



2011

## Introduction

360° Product Testing has been retained to perform functional, durability testing and analysis upon provided Brand mixers, as shown to the right. This testing included:

- Measurement of the stopped (stalled) torque of the motor;
- Measurement of the motor speed at various states of charge of the batteries;
- Measurement of current draw, and estimation of battery life based upon published typical quality AAA battery capacities;
- Disassembly of and evaluation of the motor design and performance;
- Evaluation of the construction and robustness, including componentry;
- Evaluation of the capability of the mixing blade (stirrer) to handle various kinds of food items; and
- Checking the calibration of the mixing chamber's markings.



The following presents 360° Product Testing's findings for the branded mixer.<sup>1</sup>

### Measurement of Stalled Motor Torque

Each branded mixer was disassembled sufficiently as to perform measurement of the stalled motor torque. This test was done by mounting the motor's pinion gear in a bench vise so that the rotor remained stationary, then, using a lightweight wire attached to the motor case, attempting to lift a weight off a calibrated scale. This method is equivalent to attaching a lever to the motor shaft while the motor case is held stationary, then lifting a weight attached to the end of the lever. The product of the lever length and weight then gives the stalled motor torque.

In this measurement technique, the motor case was used as the lever; thus, the radius of the motor case is the length of the lever. A 500 gram weight was placed on a scale then one end of the thread attached to the weight and the other end secured to the motor case. Power was then applied, and the amount of weight change shown on the scale noted. Since the motor was attempting to lift the weight, the 500 gram weight showed a lighter weight, which is the amount of weight that the motor is capable of lifting. The product of the measured weight lifted and the lever length gives the torque. Since the motor case radius is larger than one centimeter, in practice, dividing the lifted weight by the radius yields the motor torque as expressed in grams-cm. The following table presents the results.

<sup>1</sup> The three sample mixers have been numbered MM01, MM02 and MM03 by the client.

branded mixer #	Weight Lifted (grams)	Motor Radius (cm)	Calculated Stalled Motor Torque	Stalled Motor Current	Stalled Motor Voltage	Calculated Motor Power (watts)	Calculated Stalled Motor Power (hp)
CM01	34.7	1.19	29.16	2.50	3.15	7.88	0.01055630
CM02	52.6	1.19	44.20	2.59	3.14	8.13	0.01090161
CM03	51.8	1.19	43.53	2.50	3.14	7.85	0.01052279

As can be seen above, one motor appeared to be somewhat weaker than the others, although all three drew about the same amount of current.

### Measurement of Motor Speed

Measurement of motor speed was done at no load (no liquid in the cup), with 8 fluid ounces of tap water in the cup, then with the following concocted “beverage drink” (only one branded mixer unit, CM01, was tested with the concoction):

- 8 fl. oz. milk;
- 1 teaspoon of Fancy Clover Honey
- 2/3rds package of Carnation “Breakfast Essentials” mix; and
- 1 medium egg.

The ingredients were added to the cup in the order listed above.

Because no rotational part could be observed with a concoction in the cup (so that, for example, a stroboscope or laser tachometer could be used), it was necessary to measure the motor speed electronically, by counting the number of electrical noise spikes as the motor’s commutator rotated between the brushes. Since these DC permanent-magnet motors have two magnets (called “poles”) and three coils, six current spikes can occur for every revolution of the motor. However, some spikes will be fairly small while others may be very large in comparison, due to loading on the motor and the position of the rotating coils with respect to the stationary magnets. Thus, this electrical measurement is only modestly precise and may tend to understate the actual motor speed, which, unloaded, can be up to 10,000 or higher RPM (some toy slot car motors spin at over 40,000 RPM when unloaded, for example). However, the heavier the loading on the motor (such as when stirring a thick liquid), the slower the motor spins and the wider are the spikes, which makes them easier to detect. Using a proprietary test jig with a standard frequency counter, engineers counted the number of spikes per second which, when divided by six (the minimum number of spikes per motor shaft revolution), yields the motor RPM.

The following table lists the measured motor speed, current and applied voltage when unloaded (removed from the mixer altogether), when installed into the empty mixer cup, and when loaded and stirring 8 fluid ounces of tap water. Measurements with the concoction described above are presented later. For these measurements, to obtain repeatable results, the motors were operated from a regulated DC power supply which provided 3.15 VDC at the motor terminals.

branded mixer #	Mo mixer Cup (no load)			Mixer Cup But No Water			8 Fluid Ounces Water		
	Applied Voltage	Current (amps)	Approximate Motor Speed (RPM)	Applied Voltage	Current (amps)	Approximate Motor Speed (RPM)	Applied Voltage	Current (amps)	Approximate Motor Speed (RPM)
CM01	3.41	0.12	10000	3.27	1.15	10000	3.26	1.45	6667
CM02	3.40	0.17	12500	3.26	1.40	7500	3.33	1.35	16667
CM03	3.40	0.15	20000	3.26	1.24	10000	3.23	1.40	8333

When first tested, the mixer stirrer of CM02 would not rotate at all, and the stirrer of CM03 rotated very erratically. Later, after the concoction-mixing tests, close examination revealed that the pinion gear might be pressed too far onto the stirrer shafts, causing the stirrers to bind; see the photo at right.



In response, engineers pressed out the steel shaft by about 0.010” on CM02, which then allowed the stirrer to be easily spun by hand (by reaching into the cup) with less friction. After this “adjustment”, the motor to able spin the stirrer.

In fact, the difference is such that CM02 achieved the highest motor RPM of the three when stirring 8 fl. oz. of water, 16,667 RPM. In contrast, CM01 spun only 40% of that speed while CM03 spun about half the speed of CM02. This spacing of the pinion gear on the stirrer shaft seems to vary somewhat between the three MM units due to slight differences in the silicone gland seal mounted under the stirrer, inside the cup. This seal prevents liquids from leaking down the shaft.

### Battery Life Test

Engineers performed a battery life test by filling the cup of CM02 with 8 fluid ounces of water, inserting two new Panasonic “Digital Power” AAA batteries, then turning on the mixer and letting it run until the batteries were too depleted to rotate the stirrer. Measurements of the battery voltage, current consumption, and apparent motor speed were taken every minute. The mixer operated for 31 continuous minutes, at current draws around 0.7 to 0.75 amperes, and a battery voltage of 2.10 dropping to 1.75 at the 20 minute point, and finally down to 1.37 volts at 31 minutes. After another 30 seconds, at 31.5 minutes, the batteries suddenly began shutting down completely, dropping rapidly from 1.1 volts to less than several hundred millivolts in only several seconds. The mixer itself stopped rotating at about 0.9 volts.

Typically, the mixer would likely be operated for only several minutes each time, and perhaps no more often than twice a day (unless shared by several people). Thus, the batteries would have considerable “rest-time” before the mixer again so-heavily loads them, and would regain some small portion of their capacity. Therefore, engineers believe that the actual number of two-minute mixing operations that new batteries may provide would be at least 20 and possibly as many as 30, depending upon the thickness of the mixture.

The following table shows the elapsed time, measured battery voltage, and mixer current, as well as the estimated motor speed based on the frequency counter reading (erratic due to numerous noise spikes, particularly during the first 15 - 20 minutes).

Elapsed Time (minutes)	Measured Battery Voltage (volts)	Measured mixer Current (amps)	Measured Motor Speed (RPM)	Comments
0	2.01	1.19	2833	Vortex only
1	2.10	0.75	2833	Robust vortex with air
2	2.03	0.74	2633	Robust vortex with air
3	1.97	0.72	2050	Robust vortex with air
4	1.93	0.72	1867	Robust vortex with air
5	1.90	0.71	1883	Robust vortex with air
6	1.87	0.70	2050	Robust vortex with air
7	1.90	0.65	2100	Robust vortex with air
8	1.90	0.66	2067	Robust vortex with air
9	1.88	0.67	1950	Robust vortex with air
10	1.83	0.69	1867	Robust vortex with air
11	1.80	0.71	1833	Robust vortex with air
12	1.80	0.70	1967	Robust vortex with air
13	1.80	0.70	2067	Robust vortex with air
14	1.80	0.69	1967	Vortex with air
15	1.80	0.69	2067	Vortex with air
16	1.78	0.65	2083	Vortex with air
17	1.78	0.66	1967	Vortex with air
18	1.78	0.66	2033	Vortex with air
19	1.76	0.67	2000	Vortex with air
20	1.75	0.66	2567	Vortex with air
21	1.74	0.66	3333	Vortex with air
22	1.64	0.74	1667	Barely vortex with air
23	1.60	0.75	1500	Barely vortex with air
24	1.58	0.76	1500	Barely vortex with air
25	1.57	0.75	1417	Barely vortex with air
26	1.53	0.77	1083	Barely vortex with air
27	1.53	0.76	1317	Vortex only
28	1.51	0.75	1250	Vortex only
29	1.47	0.75	1167	Vortex only
30	1.44	0.75	1000	Vortex only
31	1.37	0.73	833	Vortex only
31.5	1.10	0.50	0	Batteries died, stopped
31.75	0.30	0.10	0	Within seconds, battery voltage dropped very low

Note the sudden apparent jump in motor speed at about 20 minutes. Engineers believe that at this point, the batteries had depleted considerably, as the noise spikes had increased in intensity, causing the frequency counter to read more pulses than usual; i.e., the motor speed was likely lower than shown for minutes 20 and 21. As the batteries continued to discharge at minute 22, the motor slowed down and its current pulses began elongating, allowing more-accurate measurement of the pulses.

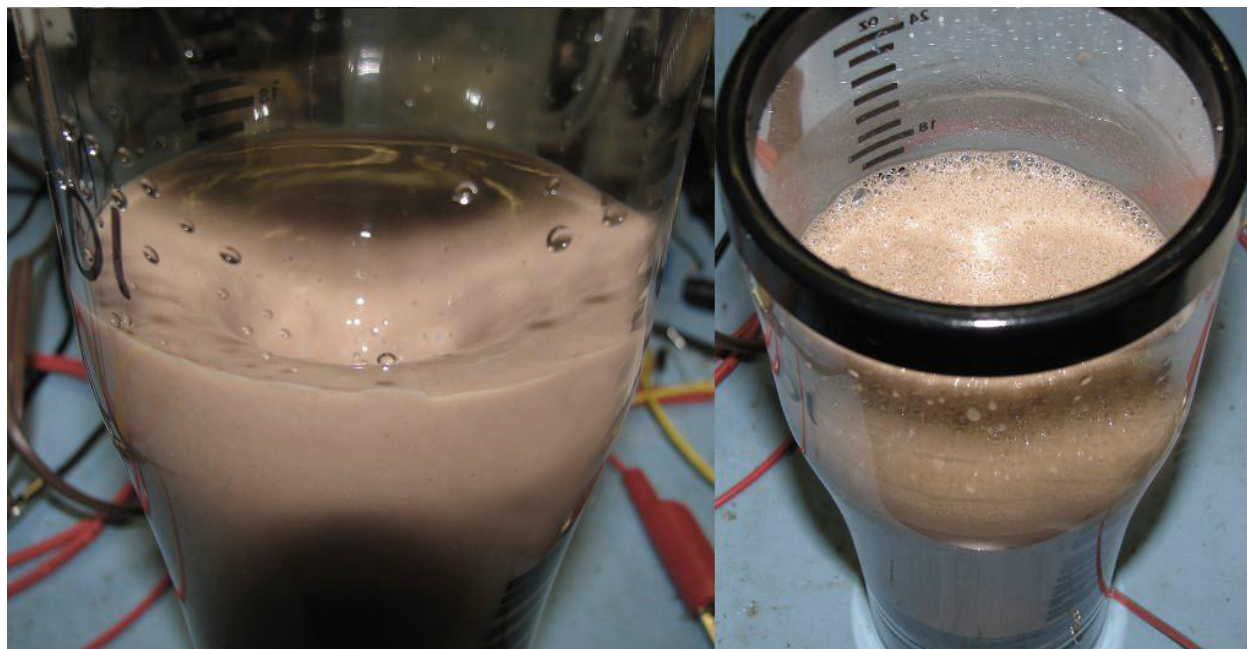
It should be noted that when the mixer is first turned on and the stirrer is spinning at slow speed, there is no vortex with air mixing taking place and this increases the load on the motor; thus, at minute 0, the current can be seen to be highest. After the stirrer has attained sufficient speed as to cause vortex with air, the current then drops since the motor is doing less work. The following two pictures of CM03 illustrate the difference between vortex only and vortex with air mixing.



As the stirrer begins rotating, the rotating motion of the stirrer causes the liquid to rotate within the cup, which gradually causes a vortex to begin forming downward from the surface of the liquid. As the vortex stretches down to and reaches the stirrer, the stirrer mixes air drawn from the vortex into the liquid, then the lower arms of the stirrer toss the air around in the liquid. As air is tossed outward from the stirrer's lower arms, air-mixing occurs which causes the stirrer to encounter less liquid and more air, thus causing less mechanical resistance. The reduction in spinning-resistance lessens the torque requirement on the motor, allowing it to spin faster. The turbulence of the air being mixed in the liquid causes a constantly changing torque on the stirrer which causes the motor speed to jump up and down as the arms of the stirrer alternately encounter air and liquid.

The thicker the liquid, the more torque is required to rotate the stirrer. When mixing a thick liquid such as the concoction described previously, so much torque may be needed that the stirrer speed never gets high enough to draw air completely down the vortex to the stirrer.

Thus, while mixing the concoction, motor current remained much higher than was the case while stirring a thinner liquid such as water. When mixing 8 fluid ounces of concoction using CM01, 360° observed the motor current at 1.9 amperes while the power supply held the voltage to the motor constant at 3.14 volts. The rotational speed appeared to be about 1500 RPM, considerably slower than when mixing the same volume of water. While a vortex did form, the vortex apparently never brought enough air down to the stirrer to allow vortex with air to begin (had vortex with air begun, the motor would have drawn less current, thus extending battery life). The left-hand photo below shows a clear vortex formed while the concoction was being mixed; the right-hand photo illustrates the thoroughness of the mixing process after two minutes.



### **Motor Quality and Performance**

The DC motor used in the Brand mixers is a standard 2-pole, 3-coil type, as shown in the photos on the following page. The pictured motor is from CM01 and has been operated off-and-on, with liquid and without, for about 45 minutes. It is already showing signs of wear on the commutator and brushes; note the uneven edges on the sides of the three commutator pieces, and the bent motor brushes. Although a slight amount of bending of the brushes occurred when the motor was disassembled, there is also some bending of one brush that could not have occurred during assembly or disassembly. The end of the motor shaft that rides inside a bronze bushing also shows signs of wear.

A 390-ohm resistor can be seen mounted across the motor terminals on the exterior; the purpose of this resistor is unknown, but will cause a small amount of current (approximately 7 milliamperes at 3.0 volts) to be drawn while power is being applied to the motor. A resistor across the motor terminals will not affect any commutator-brush sparking, whereas a small capacitor might reduce such sparking.

No manufacturer or part number markings were found on the motor (the CM01 seen was written on the motor case for ID purposes).

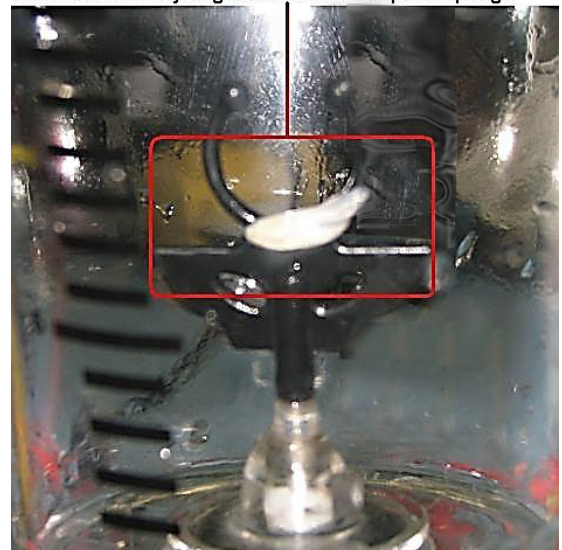


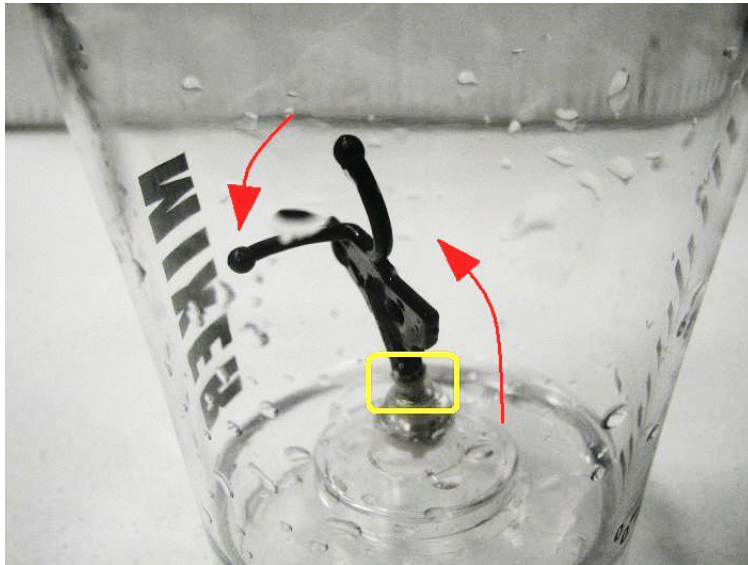
### Mixer Construction and Robustness

The mixer cup is a thick polystyrene casting. Unlike a standard household blender, however, the bottom portion holding the stirrer cannot be removed for cleaning. The narrow cup's depth makes it difficult for a large hand to reach inside with a sponge or other appliance to wipe off the stirrer or bottom of the cup. When eggs are mixed with the Brand mixers, portions of the liquid embryo tend to get wrapped around the stirrer, as seen in the photo at right.

Underneath the black mixer stirrer is a silicone gland that provides the liquid-tight seal around the mixer shaft. However, **after about 30 to 40 minutes of intermittent use, the silicone gland on CM01 began leaking water**, which ran down the stirrer and then the motor shaft. Close examination of the other two mixers also found several drops of water in the motor compartment of CM03; CM03 had approximately 20 minutes of intermittent (usually about 2 minutes each) usage.

Egg embryo wrapped around mixer stirrer that did not wash away with water. To clean this off, it was necessary to gently dab at the relatively-fragile stirrer with the tip of a sponge.





### Mixer Stirrer Robustness

Engineers purposely applied force to the mixer stirrer in several ways to try to induce it to break; however, the stirrer simply bent, as seen to the left. First, the upper “tong” was pressed sideways and down; then pressure was applied perpendicular to the stirrer shaft on the large black plastic of the stirrer, which caused the steel stirrer shaft to bend to the left.

The yellow rectangle highlights where the silicone liquid-tight gland is located.

Based on these tests, engineers believe the mixer stirrer will survive any kind of soft food that is likely to be placed within the mixer cup. If a food item is too hard, the motor will be unable to provide sufficient torque as to break up the food, thus preventing damage to the stirrer.

These mixers are clearly not intended to be used to chop or crush items such. However, 360° does not believe that the motor will have sufficient power to chop up a whole banana, but slices may be broken down satisfactorily.



### Mixing Cup Calibration

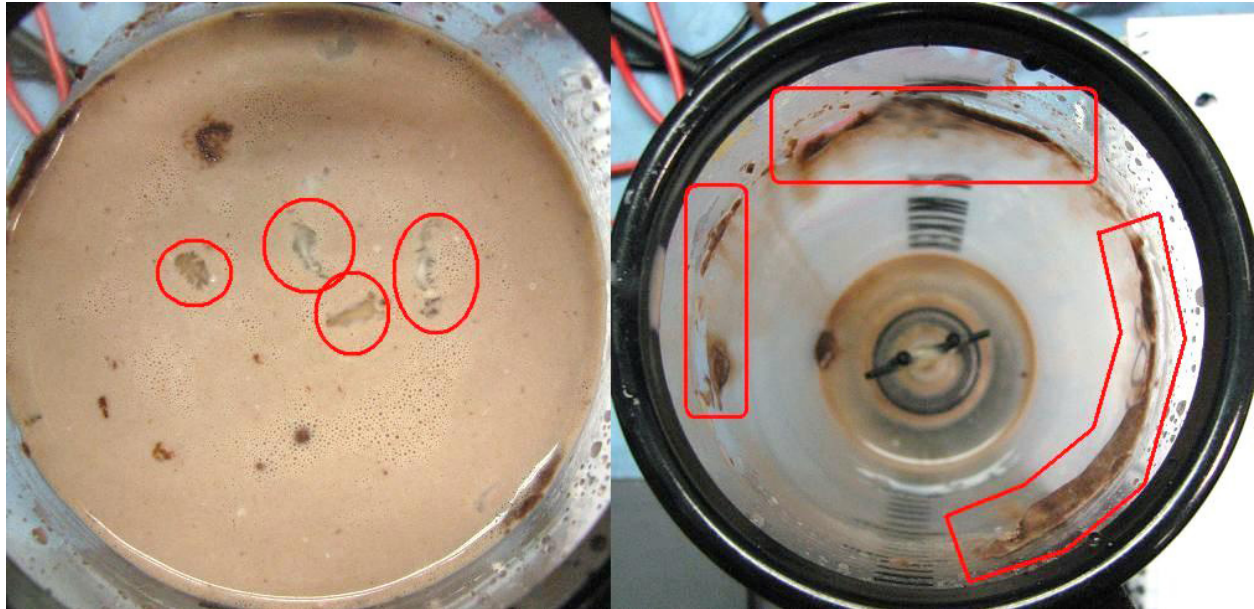
360° Product Testing checked the fluid ounce markings on the side of the MM cups using a graduated laboratory beaker. The following table shows the results:

Lab Grade Graduated Beaker	branded mixer Cup
6 fl oz	8.3 fl oz
12 fl oz	16.1 fl oz
18 fl oz	22.4 fl oz
24 fl oz	equals marked 19.0 fl oz

The markings on the MM cup are seen to be quite far off from the actual volume of fluid placed within the cup. The so-called “24 ounce” cup can actually only hold about 19 fluid ounces.

### Other Comments and Observations

Engineers found that for best mixing performance, only 8 fluid ounces liquid should be mixed at a time within the MM cups. During 360°'s first concoction mix, engineers attempted mixing 12 fluid ounces of milk, but the rest of the concoction ingredients were as previously described. This turned out to be too much liquid, and the stirrer was unable to draw a deep vortex that caused the materials to be stirred properly. As a result, after 2 minutes of mixing, there were still pieces of egg visible on the top of the concoction, as seen in the red highlighted areas in the photo to the left below.



In addition, if a powdered mix is to be mixed with liquid, the mix should be dropped into the cup and the cup slightly stirred/agitated to let the mix sink below the surface of the liquid. If the powder is allowed to sit on top of the liquid when the mixer is turned on, the powder can become deposited on the walls of the cup, as seen in the above right-hand photo within the highlighted areas. Mixing only 8 fluid ounces at a time, and making certain the powder mix has sunken below the surface of the liquid, results in the nicely-mixed concoction seen earlier.

360° also noticed that after two minutes of mixing, the lid tends to lift somewhat out of the cup, whether mixing a concoction or water. This appears to be happening due to the build-up of air pressure within the cup as a vortex forms.

During the latter part of testing, 360° found CM03 appeared to be struggling to rotate the stirrer at times. At the beginning of several tests, it was necessary to turn the mixer on and off several times before the stirrer would rotate (with water in the cup). Engineers postulate that the silicone gland is becoming worn and sticking to the plastic cup underneath, or to the metal stirrer shaft.

### Summary

The Brand mixers are light-duty mixing cups that allow concoctions to be mixed, although the thicker the concoction, the slower the mixing speed and the more battery power is consumed. If only used once or twice a day for two minutes each time, batteries may last several weeks; with a thicker mixture batteries may last 3 to 4 weeks. If the mixture is too thick, the motor may not be able to start.

The motor, silicone watertight seal, capacity to mix thoroughly, and inaccurate volumetric markings seem to be the weak points of the mixers.