they didn't have any correlation to the original engineering metrics that we came up with to meet our customer requirements. Before we could do this we needed to add our additional engineering metrics that we determined from deliverable 5, into our phase I QFD. We added heat emission, engine torque, drive shaft yield strength, attachment capability, and RPM to quantify key functional elements that our original engineering metrics couldn't. These engineering metrics were an important addition because they tied into the new parts that we added to our phase II QFD diagram. This re-evaluation of our phase I and phase II QFD was an important step in the cost-worth analysis of the weedwacker parts. The cost-worth for each part was calculated using the relative costs of each component from the costing table and importance weights from the phase II QFD. Due to the grouping of components into the parts as identified in the phase II QFD, a separate table was made to show the relative worth and cost-worth ratio for each part. The parts with the highest cost-worth ratio were Throttle Housing Assembly, Clutch Cover Assembly, and Fuel Tank Assembly. The parts with the lowest cost-worth ratio were Cutting String, Cutting Head Assembly, and Clutch Assembly. These are parts to focus on when making redesign changes for an optimal cost-worth ratio of 1.

2.2

Based on our cost-worth diagram, the part that was a candidate for cost reduction was the starter housing assembly. This was the only component that we calculated to violate the cost-worth upper bound. The parts that are candidates for value enhancement are the cutting head assembly, the flexible drive shaft, and the engine assembly. These parts were considered because they violated the lower bound of our cost-worth diagram. The other parts within the bounds of our cost-worth diagram didn't have labels attached to them due to the majority of them being clustered together which would make the labels mix together and be difficult to read. The starter housing assembly result was expected to fall outside the upper bound because it was a large complex part so the cost was expected to be high but the only functionality of the starter housing assembly was to start the product. For the cutting head assembly, all of the components were simple and cheap to make which is why the product had a low cost to worth ratio. For the flexible drive shaft, the cost-worth ratio was as expected since the worth of the drive shaft is high and the cost is also substantial since the drive shaft is a large part and it is made of steel. The only reason that we think the cost is lower than the worth is because of how simple the drive shaft is from a structural standpoint, resulting in a lower bound violation. For the engine assembly, the worth aspect of it makes sense since the engine is highly correlated with a large number of our engineering metrics such as Total Weight, Vibration, Product Lifespan, Noise Level, Fuel Emissions, Engine Displacement, Engine Torque, and RPM. The cost is lower than expected since the engine is a complex component with many parts. For the rest of the components the results make sense because the parts contribute relatively small amounts to the overall worth and they were all simple parts which explains the low cost.

2.2.3

In the Pareto Cost Analysis we found that the starter housing assembly, engine assembly, and flexible drive shaft were the most expensive parts in that order. These three same products are also found to have sub-optimal cost-worth ratios in the cost-worth diagram. The pareto cost analysis is a one dimensional analysis and only shows the relative cost of the part compared to the overall cost of the product. This doesn’t take into account how important the part is to the overall function of the product. The cost-worth is a two dimensional analysis and takes into account the worth of the product as well and helps us make better decisions for redesign. For example the pareto chart tells us to decrease the cost of the flexible drive shaft and the engine assembly whereas the cost-worth diagram tells us that we need to increase the value of the flexible drive shaft and the engine assembly. Another difference is that the pareto chart tells us that we need to make changes to nine parts which cover 80% of the overall cost while the cost-worth diagram tells us that we only need to focus on making changes to four parts since the other parts are already in the optimal range.


Legend:
S = Screwing action
H = Hook
F = Fixture
= Attachment from the side
= Attachment from above
= Attachment from below
= Rotation
Drive Shaft
Engine
Spacer
Muffler S/A
Rear Cover
Starter Housing
Clutch S/A
Fuel Tank S/A
Clutch Housing
Small Washer
Center Clutch Mount
Friction Weight S/A
Large Washer
Friction Weights
FW Springs
Fuel Tank
Fuel Cap
Insulator
Insulator O-ring
Carburetor O-ring
Carburetor
Air Cleaner Gasket
Intake Manifold
Air Cleaner Filter
Air Cleaner Cover
Air Cleaner/ Insulator S/A
Clutch Cover
Engine S/A
Throttle Housing
Throttle Trigger
Spring
Throttle Cable
Switch
Lead Wires
D-Handle
Outer Spool
Retainer
Spring
Inner Reel S/A
String
Bump Head Knob
Shield S/A
Blade

3.1

From developing our fishbone diagram we found that the shaft of our weedwacker acts as the base of our product. This is the easiest component to fix initially as it is the largest. From here, the rest of the subassemblies and components can be attached, screwed, hooked, or fixed into place. The Fishbone Diagram visually shows the progression of the assembly from one end of the weedwacker, the engine, to the opposite end, the grass shield. When thinking about the orientation of how each component attaches, we intuitively thought about how the base to which the component is attaching to, would be orientated and then based our decision on that. We assumed the drive shaft would be horizontally fixed on a flat surface so the engine could then be attached from the side. Through the progression of creating the diagram and from the end diagram, we found that many of the components that we initially considered subassemblies were in fact components that would be assembled onto the base with each other and not assembled separately and then attached to the base as one part. The development of the fishbone also showed us that many of the components needed to be attached together in order for them to stay attached to the base component. One example of this is the throttle housing which is two halves that need to be placed around the drive shaft and then screwed to each other. Neither one of the halves would stay in place without the other. We went through this logic for the entire progression of the diagram to create a correct representation of assembling our weedwacker. It was beneficial for our team to think about how the weedwacker can be assembled in the most efficient way possible. It made us realize that designing for assembly is an important aspect that ties directly into the total cost of the product. The fishbone diagram assembly logic in hand with the cost-worth analysis will be useful tools in the redesign of our product.

Drive Shaft Assembly

Time Factors (seconds)

No.	Part/Operation Description	A End-to-End Alignment	B Rotational Orientation	C Part Size	D Part Thickness	E Insertion Clearance	F Insertion Direction	G Insertion Condition	H Fastening	I Fastening Process	J Handling Condition	K Time/Each Operation (Top)	L Number of Repetitions (Nrep)	M Repetition Time (K*L) (Trep)	N Insert Part (1 = Yes; 0 = No)	O Eliminate Part (1=yes; 0 = No)
1	Engine S/A	1.8	1	0	0	0	1.4	1.5	8	8	0.5	22.2	1	22.2	1	0
2	Throttle Housing	1.8	1	0	0	0	1.4	1.5	20	20	0	45.7	1	45.7	1	0
3	Trottle Trigger	1.8	1	0	0	0.9	1.4	1.5	0	1	0	7.6	1	7.6	1	0
4	Spring	1.3	1	0.1	0	1.6	1.4	1.5	0	1	1	8.9	1	8.9	1	0
5	Throttle Cable	1.8	1	0	0	0.3	1.4	1.5	0	1	1	8	1	8	1	0
6	Switch	1.8	1	0	0	0.9	1.4	1.3	0	3	2.5	11.9	1	11.9	1	0
7	Lead Wires	0.8	0	0	0	0.9	1.4	1.3	0	3	0	7.4	1	7.4	1	0
8	D-Handle	1.8	1	0	0	0	1.4	1.5	5	4	0	14.7	1	14.7	1	0
9	Outer Spool	1.8	1	0	0	0	1.4	1.4	0	0	0	5.6	1	5.6	1	0
10	Retainer	1.8	1	0.1	0.2	0	1.4	1.3	0	3	0	8.8	1	8.8	1	0
11	Spring	1.3	1	0	0	0	1.4	1.4	0	0	0	5.1	1	5.1	1	0
12	Inner Reel S/A	1.8	1	0	0	0	1.4	1.4	0	0	1	6.6	1	6.6	1	0
13	Bump Head Knob	1.8	1	0	0	0.9	1.4	1.5	0	1	0	7.6	1	7.6	1	0
18	Shield S/A	1.8	1	0	0	0	1.4	1.5	5	4	0	14.7	1	14.7	1	0
													14	174.8	14	0
													TOP	TAT	NUP	0

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

	Summary Statistics	
NUP	14	number of unique parts (Sum of Column N)
TOP	14	total number of operations (sum of Column L)
TAT	174.8	total assembly time (sum of Column M)
NP	14	number of parts = sumproduct(L,N)
Tavg	0.08009153318	avg time/operation = TAT/TOP
Pmin	14	min # parts = NP - sumproduct(L,N,O)
AR	0.188215103	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	141.2	Assembly complexity = TAT - (2.4*TOP)
OR	5.202380952	Operation difficulty rating = TAT/(2.4*TOP)

Engine SA

Time Factors (seconds)

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
No.	Part/Operation Description	End-to-End Alignment	Rotational Orientation	Part Size	Part Thickness	Insertion Clearance	Insertion Direction	Insertion Condition	Fastening	Fastening Process	Handling Condition	Time/Each Operation (Top)	Number of Repetitions (Nrep)	Repetition Time (K*L) (Trep)	Insert Part (1 = Yes; 0 = No)	Eliminate Part (1=yes; 0 = No)
1	Spacer	1.3	0.5	0	0	0	1.4	0	0	1	0	4.2	1	4.2	1	0
2	Muffler S/A	1.8	1.5	0	0	0	0.6	0	8	8	0	19.9	1	19.9	1	0
3	Rear Cover	1.8	1.5	0	0	0	1.4	1.4	12	12	0	30.1	1	30.1	1	0
4	Starter Housing	1.8	1	0	0	0	1.4	1.4	12	12	0	29.6	1	29.6	1	0
5	Clutch S/A	1.8	1	0	0	0	1.4	0	4	4	0	12.2	1	12.2	1	0
6	Fuel Tank S/A	1.8	1	0	0	0.3	0.6	1.3	8	8	0	21	1	21	1	0
7	Air Cleaner/Insulator S/A	1.8	1.5	0	0	0.3	0.6	0	8	8	0	20.2	1	20.2	1	0
8	Clutch Cover	1.8	1	1	1	0	1.4	0	12	12	0	30.2	1	30.2	1	0
													8	167.4	8	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

Summary Statistics

NUP	8	number of unique parts (Sum of Column N)
TOP	8	total number of operations (sum of Column L)
TAT	167.4	total assembly time (sum of Column M)
NP	8	number of parts = sumproduct(L,N)
Tavg	20.925	avg time/operation = TAT/TOP
Pmin	8	min # parts = NP - sumproduct(L,N,O)
AR	0.1123058542	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	148.2	Assembly complexity = TAT - (2.4*TOP)
OR	8.71875	Operation difficulty rating = TAT/(2.4*TOP)

Air Cleaner/Insulator S/A

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
No.	Part/Operation Description	End-to-End Alignment	Rotational Orientation	Part Size	Part Thickness	Insertion Clearance	Insertion Direction	Insertion Condition	Fastening	Fastening Process	Handling Condition	Time/Each Operation (Top)	Number of Repetitions (Nrep)	Repetition Time (K*L) (Trep)	Insert Part (1 = Yes; 0 = No)	Eliminate Part (1=yes; 0 = No)
1	Insulator O-Ring	1.8	1.5	0.1	0.2	1.6	1.4	1.5	0	1	1	10.1	1	10.1	1	0
2	Carburetor O-Ring	1.8	1.5	0.1	0.2	1.6	1.4	1.5	0	1	1	10.1	1	10.1	1	0
3	Carburetor	1.8	1.5	0	0	0.3	1.4	1.3	0	1	0	7.3	1	7.3	1	0
4	Air Cleaner Gasket	1.8	1.5	0.1	0.2	1.6	1.4	1.5	0	1	1	10.1	1	10.1	1	0
5	Intake Manifold	1.8	1.5	0.1	0.2	1.6	1.4	1.5	0	1	1	10.1	1	10.1	1	0
6	Air Cleaner Filter	1.8	1.5	0.1	0.2	1.6	1.4	1.5	0	1	1	10.1	1	10.1	1	0
7	Air Cleaner Cover	1.8	1.5	0.1	0.2	1.6	1.4	1.5	0	1	1	10.1	1	10.1	1	0
8																
													7	67.9	7	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

	Summary Statistics	
NUP	7	number of unique parts (Sum of Column N)
TOP	7	total number of operations (sum of Column L)
TAT	67.9	total assembly time (sum of Column M)
NP	7	number of parts = sumproduct(L,N)
Tavg	9.7	avg time/operation = TAT/TOP
Pmin	7	min # parts = NP - sumproduct(L,N,O)
AR	0.2422680412	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	51.1	Assembly complexity = TAT - (2.4*TOP)
OR	4.041666667	Operation difficulty rating = TAT/(2.4*TOP)

Inner Spool SA

Time Factors (seconds)

No.	Part/Operation Description	A End-to-End Alignment	B Rotational Orientation	C Part Size	D Part Thickness	E Insertion Clearance	F Insertion Direction	G Insertion Condition	H Fastening	I Fastening Process	J Handling Condition	K Time/Each Operation (Top)	L Number of Repetitions (Nrep)	M Repetition Time (K*L) (Trep)	N Insert Part (1 = Yes; 0 = No)	O Eliminate Part (1=yes; 0 = No)
1	String	1.3	1	0	0.2	0	0.6	6	0	1	6	16.1	2	32.2	1	0
2																
3																
4																
5																
6																
7																
8																
9																
10																
													2	32.2	1	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram

Step 2: List Parts & operations in order (left column)

Step 3: Enter times from Estimated DFA Time Chart

Step 4: Sum time per part/oper. in column K

Enter no. of repetitions for each operation in col. L

Enter K*L in col. M

Step 5: Enter a 1 in col. N if a part was inserted during operation

Enter a 1 in col. O if part or operation can be eliminated

Step 6: Calculate Summary Statistics

Summary Statistics

NUP	1	number of unique parts (Sum of Column N)
TOP	2	total number of operations (sum of Column L)
TAT	32.2	total assembly time (sum of Column M)
NP	2	number of parts = sumproduct(L,N)
Tavg	16.1	avg time/operation = TAT/TOP
Pmin	2	min # parts = NP - sumproduct(L,N,O)
AR	0.1459627329	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	27.4	Assembly complexity = TAT - (2.4*TOP)
OR	6.708333333	Operation difficulty rating = TAT/(2.4*TOP)

Friction Weight S/A

No.	Part/Operation Description	A End-to-End Alignment	B Rotational Orientation	C Part Size	D Part Thickness	E Insertion Clearance	F Insertion Direction	G Insertion Condition	H Fastening	I Fastening Process	J Handling Condition	K Time/Each Operation (Top)	L Number of Repetitions (Nrep)	M Repetition Time (K*L) (Trep)	N Insert Part (1 = Yes; 0 = No)	O Eliminate Part (1=yes; 0 = No)
		Time Factors (seconds)														
1	Friction Weight Springs	1.3	0.5	0.1	0	0.9	1.4	1.5	0	1	6	12.7	2	25.4	1	0
2																
3																
4																
5																
6																
7																
8																
													2	25.4	1	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

Summary Statistics

NUP	1	number of unique parts (Sum of Column N)
TOP	2	total number of operations (sum of Column L)
TAT	25.4	total assembly time (sum of Column M)
NP	2	number of parts = sumproduct(L,N)
Tavg	12.7	avg time/operation = TAT/TOP
Pmin	2	min # parts = NP - sumproduct(L,N,O)
AR	0.1850393701	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	20.6	Assembly complexity = TAT - (2.4*TOP)
OR	5.291666667	Operation difficulty rating = TAT/(2.4*TOP)

Fuel Tank

No.	Part/Operation De	A End-to-End Align	B Rotational Orientation	C Part Size	D Part Thickness	E Insertion Clearance	F Insertion Direction	G Insertion Condition	H Fastening	I Fastening Process	J Handling Condition	K Time/Each Operation (Top)	L Number of Repetitions (Nrep)	M Repetition Time (K*L) (Trep)	N Insert Part (1 = Yes; 0 = No)	O Eliminate Part (1=yes; 0 = No)
1	Fuel Cap	1.8	1	0	0	0	1.4	1.5	8	8	3.5	25.2	1	25.2	1	0
2																
3																
4																
5																
6																
7																
8																
													1	25.2	1	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

	Summary Statistics	
NUP	1	number of unique parts (Sum of Column N)
TOP	1	total number of operations (sum of Column L)
TAT	25.2	total assembly time (sum of Column M)
NP	1	number of parts = sumproduct(L,N)
Tavg	25.2	avg time/operation = TAT/TOP
Pmin	1	min # parts = NP - sumproduct(L,N,O)
AR	0.09325396825	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	22.8	Assembly complexity = TAT - (2.4*TOP)
OR	10.5	Operation difficulty rating = TAT/(2.4*TOP)

Shield SA

		Time Factors (seconds)														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
No.	Part/Operation Description	End-to-End Alignment	Rotational Orientation	Part Size	Part Thickness	Insertion Clearance	Insertion Direction	Insertion Condition	Fastening	Fastening Process	Handling Condition	Time/Each Operation (Top)	Number of Repetitions (Nrep)	Repetition Time (K*L) (Trep)	Insert Part (1 = Yes; 0 = No)	Eliminate Part (1=yes; 0 = No)
1	Blade	1.8	1	0.4	0.2	0	0.6	1.4	8	8	0	21.4	1	21.4	1	0
2																
3																
4																
5																
6																
7																
8																
9																
10																
													1	21.4	1	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

	Summary Statistics	
NUP	1	number of unique parts (Sum of Column N)
TOP	1	total number of operations (sum of Column L)
TAT	21.4	total assembly time (sum of Column M)
NP	1	number of parts = sumproduct(L,N)
Tavg	21.4	avg time/operation = TAT/TOP
Pmin	1	min # parts = NP - sumproduct(L,N,O)
AR	0.1098130841	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	19	Assembly complexity = TAT - (2.4*TOP)
OR	8.916666667	Operation difficulty rating = TAT/(2.4*TOP)

Clutch Housing SA

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
No.	Part/Operation Description	End-to-End Alignment	Rotational Orientation	Part Size	Part Thickness	Insertion Clearance	Insertion Direction	Insertion Condition	Fastening	Fastening Process	Handling Condition	Time/Each Operation (Top)	Number of Repetitions (Nrep)	Repetition Time (K*L) (Trep)	Insert Part (1 = Yes; 0 = No)	Eliminate Part (1=yes; 0 = No)
1	Small Washer	1.3	0.5	0	0.2	0.9	0.6	0	0	0	0	3.5	1	3.5	1	0
2	Center Clutch Mount	1.3	0.5	0	0	0.9	0.6	0	0	1	0	4.3	1	4.3	1	0
3	Friction Weight S/A	1.3	0.5	0	0	0.9	0.6	1.5	0	1	3.5	9.3	1	9.3	1	0
4	Large Washer	1.3	0.5	0	0.2	0.9	0.6	0	0	0	0	3.5	1	3.5	1	0
5															1	0
6																
7																
8																
													4	20.6	5	
													TOP	TAT	NUP	

Step 1: Draw the Assembly Sequence Diagram
Step 2: List Parts & operations in order (left column)
Step 3: Enter times from Estimated DFA Time Chart
Step 4: Sum time per part/oper. in column K
Enter no. of repetitions for each operation in col. L
Enter K*L in col. M
Step 5: Enter a 1 in col. N if a part was inserted during operation
Enter a 1 in col. O if part or operation can be eliminated
Step 6: Calculate Summary Statistics

Summary Statistics

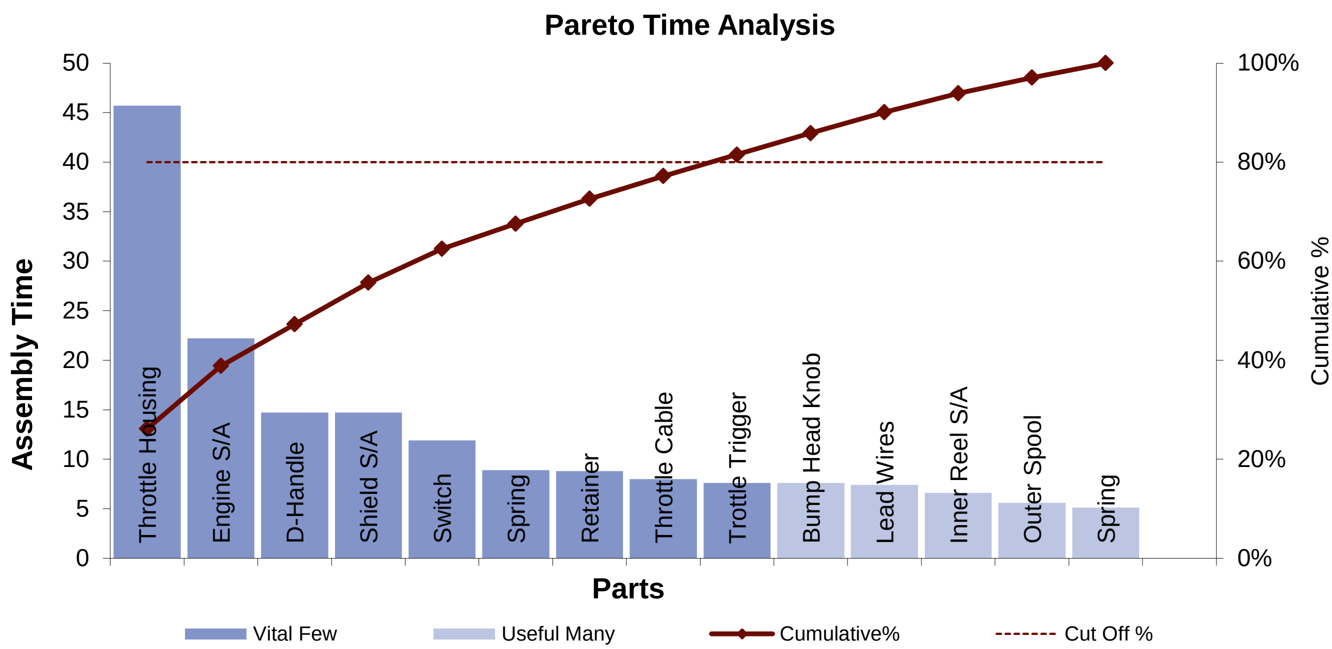
NUP	5	number of unique parts (Sum of Column N)
TOP	4	total number of operations (sum of Column L)
TAT	20.6	total assembly time (sum of Column M)
NP	4	number of parts = sumproduct(L,N)
Tavg	5.15	avg time/operation = TAT/TOP
Pmin	4	min # parts = NP - sumproduct(L,N,O)
AR	0.4563106796	Assembly rating = 2.35 * NP /TAT
PE	1	Part Effciency = Pmin/NP
C	11	Assembly complexity = TAT - (2.4*TOP)
OR	2.145833333	Operation difficulty rating = TAT/(2.4*TOP)

Total Assembly Time	Assembly Process	Time To Assemble (Seconds)	
	Drive Shaft Assembly	174.8	0.3267900542
	Engine Assembly	167.4	0.3129556927
	Air Cleaner/Insulator S/A	67.9	
	Inner Spool S/A	32.2	
	Friction Weight S/A	25.4	
	Fuel Tank	25.2	
	Shield S/A	21.4	
	Clutch Housing S/A	20.6	
	Total Time	534.9	

3.2

Using the Westinghouse method was an interesting task for our team. We realized that some of the time factors were easy to come up with but there were also some time factors that were difficult to come up with. For example, part size is fairly obvious and easy to estimate but insertion clearances appeared subjective and could vary in time from user to user. We also realized that there were operations that were missing. For example, when completing the inner spool, there was not an accurate way to capture the time it takes to wind the string onto the spool. However, it was understood that if the method captured every possible way to add time, the method would quickly move from being simple to very complex. It might be beneficial, though, to add a few more important categories, if possible, to suit your product's characteristics better. So for our product, adding in an accurate measure of how long it takes to wind the string might be beneficial as it would give a closer approximation to the actual assembly time.

Our results of the Westinghouse method show that the Drive Shaft Assembly requires the largest amount of time to assemble, taking 174.8 seconds. The next closest was the Engine Assembly at 167.4 seconds. These two assemblies combined take up 64% of the total assembly time of our product which is 534.9 seconds. This assembly time tells us the amount of value added time spent when making our product. There are aspects such as motion, transportation, quality checks, and human variation in manual assembly that would increase the time of 534.9 seconds substantially. The importance of this method is that there is a quantitative way to analyze the assembly of this product. The objective is to cut down on assembly time by simplifying components or by combining components. This would in-turn reduce the overall cost of the product and make room for enhancing the worth of the product. The Drive Shaft Assembly is the major assembly of focus for reducing part count and/or simplifying part design. Part of this comes from it having the most parts out of any of our assemblies and the other aspect is the complexity of the parts in this assembly. By reducing both of these the overall time needed to complete the final assembly will be reduced.



The first 9 Parts cover 81.52% of the Total Assembly Time

Cumulative Percentage Cutoff: 80%

#	Parts	Assembly Time	Cumulative%	Assembly%	Part%
1	Throttle Housing	45.7	26.1%	8.5%	9.4%
2	Engine S/A	22.2	38.8%	4.2%	57.6%
3	D-Handle	14.7	47.3%	2.7%	4.7%
4	Shield S/A	14.7	55.7%	2.7%	10.6%
5	Switch	11.9	62.5%		
6	Spring	8.9	67.6%		
7	Retainer	8.8	72.6%		
8	Throttle Cable	8	77.2%		
9	Trottle Trigger	7.6	81.5%		
10	Bump Head Knob	7.6	85.9%		
11	Lead Wires	7.4	90.1%		
12	Inner Reel S/A	6.6	93.9%		
13	Outer Spool	5.6	97.1%		
14	Spring	5.1	100.0%		

3.3

The Drive Shaft Assembly was the assembly sequence with the longest calculated time. The results of our Pareto Analysis of the Drive Shaft Assembly showed that the Throttle Housing and Engine Subassembly were the two operations with the largest assembly times while the D-Handle and Shield Subassembly tied for third. These four operations combined represent 55.7% of our total assembly time and 82.4% of our total number of parts. The Throttle Housing is a candidate for part simplification because it takes up a relatively high 8.5% of the total Assembly time of our weedwacker with 45.7 seconds. The Engine Subassembly is a candidate for part reduction because it takes up a relatively high 57.6% of the total parts of our weedwacker with 49 parts. The pareto analysis of assembly time is a valuable tool for focusing in on which areas of the weedwacker have the largest opportunity for redesign.

3.4

One of the areas of redesign that we considered was the d-handle assembly because it was the third most time consuming operation of our longest assembly sequence. The d-handle assembly is made up of 4 parts and requires a screwing action in order to attach it to the drive shaft. The redesign that we had in mind was to combine all 4 of those components into one piece that would then clip onto the drive shaft in one simple action. The redesign will also include a mechanism for a friction stop that'll allow or prevent the d-handle from moving along the drive shaft.. The reasoning behind this is that it would be a simple change that would reduce the assembly time and reduce the number of parts required to a quarter of the original parts. This also still allows for the handle to be adjustable by the user in a quick easy fashion. Another area of redesign is to do something similar to the shield to allow for quick and easy attachment with reduced parts needed. The shield would require less time to attach to the drive shaft with no tool requirements. The number of parts would also be reduced from four to one. Another area of redesign would be to combine the two halves of the throttle housing into one piece that is flexible enough to wrap around the drive shaft but still hard enough to act as a solid handle. This would reduce the number of screws needed to hold the throttle housing together which would reduce overall part count. This would also reduce assembly time substantially since the screw holes would automatically line up which would reduce the amount of time taken to match up the two halves. The reason this component was focused on was because it required the longest amount of time to attach it to the drive shaft. An improvement here would be extremely beneficial to the overall assembly time.