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10. Check list

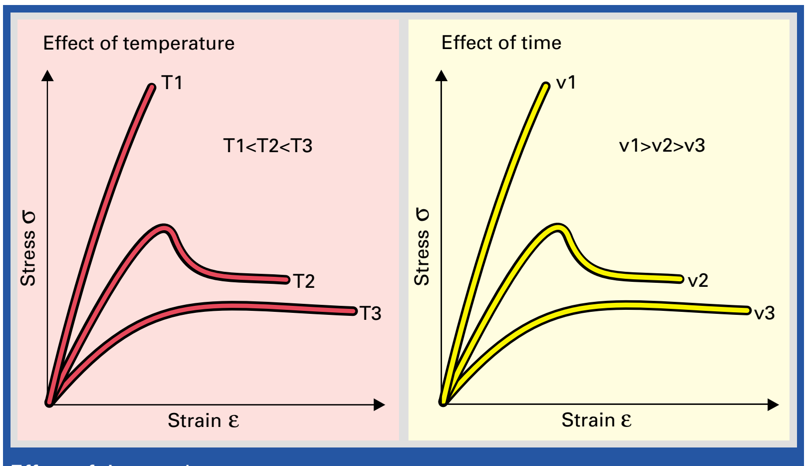
Some Guidelines

Design check list – The aim of new product development or further development of an existing product is to achieve a technically good design that can be produced at an economic cost. The main design tasks involved here are material selection, choice of a suitable production process, strength calculation and moulding design.

A high-quality, commercially viable moulding can be produced only by giving full consideration to each of these design steps and following them through systematically. Design departments often seek only a functional solution. It has to be stressed, however, that the functionality and cost-effectiveness of a plastic component cannot be taken for granted unless designers pay proper attention to developing the right solutions for the material and the production process.

A plastic's properties are not immutable material constants

The property profiles of plastics can be influenced by the service environment, production process, moulding design and operating conditions (Fig. 1). Plastics properties are determined in tests under laboratory conditions. Test bars are produced in highly polished moulds with optimized parameters and tested under standardized conditions with precisely defined stresses. In practice, however, plastic components are never produced exactly under such conditions and are not exposed to precisely the same stresses in service. For these reasons, when setting out on any plastics design project, the exact requirements and boundary conditions must be carefully analysed and listed. A design check list can provide useful assistance here (Fig. 2).



Effect of time and temperature on deformation behaviour

Fig. 1

Production of prototypes

To develop a component from the design phase to market-readiness, it is generally necessary to prepare prototypes for trials and modification. Care should be taken to ensure that the method used to prepare the prototype is broadly similar to the intended full-scale production method. Prototypes for parts that are to be produced by injection moulding should also be prepared by injection moulding. If no mould is available, it is sometimes necessary to resort to machined trial components. However, this is not always without its problems, for the following reasons:

– the effect of weld lines in the injection moulded part cannot be studied
– the grooves produced by machining can sometimes considerably reduce strength properties compared with those of an injection moulded part
– the strength and rigidity of extruded bars and sheets can be higher than those of an injection moulded part on account of higher crystallinity
– the effect of fibre orientation cannot be studied.

A. General
1. Function of the component
2. Possibilities for modification and integration (increase in functionality)

B. Service conditions
1. Stresses: type, duration, level
   - static, dynamic
   - short-term, long-term, intermittent
   - maximum and minimum values
2. Service temperature
   - maximum and minimum values
   - duration of exposure
3. Service environment
   - air – water – humidity
   - chemicals
   - UV stress
   - ...

C. Design requirements
1. Tolerances
2. Maximum permissible moulded-part deformation
3. Assembly – dismantling (joining techniques)
4. Specifications and approvals
   - official regulations
   - company's internal guidelines
5. Surface quality
   - permissible markings

D. Test conditions
All test methods that can be used to determine the performance and assess the quality of the plastic part should be listed in detail.

E. Cost efficiency
1. System or part costs for the old component assembly
2. Production quantity

F. Other
1. Environmental regulations
2. Safety factors
3. All additional information permitting a complete understanding of part functions and the service conditions, mechanical and environmental stresses and possible misuse that the part will have to withstand.

Design check list

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Fig. 2

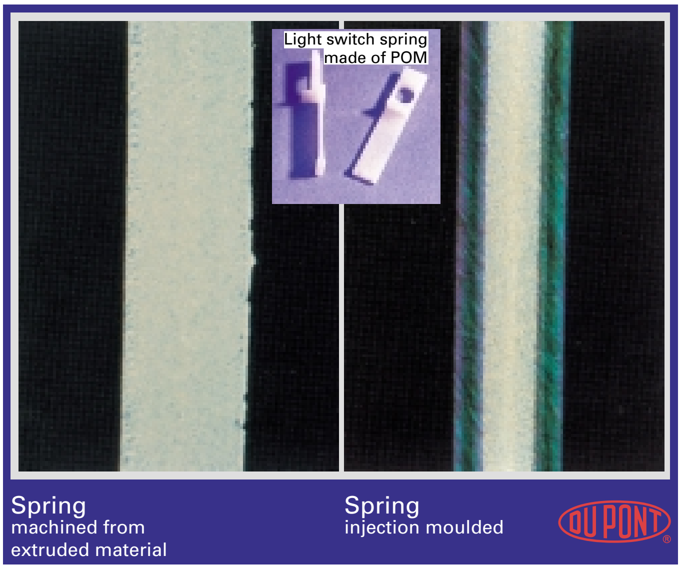

Fig. 3

The machined prototype for a spring in a light switch, produced from an extruded material, withstood 180 000 stress cycles without fatigue. The same part, when injection moulded, showed fatigue fracture after 80 000 stress cycles. The reason for the failure was the different crystalline structure of the injection moulding (Fig. 3).

Prototype moulds

To produce prototypes, existing pressure-diecast moulds or prototype moulds made from easily machinable or low-cost materials such as aluminium or brass are used. It should be kept in mind, however, that important injection-moulding parameters such as temperature and pressure cannot be reproduced with these moulds. In addition, their different cooling characteristics lead to different shrinkage and warpage behaviour. Preliminary production moulds made from hardened steel are recommended. These can be single-cavity moulds or a single mould cavity in a multi-cavity mould.

Testing plastics designs

With modern computer simulation techniques, such as strength analysis and flow analysis, potential weak points in the design or in processing can sometimes be identified at a very early stage. However, it is not possible to give a 100 per cent guarantee for the quality of the end product and its behaviour under real-life operating conditions. The most reliable information is always obtained by testing prototypes under real operating conditions. This type of testing should never be omitted with engineering parts that have to meet high functional and quality requirements.
If it proves difficult to test under the actual operating conditions, tests under simulated service conditions may also be used. The value of such tests, however, depends very much on how accurately the operating conditions can be simulated.
Time-consuming series of tests to assess long-term behaviour under the effects of mechanical stress or heat are sometimes impracticable or not commercially justifiable. On the other hand, predictions as to long-term behaviour on the basis of accelerated tests under harsher conditions are not always clear-cut and should be treated with extreme caution. The behaviour of a plastic under stress in a long-term test may be completely different from that determined in a short-term, accelerated test.

By Jürgen Hasenauer, Dieter Küper, Jost E. Laumeyer and Ian Welsh

Innovating with plastics

Many different applications from all industrial sectors demonstrate that the future belongs to plastics. If the material properties of polymers are intelligently exploited, then multi-functional components can be produced that are commercially and functionally superior to previous designs.

Today's designs require increasingly complex geometries and materials. Plastics can and will solve many different types of problem. It is important, however, to match the plastic to the application very carefully. Raw material (resin) manufacturers have extensive experience of this. Full use must be made of their expertise to translate new plastics design ideas into reality.

- Avoid material accumulations
- Aim for uniform wall thickness
- Design wall thicknesses as thin as possible and only as thick as necessary
- Use ribbing instead of greater wall thickness
- Provide radiusing
- Avoid flat areas
- Provide demoulding tapers
- Avoid undercuts
- Do not design to greater precision than required
- Design multi-functional components
- Use economic assembly techniques
- Gate mouldings on the thickest wall

When replacing metals,
redesign is always necessary.

Rules for designers
of plastics parts

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Fig. 4

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