Dienamics
Ideas Moulded by Experience

Guide to Product Design

Issue #2: Making Features from Faults & Understanding Design Language (Surfboard Scenario & Drill Comparison)

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Design Knowledge Series (White Paper – Long Form)

Design and manufacturing is a competitive industry. In this industry, learning how to 'read' products and understand how and why they have been made the way that they are is a critical skill.

For plastic injection moulded products, there are telltale signs you can see in the way the product itself is designed, as well as in the way it looks after being manufactured that allows you to decipher –

- What was the priority? Price, materials, finish quality, or including specific features.
    - Whether they have focused on making the product cheap? Whether they have focused on making it a premium product? Or whether it has been designed / manufactured in order to include key product features?
- If the product has been designed in a specific way to aid ease-of-manufacturing or to avoid unsightly faults/blemishes showing in injection moulding?
    - Has the product been designed to hide / not show ejection marks from tooling? (like blade ejector marks, or air popper valve marks?)
    - Does the design include features that will prevent faults / blemishes showing after moulding (e.g., hide sink marks, not have weld lines, etc.)?

Manufacturing is always within a tolerance, and often the tighter the tolerance, the more expensive/longer it takes to design/manufacture components. Good design means manufacturing your product at its' optimum tolerance. Having an extremely tight tolerance where it is not necessary is wasteful and ultimately indicates that the part has not been designed correctly. If you can save money in manufacturing, without compromising the design, it is advantageous to do so.

Learning how to read the signs and signals as to whether a product has or hasn't been designed optimally is an ability all good designers must possess. To be able to do this, you need to develop a complex understanding of injection moulding and learn the possibilities of how you can turn a design concept, into a real-world product without compromising the products' intent or aesthetics.

Why Make Features Out of Faults

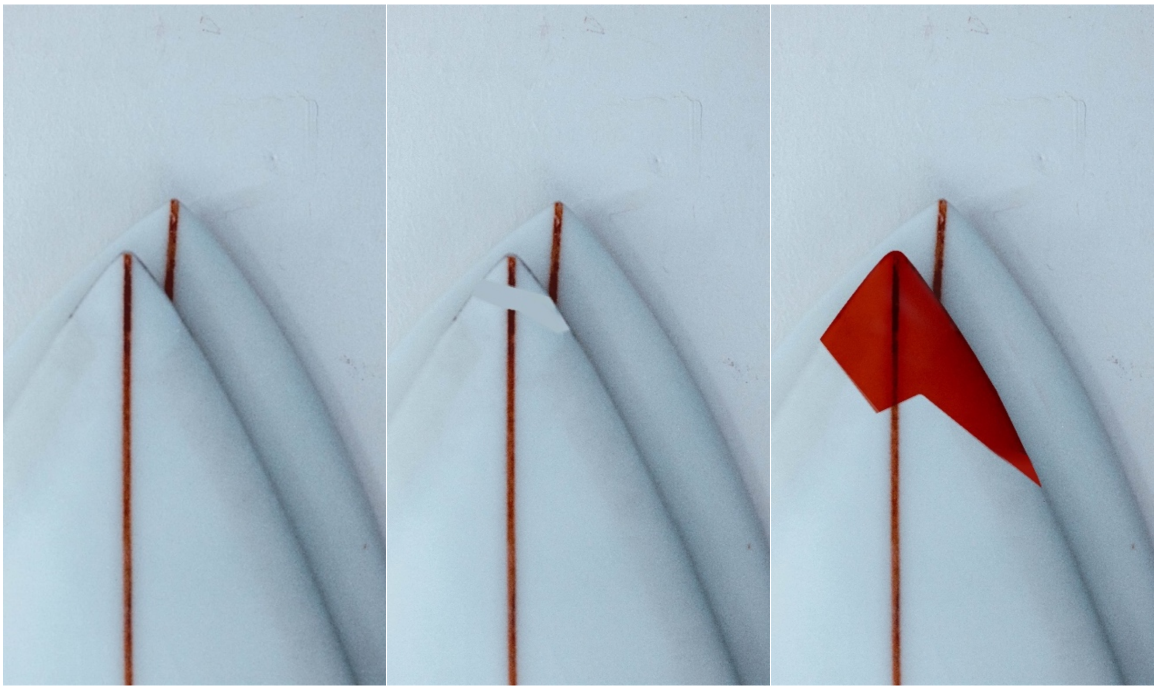
When trying to solve issues or problems with a design or its' manufacturing, where a design cannot be overhauled, or a simple solution does not exist, instead of trying to cover the problem up, or trying to put a band aid over it, it is often best to highlight the issue and actually make it a feature of the design. Doing this, makes the problem seem like a purposeful design decision and it won't look out of place.

In practice, let us consider to following scenario:

You've gone out and bought yourself a surfboard. You take it out into the surf a few times and it is perfect, you love the board, and you love the way it looks. Then, you forget to tighten the straps holding it to your roof racks completely – as you drive out of the beach car park the board slides down off your roof, over the bonnet, and hits the road – snapping the nose off.

After getting a couple of overpriced quotes to get it fixed you decide to give it a go yourself. Most people would simply pick up a fiberglass kit from their local hardware store, attach the nose back onto the board, and leave it at that. Whilst this makes your board usable again, it will never look as good as it did before it broke.

What do you do? Easy – the best thing to do here is to go one step further, get some bright red paint, and paint the nose with it – giving the board a bit of flare and making a feature out of the problem. Often in design, if something goes wrong, or if a problem is unavoidable, it is best to embrace it completely than it is to try and cover it up.



Injection Moulding: Features from Faults & Understanding Design Language

For injection moulded products, some similarity is found with the surfboard scenario, in that unforeseen problems will arise – you may see these throughout prototyping, tooling stages, and manufacturing trials. Differingly however, there is also a number of potential cosmetic faults that can be identified in injection moulded products at the very start of a project, when still in design and CAD devlopment phases. Learning how to predict these potential faults through understanding injection moulding, and understanding tooling, allows you to design attractive real-world products.

To highlight some of these potential faults, illustrate how and why different design decisions are made for injection moulded products, and show you how to identify or read these decisions, let us comapre two real-world products – a cordless hammer drill from Ryobi, and another by Hilti.

Ryobi's 18V ONE+ vs. Hilti's SF 6H-A22 - Cordless Hammer Drill Comparison:

Overall Design:

Product brands, like Ryobi (which is currently licensed By Techtronic Industries or TTI who also owns other power tool manufactures AEG and Milwaukee) or Hilti, generally follow a visual design language that the company develops to suit their target market and consumer. Visual design languages include a number of design elements like shape, colour, materials, and finish.

When evaluating a product, it is important to consider what the brands prescribed design language is. You want to do this because it gives you an insight into why the product has been designed the way it has – why it has a certain shape and why it uses particular colours? After you've figured this out, you can then start to see if the product and its' features have been designed with aesthetics or functionality in mind.

Looking at the two drills, the Ryobi's overall design is much more geometric, with the drills' form having numerous protruding sections and cutaways; it has an additive and subtractive form. Ryobi's target market is homeowners, hobbyists and DIY'ers, and whilst cutaways provide functional electrical venting, much of the reasoning for this form is to give the drill a rough and rugged appearance – they want their product to look like how their target market perceives the construction and building industry.

In contrast, Hilti's brand targets building and construction professionals. This is reflected in their SF 6H-A22 Hammer Drill's design, where unnecessary aesthetic additions have been avoided to give the Hilti a more sophisticated and premium appearance. Compared to the Ryobi, the Hilti's design is more compact, smoother, and ultimately looks more refined.

Design, Materials, and Manufacturing:

Taking a closer look at each of these drills, let us focus on some-key elements that provide insight into the design and manufacturing decisions and direction each company has made.

Drill Body / Main Housing – Material:

For both drills, the main body of the product consists of two assembled plastic injection moulded housing halves that have been overmoulded with a soft elastomer (rubberized plastic). It is likely that the housings are moulded in a glass-reinforced plastic, likely either ABS or Nylon, and the overmould a TPE or TPU.

- Nylon has good heat resistant, but reduced impact resistance, whereas ABS is lighter and exhibits superior impact resistance.
- Glass fibre (GF) is often used when injection moulding powertool housings as it increases the tensile strength of the product whilst still allowing for some flex.

Without being able to test the material or look for a material code on the inside of housings, it is not 100% clear what material each drill is made from – though if it isn't either ABS or Nylon, and then isn't glass reinforced, it immediately indicates that the material used is likely not fit for purpose.

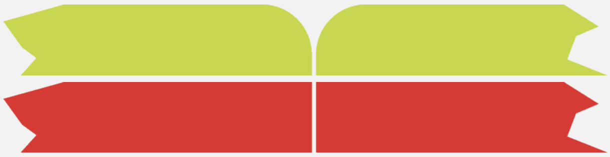
Drill Body / Main Housing – Assembly:

The join or assembly line between each drills' housings is very noticeable on the Ryobi, whereas on the Hilti it is almost seamless.

Noticeable join/assembly lines are indicative of components trying to be manufactured cheaper. However, this isn't necessarily a bad thing, particularly for power tools which will be used outside, and will likely suffer damage and still need to be usable. This noticeable join could be resultant from several things, such as:

- Suboptimal design – the opposing Ryobi housings have been designed differently (e.g. different internal walls, structural ribbing, or wall thickness), causing each housing to warp and shrink differently as the plastic's temperature lowers after injection moulding.
    - This is highly plausible as electronic products are often designed to have all electronics and wiring fitted into one side of the product to make assembly easier and quicker – the additional mounting points required in that side may have caused a discrepancy in how it shrunk/warped compared to the other.
- Inaccurate tooling – the tool that produces the LHS housing may have been dimensionally inaccurate compared to the RHS housing (or vice versa). This may have happened as the mould cavity was being machined into the tool, even though the designed CAD model itself aligned perfectly.
    - This may occur if less time is spent setting up the CNC mill to machine the mould cavity correctly, or if the CNC mill makes an error, or if the steel cutter is compromised.
- Injection moulding parameters have not been set correctly, or differences in moulding parameters between housing sides (e.g. tool heat, injection pressure, barrel heat) are having an impact on how the part cools and shrinks/warps.

- Looser quality control standards
    - When moulding, there is often 'acceptable' defects that the client approves / will allow. Ryobi likely allows for more slight defects in moulding than Hilti. You do this so that you have less wastage (saving material costs) and have shorter run times, allowing the order quantity to be fulfilled quicker (saving machine running costs).
- Ryobi's designers attempting to highlight the assembly/join line by purposefully rounding the edges of the housing surfaces that meet to counteract or allow for the potential issues mentioned above. In doing so, they're increasing their product's tolerance, allowing them to reduce costs.



Moulding different components that join seamlessly is an exceptionally hard task due to the many variables that can affect an injection moulded components dimensional stability. These variables are found throughout all product development stages from design, to tooling, to the moulding itself. Accordingly, it is evident that Hilti spent a great deal of time and money adjusting the design and manufacturing of their components to achieve such a seamless join.

Rubberised Grip – Overmoulding:

Alike the joins on the main drill body housing, the overmould grips on the Hilti are also remarkably seamless. Overmoulding is often susceptible to plastic flashing when moulding. However Hilti, instead of trying to design to make a feature out of a potential fault, have chosen to maintain a tight tolerance and to spend time and money perfecting their tooling and moulding.

On the Ryobi however, we can see where they have made a few design decisions to make the overmoulds easier to injection mould and they have turned potential faults into features. Nothing is wrong with how Ryobi has designed their overmoulds, in fact, it is the advised way to design them.

- Overmoulding flush with the substrate is prone to flashing, as such, it is advised to always run a 0.30mm to 0.75mm ledge or a grove in the overmould or the substrate to give the overmould tool a surface to 'shut-off' on against the substrate component.

- Further, Ryobi has textured the drill's grip, as this is an easy yet effective way to hide potential cosmetic blemishes (e.g., sink marks, or weld lines) when moulding.

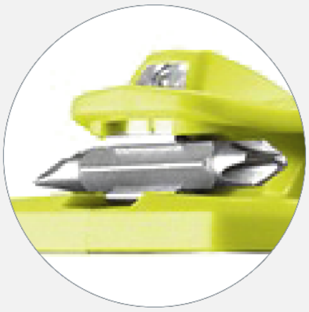
Drill Bit Holder / Lights / Handles – Product Features:

Beyond their primary use, both companies have built additional product features into their drills. The Ryobi features a drill bit holder, light, depth gauge, and handle. Conversely the Hilti has fewer, with just a light and a handle.

The inclusion or exclusion of these additional features aligns with each company's respective brand identities. Namely, you would not design a Hilti drill with a bit holder and a depth gauge because those features wouldn't be utilised in a professional environment.

For both, incorporating additional product features comes at an increased design, tooling, and manufacturing cost. Though by examining how they incorporate the features provides insight into what priorities each company had when designing their drills.

Drill Bit Holder:



- However, it can also be deciphered that keeping manufacturing and assembly costs low is Ryobi's main priority here as instead of overmoulding the drill bit holder in-place which would've required paying an operator (or using a robot) to place the component into the tool, or designed it to be along the side of the product which would've required further components and assembly, the holder has simply been assembled along the line where the two housing halves meet – meaning that when the drill is assembled this component is placed in loosely until the opposing half is assembled over the top of it.

Lights:

- Positioned forward facing to illuminate the workpiece being drilled, both drills have lights assembled along the centre join/assembly line of the housing halves.
    - As it makes logical sense to position the light in line with the drill chuck, this indicates that both companies have prioritised including this feature above saving costs, as it would have been cheaper to neglect having it.

Handles

- Comparing the two, the Hilti handle prioritises aesthetics over saving manufacturing expense. This conclusion is reached by seeing that the injection mould tooling that would be required to manufacture Hilti's circular handle clamp is more complicated and, if a comparable tool to the Ryobi handles' one, more expensive, requiring sliding cores and not being a simple open/close tool.

Ultimately, Ryobi has prioritised keeping costs down, and has likely include additional features at as little cost as possible to aid the marketability of their product to their chosen target market. Conversely, Hilti has favoured quality and functionality above reducing costs.

‘Ryobi’ and ‘Hilti’ – Logos:

Another indicator of cost cutting vs. favouring aesthetics and quality, is that the Ryobi drill has a cheap stick-on logo label whereas the Hilti logo is separately overmoulded into the side of the main housing, a feature which requires its own injection overmoulding tool.

Having a comprehensive understanding of how things are manufactured allows you to avoid problems before they arise, but also teaches you how fix them when they spontaneously come about.

The curse of understanding how products are manufactured is that you’ll often pick up things in stores and see ways that it could have been designed better, or made for less without sacrificing quality. Worse yet, is that you’ll start to notice how much you’re being ripped off.

Ultimately, if you want a product to be designed correctly, it needs to be designed by someone who understands manufacturing, otherwise you might end up with a very overpriced CAD file that has no real-world application. At Dienamics, we see this as our main selling point, we have the industry experience and the knowledge to be able to make you product to your optimum standards.