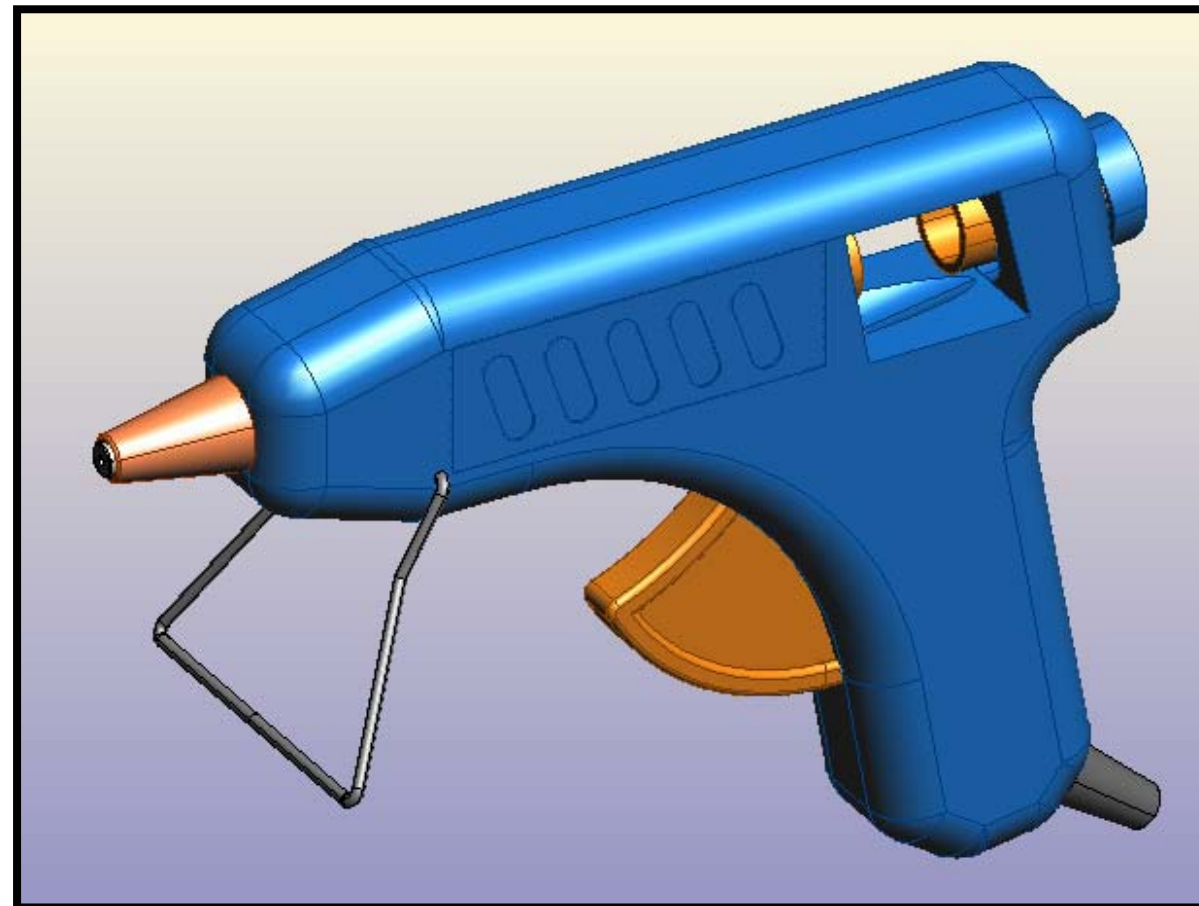


GCE Design & Technology:
Product design

Resistant Materials Technology - Exemplar Sample

Product investigation:
HOT MELT GLUE GUN



Performance analysis

Before designing the hot melt glue gun, the designer would have developed a specification consisting of points that had to be met in order to produce a successful prototype and these points would have been referred to throughout the design / development / manufacturing stages. As the specification is used to check 'specific' points, technical, measurable points would be included wherever possible.

Specification for the Glue Gun

Function/purpose

- The purpose of the glue gun is to deliver a controlled amount of hot glue from a nozzle when the trigger is pressed.

User requirements

- The glue gun must be safe to use, so that users are insulated from mains electricity supply and from the internal heat generated inside the gun.
- It should be lightweight so that it can be easily held and controlled while in use
- It should be maintenance free, so that no technical knowledge is required to use it.
- It should be robust and well assembled so that it will stand up to the day to day rough treatment it may receive.

Scale of production and cost

- The glue gun will be designed to be batch produced in relatively high numbers rather than mass produced, as the design may need change quickly to accommodate market trends.
- The design must be simple enough to be produced using fast automated processes, so that costs to users can be kept as low as possible.
- The materials and components used should be capable of being continuously sourced so that production processes are not held up during production runs.
- The cost of the glue gun in this analysis is £7 - 99

Performance requirements

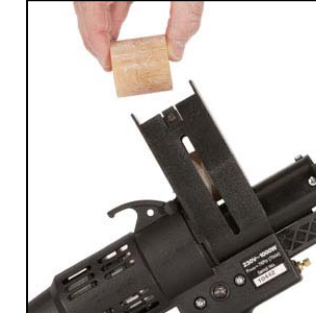
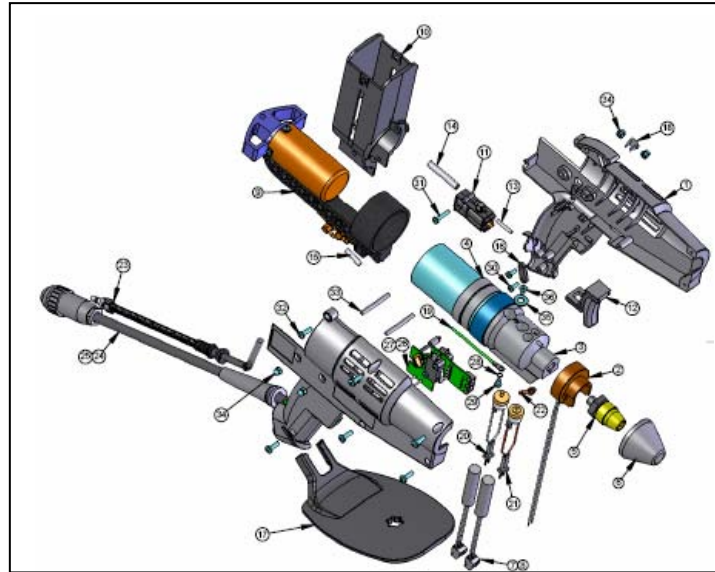
- The glue gun must be ergonomically designed so that it is comfortable to hold and does not produce strain on the hand of the user.
- The glue gun must be capable of producing heat internally of 180° C. so that a range of glue stick materials can be used.
- The heat produced externally must not be great enough to burn the user when used appropriately and must not be felt in the handle.
- The trigger mechanism must produce mechanical advantage so that melted glue is ejected from the nozzle with little effort.
- The volume of glue delivered should be adjustable and dependent on movement distance of the trigger.
- Glue sticks must be easily added when needed, so that gun use is not interrupted.
- The inside parts of the gun should only be accessible through the use of special tools, so that general users cannot gain access to potentially dangerous parts.
- The gun must be capable of being 'parked' in a stable position when in use, so that it does not fall over and become a potential hazard.

Materials

- The materials used for the body of the glue gun must be capable of being formed into complex shapes quickly, so that the production time of each gun is short.
- The materials used must be light, so that the overall weight of the glue gun is kept low.
- The materials should be readily available and relatively cheap so that production costs can be minimised.
- The materials used must be tough and long lasting so that they can withstand consistent use over a long time period.
- The materials used must insulate the user from internal electrical connections and heat produced during glue stick melting.

Comparison with a similar product

Industrial cordless pneumatic spray hot melt glue gun



The hot melt gun shown above has a similar function to the one under analysis. But it uses compressed air to spray hot glue from its nozzle. In comparison with the glue gun under analysis, the designer will have considered the following points when developing the specification:

Function/purpose

- The purpose of the glue gun is to spray an adjustable amount of hot glue pneumatically from a nozzle when the trigger is pressed.

User requirements

- The glue gun must be safe to use, so that users are insulated from mains electricity supply and from compressed air as it passes through the gun.
- It should be comfortable to hold and easy to use so that it can be used for long periods without discomfort.
- It should be maintenance free, so that no technical knowledge is required to use it other than knowing how to change nozzles and adjust heat and pressure settings.
- It should be robust and technically reliable so that it will stand up to the heavy duty use it will receive.

Performance requirements

- The glue gun must be ergonomically designed and well balanced so that it is comfortable to hold and does not cause problems of tiredness through all-day use.
- The glue gun must be capable of producing heat internally of 200° C. as this is the temperature requirement of the glue cartridges.
- The trigger mechanism, when operated, must immediately connect to the compressed air supply so that the hot glue spray is instantaneous.
- The volume of spray glue delivered must be adjustable for force and heat by the user.
- There must be a range of easily interchangeable spray nozzles so that spray pattern can be adjusted.
- The gun should have a built in speed-loader so that glue cartridges can be loaded automatically while the gun is in use.
- The inner components of the gun should only be accessible to maintenance experts, so that users cannot gain access to potentially dangerous parts.

- The gun must be capable of being 'parked' in a stable position when in use, so that it does not fall over and become a potential hazard or suffer damage.

Materials

- The materials used for the body of the glue gun must be capable of being formed into complex shapes quickly, so that the production time of each gun is optimised,
- The materials used must be light, so that the overall weight of the glue gun is kept as low as possible.
- The materials used must be very tough and long lasting so that they can withstand continuous use on a commercial scale over a long period of time.
- The materials used must insulate the user from internal electrical connections and pneumatic power during glue gun use.

Scale of production and cost

- The glue gun will be batch produced as it will be sold in a specialist market place.
- The design must be appropriate to fast automated production processes, so that costs to users can be kept as low as possible.
- The materials and components used should be capable of being continuously sourced so that production processes are not held up during production runs.
- The cost of the glue gun in this comparison is £596. 95

Materials and components

Glue stick guide –
moulded from
polyamide

Heating chamber – cast
from zinc alloy

Body – Injection
moulded from
HDPE

Nozzle
cover –

Trigger mechanism –
moulded from ABS
monomer

Stand – bent
from plated



The external body casing

The material used in manufacturing the body of the glue gun is High Density Polyethylene (HDPE). This material has properties that make it suitable for this product such as:

- Good impact resistance
- Good resistance to chemicals
- Light weight
- High tensile strength
- Flexible – not brittle
- High melting point – can accommodate outside temperature of heating chamber
- Good electrical and heat insulation properties
- Good flow characteristics – suitable for moulding
- Halves of gun casing can be joined mechanically – screwed for access
- Can be pigmented and is available in a range of colours.

A suitable alternative material for the body could have been aluminium alloy, which has the following properties:

- Very good impact resistance
- Resistant to corrosion
- Good strength to weight ratio
- Strong in compression and tension
- High melting point – much beyond the requirements of the gun body
- Good conductor of electricity and heat
- Can be formed to high quality finish when die-cast
- Halves of gun body can be moulded to include fixings for joining parts together
- Can be coloured using anodising or painting.

When comparing HDPE and aluminium for use in manufacturing the glue gun body, HDPE is the preferred choice for the following reasons:

- Both materials have good impact resistance, strength to weight ratios, rigidity and appropriate melting points to cope with the heat generated inside the heating chamber, but aluminium has these properties at levels that are far above what is required from the gun body, which is unnecessary
- Both materials can be moulded into complex shapes to a high finish and any rejected mouldings can be recycled in both cases. However, the cycle time for moulding HDPE is lower and the plastic moulding process and material used, produce a cheaper product for the market place.
- Both materials can be coloured, but anodising is a much more expensive and lengthy process than adding pigment pellets to the plastic granules during the moulding process. Painting also adds time and cost to manufacturing.
- HDPE is a natural insulator of heat and electricity, while aluminium is an effective conductor of heat and electricity, so if the gun body was made from aluminium, there would be significant health and safety risks to address, particularly over a long period of time.
- Cost comparisons show that aluminium is more expensive than HDPE, which means that an HDPE body would be a cheaper alternative to aluminium.

Trigger Mechanism

The material used in the trigger mechanism is Acrylonitrile Butadiene Styrene comonomer (ABS), which is appropriate to the requirements of the trigger mechanism; properties include:

- High impact strength
- High mechanical strength
- Good dimensional properties – retains shape and size over time and conditions
- Maintains high quality gloss finish
- Properties can be modified to suit needs, by adjusting % content of Acrylonitrile, Butadiene and Styrene monomers
- Can be coloured easily through pigmentation
- Can be moulded easily – good flow characteristics
- Moulded parts can be ‘snapped’ together to form joints.

An alternative material that could have been used for the trigger mechanism is Acrylic, which has most of the same properties as ABS, but has these differences:

- It is brittle and has low shear strength, which means if the glue gun is dropped, the trigger could break.
- Acrylic sheet products can be made attractive by using the ability of the edges to transmit light and colour, but the material scratches easily and the trigger on a glue gun is functional rather than aesthetic.
- Acrylic has less dimensional stability than ABS, so moving joints on the trigger mechanism could fail over time.

Although these two materials are similar in several respects, ABS is the preferred choice of material for the trigger, because overall, it is tougher, more dimensionally stable and is not as brittle as acrylic.



The material used in the nozzle cover and glue stick guide is polyamide (nylon), which has the following properties:

- Very durable and strong in tension
- High elongation and recovery – can stretch without work hardening
- High abrasion resistance – can rub against other materials without deterioration
- Highly resilient – not easily damaged
- Good resistance to chemicals
- Self lubricating
- Flexible when thin walled

An alternative material that could be used in the production of the nozzle cover and glue stick guide is rubber. The properties that make rubber appropriate are:

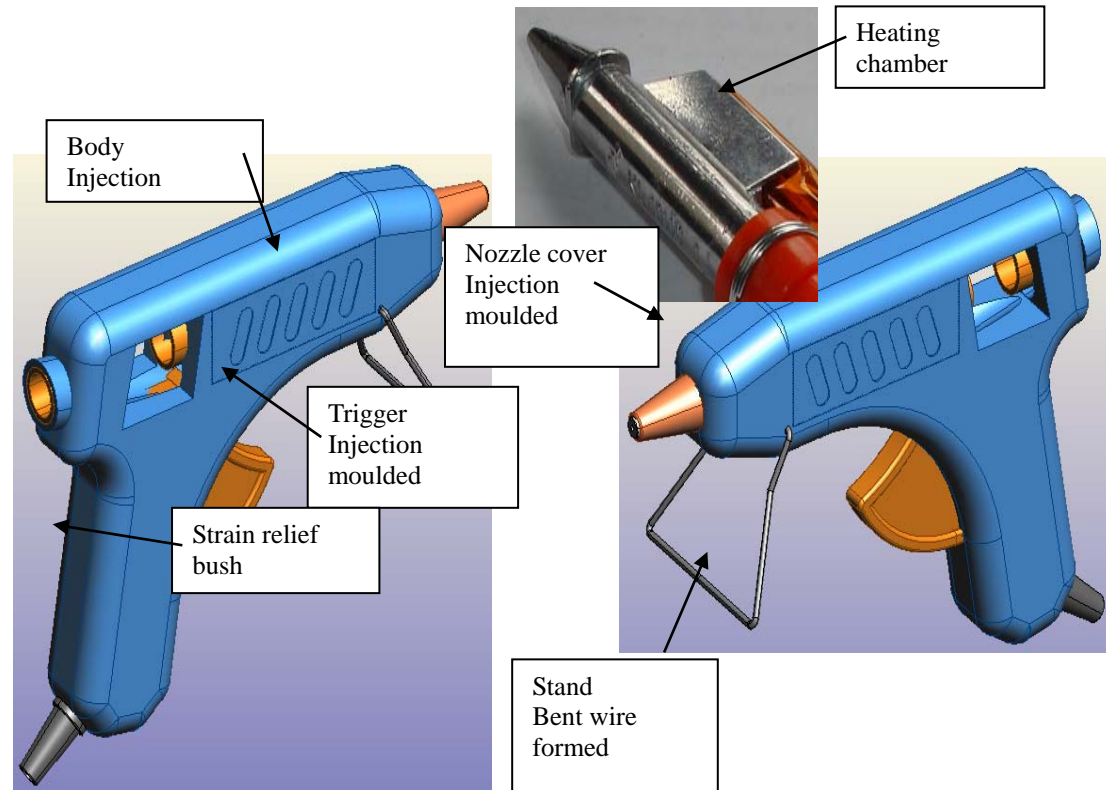
- It is very flexible - can move to accommodate glue sticks as they are replaced
- It has a high elastic limit - can stretch further than any polymer
- It has a high gripping (friction factor) for holding components/materials.

The preferred choice of material for the nozzle cover and glue stick guide is polyamide, because rubber needs additives such as silicone to make it into a useful engineering material; rubber's ability to grip and produce friction would hinder the movement of the glue stick when the trigger was pressed and rubber is less stable than polyamide, as it can become brittle over time with exposure to sunlight and it loses its elastic properties at low temperatures.

Nozzle cover and glue stick guide



Manufacture



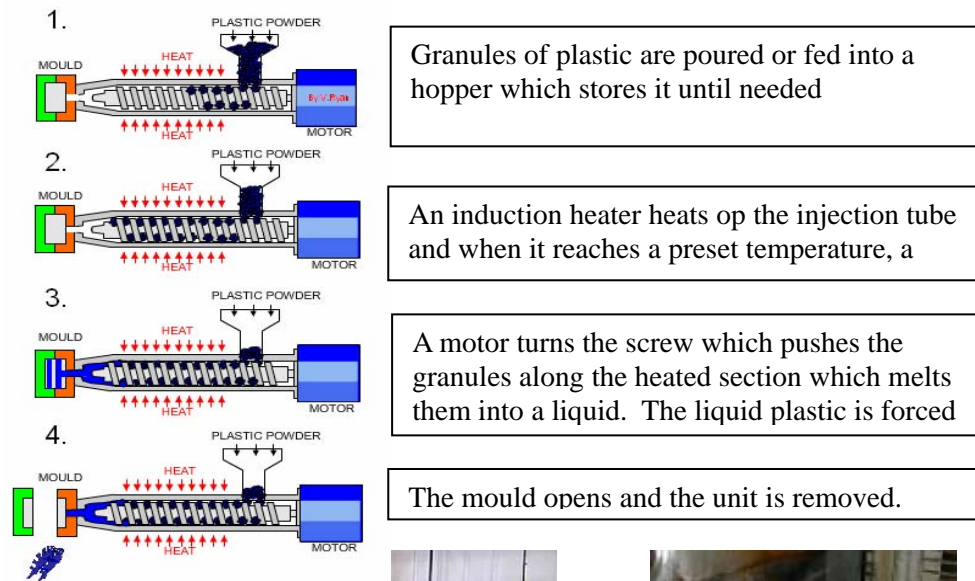
The diagram above labels the manufacturing processes of each component part of the glue gun. The main process used is injection moulding, which is the most common process for forming thermoplastic materials. The advantages of injection moulding are:

- Almost all thermoplastics can be injection moulded
- Complex geometry and fine features are easily produced because very high pressures are possible
- Very thin walled parts are easily produced
- Cycle times are very low – only a few seconds
- Many parts can be made from a single mould – millions of parts per year are possible
- Very little finishing is required beyond removal of runners
- Reject components are recycled and reused – no waste
- Locating pins, holes for screws and fittings and metal inserts can be moulded integrally
- Injection moulding machines are usually automated, so are cheap to run – a single operator can look after more than one machine
- Costs per unit moulded are small once mould costs are recovered

The disadvantages of Injection moulding are:

- Large undercuts cannot be formed e.g. bottle shapes
- Capital equipment and set-up costs are high
- Mould costs are high, so low volume manufacture of parts is uneconomic – most parts produced exceed batches of 100,000 per year
- Machinery requires skilled maintenance, which can be costly – down time means that production halts

A simplified illustration of the injection moulding process is shown below.

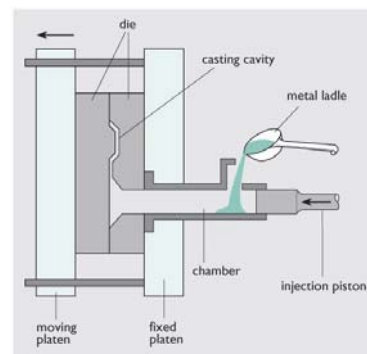


For HDPE, ABS and polyamide, the chosen plastic materials for the glue gun, there is no other alternative production process that could be used. However, if the body was to be made from aluminium alloy, as discussed earlier. The process of die casting could have been used, which is the same process used to produce the heating chamber, except that pressure die casting would be used to produce details of surface texture and finish.

Environmental considerations

The processes involved in manufacturing the glue gun can have detrimental effects on the environment and these include:

- Using valuable non-renewable resources such as fossil fuels
- Contributing to global warming through emissions of greenhouse gases
- Packaging and transportation contribute to resource wastage and pollution
- Using 'new' materials instead of recycling and re-using



Pressure die casting is a development of gravity die casting in which molten metal is injected into a steel mould under pressure; it is the metal equivalent of injection moulding. The diagram opposite shows how the process operates. Molten metal is poured into a chamber; the injection piston is pushed forward, usually hydraulically, forcing the metal into the mould where it solidifies. The casting is removed and any necessary finishing is carried out. Fine detail and thin sections can be produced using this casting method.

Quality

During manufacture, the glue gun will have been put through a range of quality control checks to ensure that at each stage, component parts were manufactured to the highest standards possible. These include:

- Raw materials checked for quality and consistency – uniform colour and pellet size of HDPE
- Check machine for correct function and set-up – correct settings for material delivery, heat levels, pressure.
- Check mould for perfect internal finish, defects, debris – ensure it opens, closes, aligns properly
- Check electrical safety of all equipment
- Check quality of moulding when produced visual check – computer check for dimensional accuracy and shape
- Check moulding for required qualities of toughness, flexibility resilience – test to destruction
- Check trigger assembly for function – leverage, ease of use, robustness – destructive test
- Check heating chamber for temperature levels and electrical insulation
- Check assembled glue gun for function as designed – time taken to heat to required temperature, flow rate of hot glue when triggered, ease of changing glue stick
- Check for residual heat levels in the gun body – ensure they are below stated tolerances
- Check stability and safety in use of glue gun when parked

Quality control is part of a 'quality assurance' system which is designed to ensure that the product leaving a factory is of the highest all round quality possible. A quality assurance system could be designed as follows:

Codes of practice

Comply to commonly agreed principles of good practice, rules, standards relating to specific manufacturing industry

Customer requirements

Understand current and future customer needs, strive meet and exceed customer expectations

Focus groups

Quantitative research where groups of people are asked about their attitude towards products

Regulations compliance – external agencies

ISO, consumer association, trade associations, health & safety executive

Standards and regulations

All manufacturing companies must comply to certain standards and regulations during the management and manufacture of their products. During the manufacture of the glue gun, some of the standards that would be in place are:

- International Organisation for Standardisation (ISO) – ensures compatibility, quality and conformity
- ISO 9000 – refers to quality management
- ISO 14000 – sets standards on quality and the environment
- ISO 294: 1996
- ISO 1873: 2007 } Standards for plastic moulding and extrusion
- ISO 15103: 2007

British Standards Institute (BSI) kitemark and the CE mark are important standards of quality that manufacturing companies strive to be awarded. The CE mark confirms that products meet EU directives.