The power
of design for assembly

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At IDC, we've had a few projects recently where design for assembly has been the critical factor in developing the next generation of products for clients. With this in mind, we asked IDC's MD, Stephen Knowles, to advise about how to achieve the best solutions and give some top tips.

Q: Why is design for assembly so important?

A: "Design for assembly is important because a large proportion of the product's cost is in manufacturing. Production and assembly can be time consuming, and equally, it can lead to quality problems if the assembly process is complicated with too many steps. In short - it has potential to go wrong if not properly planned and tested!

Part of the product design process is to define the requirements of the product - it's not just visual, it's manufacturing methods, volumes, costs, quality and reliability. By planning manufacturing right at beginning, alongside functional engineering, you can ensure that your design is going to fulfil the criteria. Assembly requirements should be in the product requirement specification and you should aim to make assembly processes as simple and foolproof as possible."

Q: So what are the benefits?

A: "Reduced product costs and improved reliability are the two big gains. There can also be benefits of sustainability too as you're not necessarily just designing for assembly, but often you're designing for disassembly, service and for reuse - which must be considered at the same time. Sustainability can be a real advantage to a product in being able to keep it going for longer and making it suitable for repair and maintenance."

Q: Where do you start as a product designer when you are looking at simplifying a process for assembly?

A: "Well you start by working out what the requirements for the product are. For example, if it is a low cost high volume mass market device you'd be looking for reliable, low cost assembly. In this case it's sometimes about designing for automated assembly, not just thinking about the assembly process, but designing so that these processes can actually be automated. Then it's integrating features into parts that can be aligned by machine. Designers need to design features (such as snap or rib features for correct positioning) to simplify assembly and make parts as self-aligning as possible. This is the level of detail that needs to be applied to ensure the best solutions - and it becomes so technical that it's a specialist discipline in itself!

At the other end of the scale you've got the high value equipment such as laboratory instruments, that are made in relatively low numbers, but often include electrical and precision components that need to be put together by hand. These are often packed into a relatively small space, so it's important to understand the order in which things fit together, and how easily they fit into the housing. The fixings are also important - if you've got to get the screws into the bottom of the hole, can you get access to it or might there be a better solution?

It's often good to try and make the assembly as modular as possible so that much of the assembly happens away from the main body of the product. This means you could assemble one particular module with lots of space around it and then assemble another module with the first module so that these two modules simply get slotted into the main product. This can help greatly with the assembly process and can also benefit servicing and maintenance, because if you have a problem with the machine, the service engineer can quickly switch modules for repair and then repair the faulty module back at their workshop. Sometimes the end user can take the module out so that manufacturers can just ship a new part to the customer, saving more time and expense. Modular products can be really useful for keeping maintenance costs low and sustainable."

Q: Is research important when designing for assembly?

A: "Yes, when establishing the product requirement specification at the beginning we need a thorough understanding of manufacturing volume requirements, assembly location, the skills of the people making it and the assembly process itself. Obviously the target cost is a big factor anyway so that tells you how much time can be allowed for these kind of assembly processes. We work closely with clients to understand the process inside-out - we will go on site, speak to staff on the production line and thoroughly understand how we can refine and improve the design to simplify assembly, improve quality, save time and cut costs."

Q: How does quality come into the process?

A: "Quality comes into this process throughout. When we develop a product we would typically do a design FMEA (Failure Modes and Effects Analysis). Then we can also, with the manufacturer, do a process FMEA which is looking at the processes and what could go wrong. If you were just looking at the design, you'd look at all the components and you'd look at all the ways in which they could fail and obviously how they could potentially be misassembled too.

When products are hand assembled, we need to ensure that they are assembled exactly the same every time because the reliability and safety of a device depends upon it being right and this is very much a quality issue. So then we are thinking about that design from a manual point of view. We are thinking about what jigs and fixtures would be necessary to facilitate repeatable and reliable assembly processes.

When we developed the AP Advance Video Laryngoscope for Venner, we actually manufactured the first fifty units here at IDC. In the process of doing this, we manufactured a number of jigs that would help hold the PCB in the right position while certain parts were fitted. Jigs and fixtures can be a good way of making manufacturing precise and efficient. Jigs are bits of specialist equipment, designed specifically to do a certain job that will help the assembling of the parts.

To ensure quality and reliability during the actual assembly process, there are common design tricks you can use. For example, poka-yokes can be used, which are any type of mechanism to help an operator avoid mistakes when assembling components. They are designed to eliminate misassembly by preventing, correcting or drawing attention to errors as parts are assembled. A poka-yoke could be added to a component which looks like it is basically symmetrical or round, but by adding a feature, the operator can recognise the correct position for it to be fitted and it cannot be fitted in any other orientation.

Alternatively it may be possible to deliberately design parts to be symmetrical, so alignment doesn't matter. This can be really useful in speeding up the assembly process. Allowing lead-ins into holes and shafts can be helpful, so that if something is a close fit before it gets to the tight stage there's an opening that actually channels and self-aligns the component before it's pushed in tight.

So thinking about the way that things can go wrong and actually anticipating these in the design is a key principle. Prototyping is also an essential stage when designing for assembly. It means that designers get to assemble the products in the design stage and in building the prototype you understand some of the difficulties that are likely to be experienced by the people on the manufacturing line. Prototyping means that the design and assembly can be refined and tested to find the optimum solution. At the transfer to manufacturing stage, we often make jigs for trials, as well as modelling the assembly process for later on."

Q: What's the impact of reducing components and assembly steps?

A: "If you can get one part to perform multiple jobs, you not only reduce the number of parts but also reduce the amount of assembly work and reduce the possibility of misassembly too. Sometimes you can get components reduced by combining structural parts using injection moulding.

We worked on a project to develop a new lighting product for Strand – the original product had 49 components, which included time consuming parts that had to be fitted together with numerous screws. A priority of the project was to reduce the number of components to speed up manufacture. By looking at ways of integrating parts using injection moulding, the team was able to reduce the component count to just 17 pieces. Assembly time was dramatically reduced and quality defects decreased."

Q: Is simplicity best?

A: "For the majority of projects, simplification of components is the best way forward when designing for manufacture. Fewer parts means less time, and less opportunity for things to go wrong during assembly, but this is not always possible with incredibly complex devices which just can't be simplified. It's the ideal principle though. In these cases, assembly solutions such as jigs and fixtures can help speed up the assembly process and ensure quality. Prototyping and testing the production process is essential to understand what impact different solutions have."

Top Five Tips when Designing for Assembly

1. Think about manufacturing and assembly right at the start. It must be part of the design process, alongside visual and user needs.
2. Understand the volumes and nature of the product and assembly requirements. Is it high volume, single use or will maintenance and repair be needed?
3. Think about what could go wrong and design to avoid it. How could careless assembly cause problems? By anticipating problems, it's possible to design solutions to avoid misassembly.
4. Prototype & test the assembly process to check and refine the assembly.
5. Liaise with manufacturers as each one has different preferences and skills etc.

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