Working together for a world without waste

Case study

Specifying higher-quality durable power tools

June 2011

A case study of three cordless drills to illustrate and encourage specifications for durability and repair, with design principles that can be applicable to power tools.

Introduction

Why make tools last longer?

This case study compliments WRAP's buying specifications for power tools that have been developed to assist buyers and manufacturers procure and produce higher-quality products that last longer, can be more easily repaired and that have lower environmental impacts. Three cordless drills were assessed to illustrate broader practical applications of the specifications that can be considered across all power tools to encourage durability and repair.

WRAP's Environmental Assessment of Electrical Products[1] found that 91% of a household drill's environmental impact occurs in the materials and processing phase, and only 2% occur in use. There is a clear opportunity for significantly reducing the environmental impact of power tools by making them last longer through increasing their quality and durability – the potential lifetime extension benefits are strong.

This case study highlights the most beneficial measures that extend the product's life, and some of these can be relatively easy to achieve within the product's price-point constraints. The buying specifications include further detail for companies wanting to take a more ambitious approach and deliver greater environmental benefits, as well as differentiating their brand for reliability and quality.

The specifications were developed by assessing drills and power tools through discussions with manufacturers, retailers and repairers, and also through carrying out 'teardown' on a range of cordless drills to identify design features that facilitate repair.

Product introduction

Three cordless drills were selected that were broadly representative of different market segments and price-points and these are:

The Performance Power PDD144 (14v) from B&Q - a lower-cost drill intended for household use with a NiCd (nickel cadmium) battery, a 2 year guarantee and retailing at around £30.

Two professional cordless drills from leading brand manufacturers (14v and 18v) - both representative of medium to high-cost market segments with NiMH (nickel metal hydride) batteries, retailing at over £130.

One of the professional drills has a 3 year guarantee, which suggests a high level of confidence in product durability since professional tools are more heavily used and often roughly treated.

Of the three products assessed, features that encourage durability and repair were found relatively equally across the price-points and intended end users (professional or household user). The professional drills were considered to be more robust with more features that are likely to extend the life of the product.

Cordless drill durability issues

The cordless drill is one of the most commonly purchased power tools in the UK with millions of units being sold each year. Householders however may only use a power tool for a few hours a year, whilst professionals are likely to use them for hundreds of hours a year. Although the designs of professional and household cordless drills vary to some degree, the main principles and basic design are very similar.

Cordless drills are relatively simple devices, comprising a battery power pack and a DC (direct current) motor driving a shaft and a dual speed gearbox and chuck (holding the drill bit). The electronics are relatively simple, providing an on-off function, typically a forward and reverse setting and a speed control.

Research carried out for this study shows the main faults that shorten the lives of cordless drills are:

- faulty or exhausted batteries;
- motor and bearing failures;
- broken switches and speed dials;
- chuck failure (ceases to grip properly); and
- gearbox failures.

Wear is an obvious cause of failure since power tools undergo heavy work and are often roughly treated and used in a hostile environment. Dust from drilling for example can partially block the air vents and cause excessive heat build up in the body. Motor burn out can also occur, where the drill is not powerful enough to keep the drill bit turning leading to it jamming, heat building up and the motor failing.

The voltage rating and torque this delivers, and the configuration and quality of components are therefore key considerations in terms of extending drill lifetime.

Durability

Mechanical robustness

Casings

The outer casings of the three drills assessed are all made from a strong engineering polymer PCABS (poly-carbonate acrylonitrile butadiene styrene) with rubber hand grips. Some models also considered in this study, but not assessed, also have protective rubber inserts in the heel of the casing behind the motor and on the sides to provide further protection. These materials combine to make the tools more resistant to impact and help to avoid the case cracking.

Battery retention system

It is also important the battery doesn't work loose creating a poor connection or break off from the tool over time. This is avoided on some newer, and the two professional models, by designing the battery to slot horizontally into the handle base to engage with the connectors and a strong retaining clip. This ensures the battery weight (when the tool is used) is adequately supported by the handle moulding and not just by the clips.

Figure 1 Vertical battery retaining cavity and clips (older models)

Figure 2 Horizontal battery retaining system

Motor

Torque vibration in use is the leading cause of product wear. The professional models assessed use balanced motor armatures, a 4-pole (rather than the normal 2 pole) DC motor for smoother power delivery and anti-vibration damping - all of which ensure longer life by reducing vibration.

Gearboxes and bearings

The life expectancy of the motor is, in part, determined by the quality of the bearings in the motor shaft. The professional drills assessed have durable cartridge-type, high-grade bearings and premium grade steel is used in the motor armature shafts and gears.

Each of the drills assessed have metal gearboxes (figure 3) and gears, as opposed to plastic, which prolongs the life of the drill significantly, especially in the case of professional tools. In both the professional models, the gear case completely covers the gears for improved dust protection.

Figure 3 Gearbox using metal gears

Cooling fans and vents

Good design for durability involves providing a cooling fan on the motor rotor and adequate holes in the drill casing to allow cooling without the vents becoming blocked, dust getting in and that also protects the user against hot internal components. Dust or dirt on the motor reduces heat transfer and can cause further heat build-up and motor damage.

One high-cost drill has small rectangular air vents that are well placed on the side, at the rear around the motor and at the front near the gearbox. Their position also reduces dirt falling into the vents.

The B&Q drill uses relatively wide vents, however they are oriented and screened to minimise material entering the drill.

Figure 4 Cooling side vents (professional model)

Figure 5 Air cooling vents (householder model)

Electrical robustness

Motors and connectors

Drill motors are vulnerable to damage or burn-out if the drill bit becomes obstructed or labours in hard materials. The battery voltage and motor design determines the power available to the drill bit. Professional drills are generally 14v or more but 18-24v drills provide adequate power for demanding work and are becoming more common. This 'excess' power reduces stress on the tool and reduces recharging, which can also help prolong battery life.

The two professional drills assessed (14v and 18v) have electronic protection for the motor against overload. One of these models also has high-grade magnetic 97% copper wire for superior current flow and to withstand extreme temperatures, potentially prolonging motor life.

Connectors were robust and vibration-resistant, and one model has connectors coated with a protective polymer (which acts to prevent moisture and dust ingress).

Batteries

There are three main battery technologies used for cordless drills; Ni-Cd (nickel cadmium), Ni-MH (nickel metal hydride) and Li-Ion (lithium ion). The B&Q drill has a Ni-Cd battery, and the two professional drills assessed have NiMH batteries.

The best way to maintain Ni-Cd and Ni-MH batteries is to charge and discharge them fully to avoid 'memory' effects that reduce their useable life and to minimise potential overcharging. The major cause of premature battery failure is exposure to heat during charging, however this is difficult to prevent by design.

Li-Ion batteries do not suffer 'memory effects' and have a longer life. It is generally considered they have around 4 times the life of an equivalent Ni-Cd or Ni-MH battery, although they are more expensive.

Battery charging units

Battery charger units can fail leading to the tool being discarded, usually attributed to the power supply element of the charger. The B&Q drill has a charger unit (figure 4) that keeps the supply separate from the battery charger. If the power supply fails, the component part can be replaced without the need for a new charger unit.

One of the high-cost models assessed in the study has a 'smart' battery charger that diagnoses the condition of NiMH and Li-Ion batteries and can adapt the charging programme to correct memory effects and avoid heat damage. Some manufacturers provide electronic cell protection to prevent battery overloading and overheating. These are useful features that help maximise battery life.

Figure 6 battery charger with detachable power supply unit

Repair

Fault diagnosis and technical support

Power drills have a limited number of causes that generally lead to failure and diagnosis relies on observation, for example by changes in sound or visible damage once taken apart. The drills assessed did not demonstrate 'fault diagnosis' (with exception to the battery charger described above), although this could be considered.

In order to assist the repair of power drills, both of the professional power tool manufacturers provide comprehensive support services online and over the phone, including:

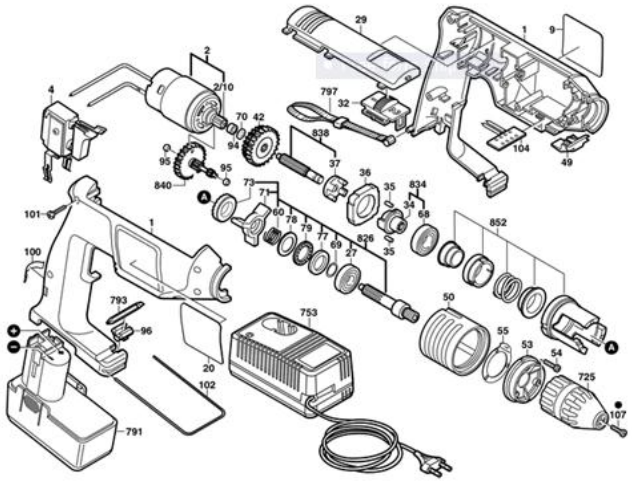
- user manuals (including trouble shooting information);
- online parts diagrams; and
- aftersales service and repair centres.

Similar services for the home improvement end of the market are less competitive, however there are opportunities for more robust mid-cost power tools that would benefit from taking up 'easy to achieve' design features to encourage repair.

Parts availability and pricing

The price and availability of spares can be a major problem for repairers once the product warranty expires and high pricing of parts inhibits the viability of repair. It can be difficult in some cases to find parts for household and lower-cost drills. This is not the case with the medium and high-cost drills, where parts are readily available at reasonable prices (compared to the cost of a new product) and in one case for up ten years after the product has ceased production.

Figure 7 Professional drill exploded parts diagram



The key parts to consider for price and availability are batteries, switches, motors, chucks and gear boxes. To give some examples for one of the professional drills (costing around £130), a switch would be less than £3, a keyless chuck around £20, a DC motor between £10-25, a gear assembly £20-40, and a Ni-Cd or Ni-MH 14.4v battery - over £50.

Access for repair and replacement

Case access

The B&Q model and one of the professional models have a small number of screws to open the main casing and the key components are easily accessible (below). This takes around 1 minute and demonstrates good practice in design for accessibility. One was more difficult to open requiring the removal of the chuck to split the body. Torx screws are used in some cases, although they are slotted to also allow a flat head screwdriver to be used.

All internal components are located by the casing moulding and require no fixings which means key parts can be removed easily and quickly.

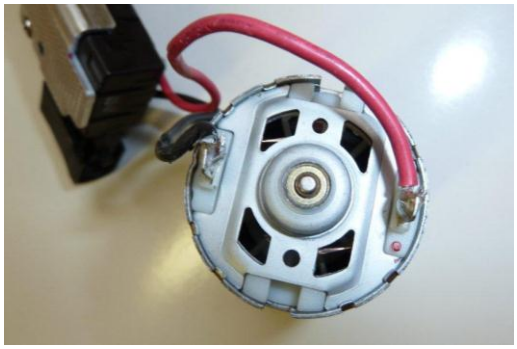
Replacement of the chuck, gearbox, motor and switches is a simple operation, however this could be further improved by the electrical joints being clipped as opposed to soldered (figure 7). As would the use of vibration-resistant clips would increase the speed and ease of component replacement, as no specialist skills or equipment (such as a soldering iron) are required.

Sealed motor units offer better dust protection and durability than units with replacable bearings, however in the event of failure the whole motor unit requires replacing.

Figure 8 Easy access to internal components for repair

Figure 9 Switch assembly, motor, gearbox and chuck

Figure 10 Soldered joints that restrict component replacement



Conclusion

The cordless drills examined in this study, and particularly the professional models, are robustly designed and provide a good level of durability, enabling many of the major parts to be easily accessed and replaced. The most beneficial specifications from the drills that can be easy to implement, include:

- online and telephone repair support service;
- free access to online repair manuals and parts listings;
- minimising the number of case screws (and standardising type);
- easy access to key components for replacement;
- a three year guarantee (higher-cost models); and
- good parts availability and reasonably priced spares.

Good design for durability can be achieved by:

- specifying a robust case made from impact-resistant polymers and carefully placed protective rubber inserts;
- using high-quality steel components in the gearbox and motor; and
- sealing components to prevent dust entering.

Good electrical design to reduce parts failure can be achieved through specifying:

- vibration-resistant connectors;
- horizontal battery retention - supported by the body (vertical slots provide less support and clips can fail);
- vents and fan to allow sufficient cooling and protect from dust;
- high-quality copper motor windings;
- electronic motor overload protection; and
- 'smart' battery charging (adjusted to suit the battery's condition).

WRAP recommends that buyers seek to specify as many of these design features into their products as possible, within their price point constraints. WRAP recommends that buyers seek to specify as many of these design features into their products as possible, within their price point constraints

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