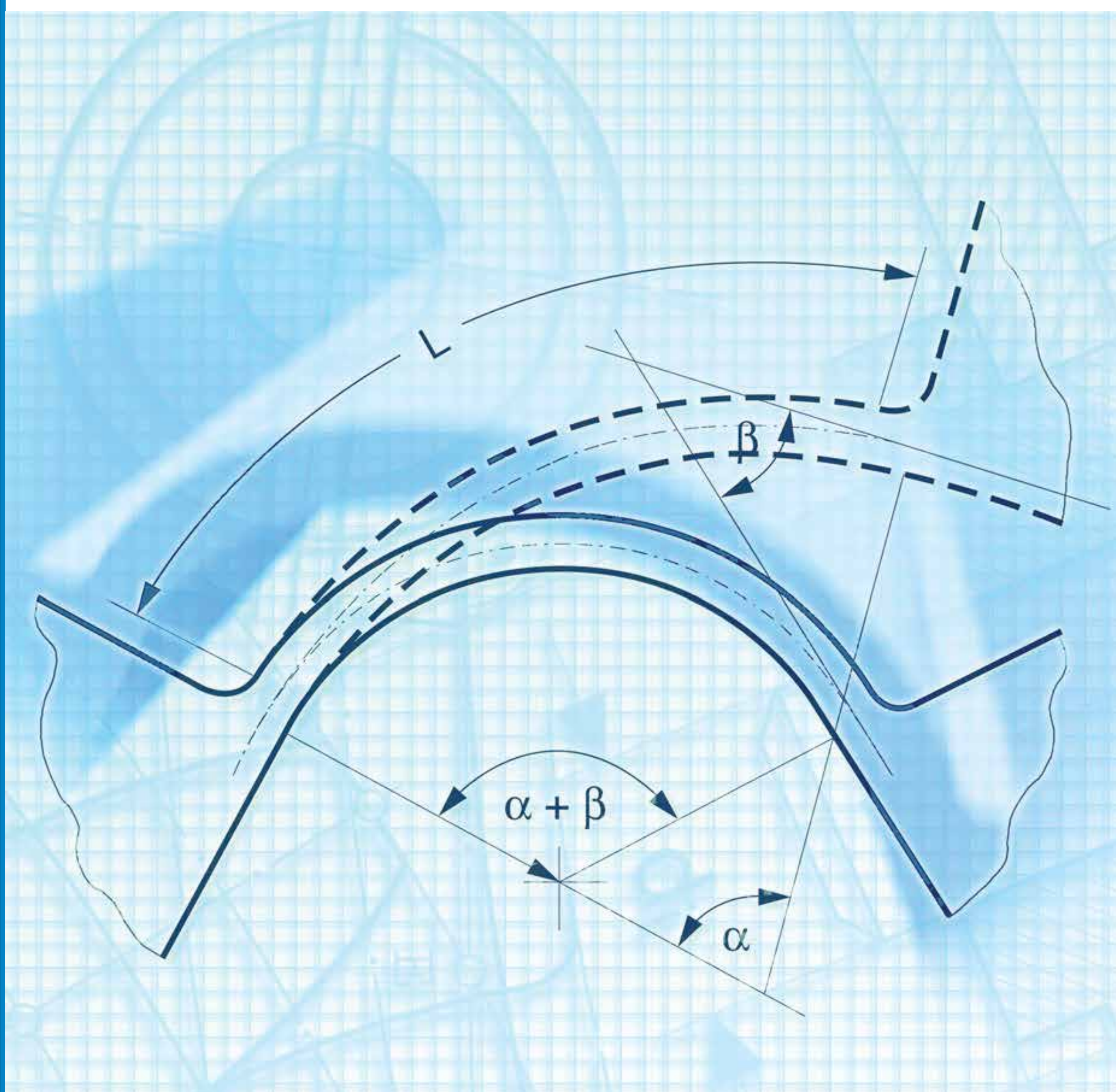
CALCULATIONS · DESIGN · APPLICATIONS B.3.5

MAS RUSPLAST

Integral hinges in engineering plastics



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Contents

®Hostaform
acetal copolymer (POM)

®Celanex
polybutylene terephthalate (PBT)

®Hostacom
reinforced polypropylene (PP)

®Hostalen PP
polypropylene (PP)

®Hostalen
polyethylene (PE)

® = registered trademark

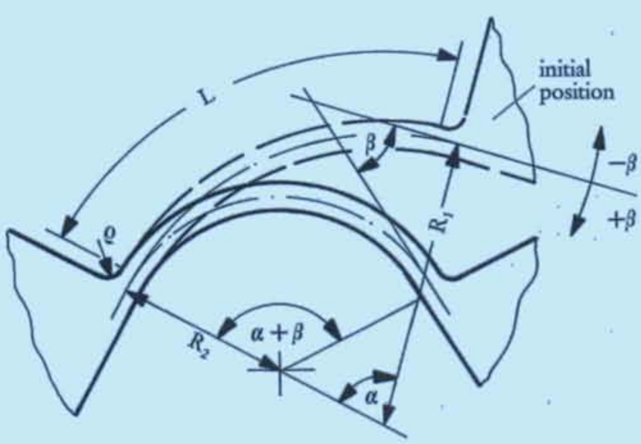
1. Introduction

Various designs of integral hinge are used for many different applications but they all utilize a principle that depends on some typical properties of plastics: high toughness, ductility and flexural fatigue strength. The number of flexes an integral hinge can withstand varies between one and several million depending on requirements.

Integral hinges are flexible connections between two movable parts made from thermoplastics. The complete assembly is produced in one piece from the same plastic without additional connecting points and is classified as a spring joint [1]. In these joints designed as flexural spring elements, the aim is generally to achieve the lowest possible restoring force (fig. 1).

Integral hinges have no mutually sliding surfaces. They are thus wear-free with low internal friction. Their disadvantages are the limited loadbearing capacity of the joint due to low hinge thickness h and the dependence – common to all thermoplastics – of mechanical properties on time and temperature.

Fig. 1: Illustration of integral hinge dimensions



2. Requirements for integral hinges

Requirements for integral hinges vary according to the number of flexes required N, the flex angle β and the flex frequency f. Whereas, for example, in the mounting of the cutting head for an electric razor high flex numbers N with a low flex angel β and high flex frequency f are required, integral hinges are often used as assembly aids where the hinge needs to be flexed only once or a few times through a relatively large angle. For this purpose, high material toughness – even at low temperatures – is generally required.

3. Method of manufacture

Components with integral hinges are normally injection moulded. In addition, extrusion blow moulding has acquired some considerable importance in the production of double-walled boxes with integral hinges for sewing machines, measuring instruments, tools etc. [2]. It is also technically possible to extrude profiles with integral hinges, e. g. for glazing gaskets. Generally speaking, this process produces the final shape of the integral hinge. By subsequent plastic deformation of the hinge in an embossing operation, the loadbearing capacity, maximum permissible flex angle and maximum permissible number of flexes can be increased. Within certain limits, this increase is higher the higher the degree of streching λ (= ratio of original thickness h_0 of the hinge to the thickness after coining h) in the hinge area. The maximum achievable degree of stretching depends on the embossing conditions, particularly on temperature and deformation rate, and varies according to the particular thermoplastic. Polypropylene is particularly suitable because it undergoes a structural transformation between about 80 and 140 °C [3] which brings a corresponding improvement in hinge properties. This characteristic means that – assuming correct hinge design – the structural transformation produced on flexing the hinge for the first time after injection moulding is sufficient to increase the loadbearing capacity of the hinge significantly.

4. Materials and material modifications

For integral hinges required to withstand high flex numbers, materials with good fatigue properties are suitable. Partially crystalline thermoplastics have better fatigue properties than amorphous thermoplastics. A good indication of fatigue behaviour is provided by fatigue strength. This is the relationship determined in the fatique test (DIN 53 442) between stress amplitude σ_a and deformation amplitude ε_a and the number of cycles to failure N of the test specimen. Among the Hoechst AG thermoplastics, the following exhibit good fatigue behaviour:

- ®Hostalen (polyethylene)
- ®Hostalen PP (polypropylene)
- ®Hostacom (reinforced polypropylene)
- ®Hostaform (acetal copolymer)
- ®Celanex (polybutylene terephthalate)
- ®Vandar (impact-modified polybutylene terephthalate).

Within each product range, high-molecular-weight grades with a narrow molecular weight distribution have better fatigue properties. On the other hand, melt flowability is limited with these products. It is therefore necessary to test in each individual case whether a particular component can be completely filled in injection moulding despite the integral hinge acting as a flow obstacle.

The incorporation of fillers and reinforcing materials generally results in inferior hinge properties, i. e. poorer fatigue behaviour and reduced ductility as toughness declines. In this respect, spherical fillers (glass microspheres, calcium carbonate, barium sulphate) and fillers with a foliated structure (talc) have a less adverse effect than fibrous reinforcing materials (glass fibres, carbon fibres). High permissible deformation amplitudes ε_a with high flex numbers N can be achieved by elastomer modification of the base material. Elastomer additions also improve hinge properties in formulations containing fillers and reinforcing materials.

5. *Designing integral hinges*

5.1 *Integral hinges without post-mould flexing*

5.1.1 *High flex numbers required*

These integral hinges are dimensioned on the basis of the Wöhler curves $\sigma_a = f(N)$, fig. 2 obtained in the fatigue test. The deformation amplitude can be assigned by calculation to the stress amplitude σ_a.

From $\sigma = \varepsilon \cdot E$ and $\sigma = \frac{M}{W}$ where $W = \frac{b \cdot h^2}{6}$ we obtain

$$\varepsilon_a = \frac{\sigma_a}{E_S} = \frac{M_b}{W \cdot E_S} = \frac{6 \cdot M_b}{b \cdot h^2 \cdot E_S} \qquad (1)$$

ε_a	deformation amplitude (strain)
σ_a	stress amplitude
E_S	secant modulus from the tensile test
M_b	bending moment
W	section modulus for rectangular cross section $= \frac{b \cdot h^2}{6}$
b	width of the integral hinge
h	thickness of the integral hinge

In table 1, the deformation amplitudes obtained for flex cycle numbers $N = 10^6$ and $N = 10^7$ are shown.

For a given flex angle β (see fig. 1) and required flex number N, the hinge length L and hinge thickness h must be selected to ensure that the deformation amplitude ε_a obtained at N is not exceeded, i.e. the

$$\text{outer fibre elongation } \varepsilon_b \leqq \varepsilon_a (N) \qquad (2)$$

Assuming that the integral hinge is circular and that the circular shape is retained in flexing, then only the radius of curvature R of the circular arc changes. The radius of curvature R_1 of the hinge with starting angle α (fig. 1) is calculated as follows:

$$R_1 = \frac{L}{\alpha} \qquad (3)$$

$\sphericalangle \alpha$ measured in radians (rad)

Conversion from $\alpha°$ into α (rad):

$360° = 6.28$ rad
$1° = 0.01745$ rad
$\alpha = 0.01745 \cdot \alpha°$

After flexure of the hinge through the angle $\pm\beta$ then

$$\text{either} \quad R_2 = \frac{L}{\alpha + \beta} \quad \text{oder} \quad R_2 = \frac{L}{\alpha - \beta} \qquad (4)$$

$\sphericalangle \alpha$, $\sphericalangle \beta$ measured in radians (rad)

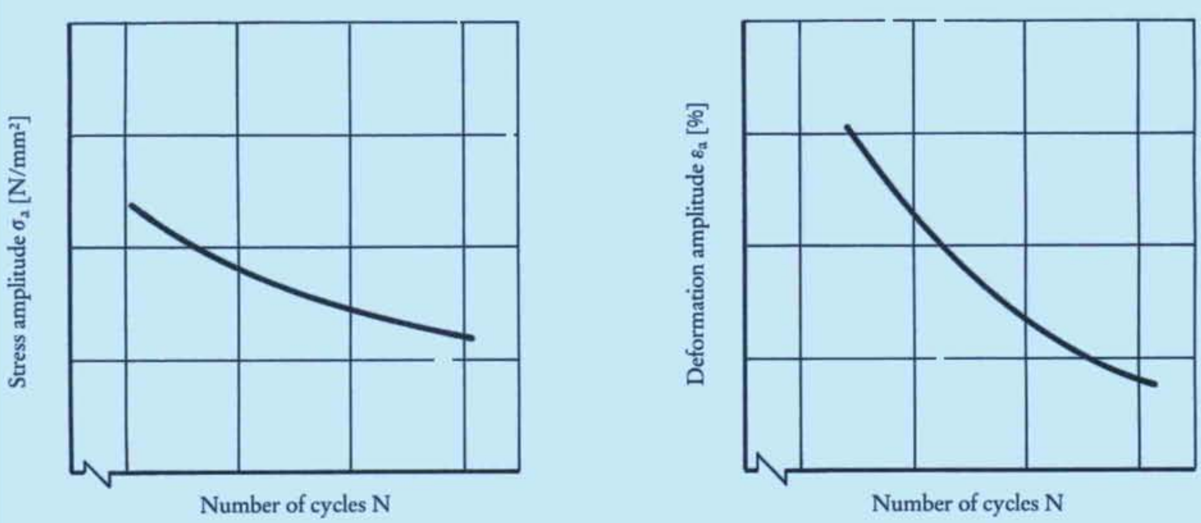
Between the outer fibre elongation ε_b and radius of curvature R the following equation applies:

$$\varepsilon_b = \frac{h}{2}\left(\frac{1}{R_1} - \frac{1}{R_2}\right), \text{ie} \qquad (5)$$

$$\text{for } +\beta \quad \varepsilon_b = \frac{h}{2}\left(\frac{\alpha}{L} - \frac{\alpha+\beta}{L}\right) \cdot 100\,\% \qquad (6a)$$

$$\text{for } -\beta \quad \varepsilon_b = \frac{h}{2}\left(\frac{\alpha}{L} - \frac{\alpha-\beta}{L}\right) \cdot 100\,\% \qquad (6b)$$

Fig 2: Wöhler curve and outer fibre elongation curve from the fatigue test (schematic)



For $R_2 < R_1$, we obtain negative values in brackets in equation 5. In further calculation, the absolute (ie unsigned) values of ε_b should be inserted.

The values quoted in table 1 for ε_a can be used as the basis for integral hinge design (after allowing a safety factor of S = 1.1 to 1.2):

$$\varepsilon_b = \frac{\varepsilon_a (N)}{S} \qquad (7)$$

Special attention should be given to the fillet radius ϱ at the transition between the moulding and integral hinge. The notch effect at this point can be reduced by suitable radiusing ("streamlining") (see C.3.3 Design of mouldings made from engineering plastics).

5.1.2 Integral hinges as assembly aids

Reliable dimensioning is ensured if the deformation ε_b occurring in the outer fibres does not exceed the deformation at yield stress:

$$\varepsilon_b \leqq \varepsilon_S \qquad (8)$$

Frequently, however, because of restricted space, greater deformation of the hinge must be expected.
Then it is important to ensure that the deformation ε_b is smaller than the elongation at break ε_R, see table 2.

$$\varepsilon_S < \varepsilon_b < \varepsilon_R \qquad (9)$$

In these cases, however, stress whitening may occur in the hinge area.

5.2 Integral hinges with post-mould flexing

An exact correlation between the degree of stretch achieved λ in embossing and hinge properties (maximum permissible outer fibre deformation ε_b, maximum permissible number of cycles N) is not yet possible. For this reason, integral hinges required to withstand a high number of flex cycles should be dimensioned for the "elastic" deformation range, $\varepsilon_b \leqq \varepsilon_S$, according to section 5.1.2.

Table 1: Stress amplitude σ_a and deformation amplitude ε_a (N) in the flexural fatigue range for Hostaform, Celanex, Hostalen PP, Hostacom and Hostalen

Material	$N = 10^6$		$N = 10^7$	
	σ_a [N/mm²]	ε_a [%]	σ_a [N/mm²]	ε_a [%]
Hostaform C 2521	46	2.6	34	1.7
Hostaform C 9021	40	2.1	28	1.2
Hostaform C 13021	37	2.0	26	1.1
Hostaform C 27021	34	1.5	19	0.75
Hostaform S 9063	48	4.0	39	3.0
Hostaform S 9064	33	3.0	26	2.0
Hostaform S 27076	21	4.0	19	3.0
Hostaform C 9021 GV 1/30	58	0.7	50	0.6
Celanex 2500	48	2.1	29	1.2
Celanex 2300 GV 1/30	35	0.5	30	0.3
Hostalen PPR 1042	28	2.7	24	2.1
Hostacom M4 N01	41	1.5	32	1.0
Hostacom G3 N01	32	0.65	27	0.5
Hostalen GM 5010 T3			21	2.3
Hostalen GF 7750			18	1.3
Hostalen GC 7260			6	0.5

For integral hinges which are to be flexed only once, the recommendations in section 5.1.2 apply. Structural transformation by once-only flexion should be confined to integral hinges made from polypropylene and its modifications. In this respect, PP copolymers behave more favourably than PP homopolymers. The tendency to white fracture is less with random copolymers than with block copolymers.

Table 2: Deformation at yield stress ε_S and elongation at break ε_R of Hostaform, Celanex, Hostalen PP, Hostacom and Hostalen

Material	ε_S [%]	ε_R [%]
Hostaform C 2521	9	35
Hostaform C 9021	9	28
Hostaform C 13021	9	25
Hostaform C 27021	9	20
Hostaform S 9063	9	60
Hostaform S 9064	9	90
Hostaform S 27076	9	> 150
Hostaform C 9021 GV 1/30	–	3
Celanex 2500	4	15
Celanex 2300 GV 1/30	–	2.5
Hostalen PPR 1042	13	> 400
Hostacom M4 N01	5	5
Hostacom G2 N01	10	50
Hostacom G3 N01	–	3
Hostalen GM 5010 T3	10	> 200
Hostalen GF 7750	10	> 200
Hostalen GC 7260	10	> 200

6. *Injection moulding of components with integral hinges*

6.1 *Processing conditions*

The integral hinge acts as a flow obstacle to the melt. The lower the melt viscosity, the more easily this obstacle can be overcome. For this reason, high melt and mould temperatures are an advantage. Since the viscosity of pseudoplastic polymer melts decreases with increasing shear rate, the injection rate should be as fast as possible. A sufficiently high mould temperature prevents over-rapid freezing of the melt in the hinge area. As a result, the hold-on pressure is able to be effective even in the mould section behind the hinge; in this way, sink marks can be avoided.

6.2 *Gate design and location*

The gate designs normally used in injection moulding may also be employed for components with integral hinges. Good hinge properties as well as high flex numbers can be achieved if the melt front reaches the hinge, if possible, at the same time across its full width and flows through it evenly and without delay. For this purpose, film gates or pinpoint gates, fig 3 are suitable. Similar conditions apply if a single gate is located at a sufficient distance from the hinge, fig. 4. As a general requirement, the mould must be gated in such a way as to prevent:

- local melt stagnation and resultant undercooling of the melt
- weld lines in the integral hinge
- trapped air in the integral hinge.

Weld lines occur when a gate is provided in both parts of the moulding separated by the integral hinge, fig. 5. In such cases, it is important to ensure through suitable dimensioning of the runner and/or gate cross sections that the weld line lies outside the integral hinge.

Fig. 3: Uniform mould filling with a film gate (left) and multiple pinpoint gate (right)

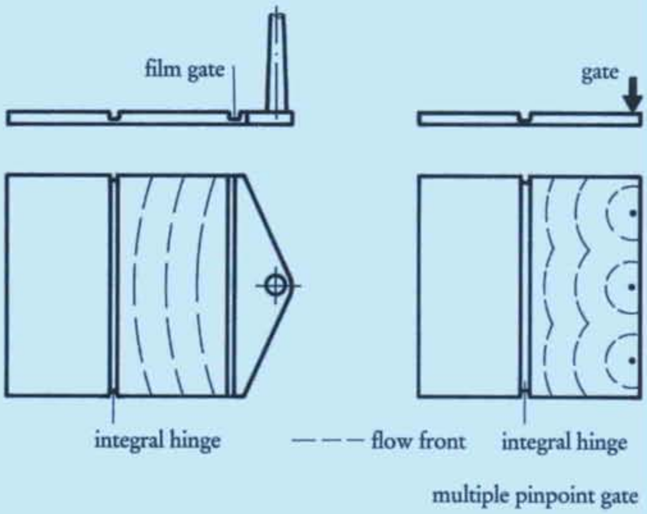


Fig. 4: Melt front approximately parallel to the integral hinge – achieved by locating the tunnel gate at a sufficient distance from the integral hinge

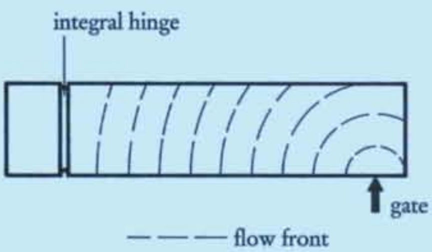
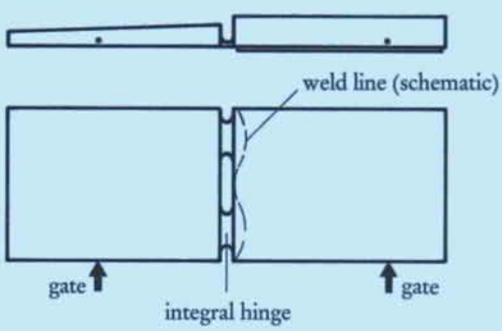


Fig. 5: Two tunnel gates: weld line outside the integral hinge owing to the different volumes of the lid and box

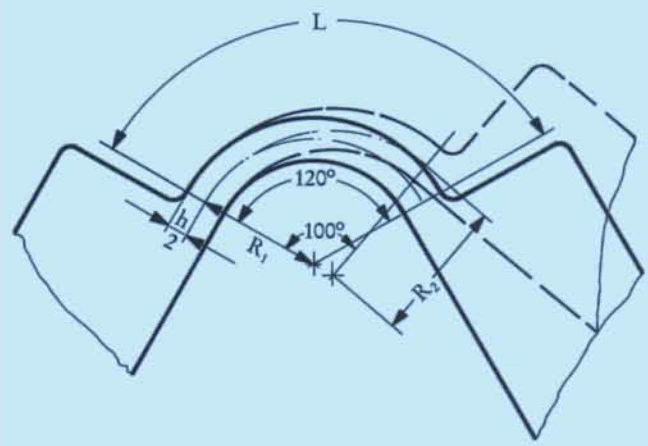


7. *Calculation examples*

7.1 Rocker switch on a cassette recorder

In a rocker switch for a cassette recorder made from Hostaform C 13021, the two sides of the switch are movably connected at an angle of $\alpha = 120°$ by an integral hinge, fig. 6.

Fig. 6: Integral hinge on a rocker switch



When the switch is operated, this angle is reduced to 100° (flex angle $\beta = 20°$). The aim is to find the dimensions of the integral hinge, which must withstand at least 10^6 flex cycles. According to table 1, for Hostaform C 13021 with $N = 10^6$

$$\varepsilon_b = \frac{\varepsilon_a}{S} = \frac{2\%}{1.1} = 1.8\%$$

is permissible.

The selected hinge length is L = 5 mm and the hinge thickness h = 0.5 mm. The radius of curvature R_1 of the unflexed hinge can be calculated as:

$$R_1 = \frac{L}{\alpha} = \frac{5\text{ mm}}{2.094} = 2.388\text{ mm} \qquad \alpha = 120° = 0.01745 \cdot 120 = 2.094\text{ rad}$$

For the radius of curvature of the deformed hinge

$$R_2 = \frac{L}{\alpha - \beta} = \frac{5\text{ mm}}{1.745} = 2.865\text{ mm} \qquad \alpha - \beta = 100° = 1.745\text{ rad}$$

With this, the outer fibre elongation ε_b can be calculated according to equation (5)

$$\varepsilon_b = \frac{h}{2}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \cdot 100\,\%$$

$$= \frac{0.5}{2}\left(\frac{1}{2.388} - \frac{1}{2.865}\right) \cdot 100\,\%$$

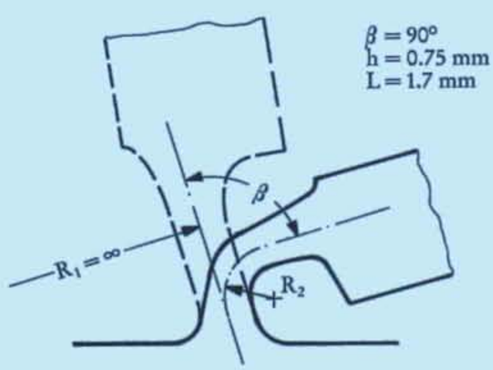
$$= \underline{\underline{1.74\,\%}}$$

The occurring deformation ε_b is thus less than the permissible deformation of 1.8 %.

7.2 Electric connector for motor vehicles

On an electric connector made from Hostacom G2 N01, a part movably joined with an integral hinge is bent through approx. 90°, after fixing on the electrical contacts, and then locked in position with a nondetachable snapfit, fig. 7.

Fig. 7: Integral hinge on an electric connector for a motor vehicle



Dimensions of the integral hinge: $h = 0.75$ mm

$L = 1.5$ mm

$R_1 = \infty$

$$\frac{1}{R_1} = \frac{1}{\infty} = 0$$

The radius of curvature of the deformed hinge is calculated as follows:

$$R_2 = \frac{L}{\beta} \qquad \beta = 90° = 1.571 \text{ rad}$$

$$= \frac{1.5 \text{ mm}}{1.571}$$

$$= 0.955 \text{ mm}$$

With this, the outer fibre elongation can be calculated according to equation (5)

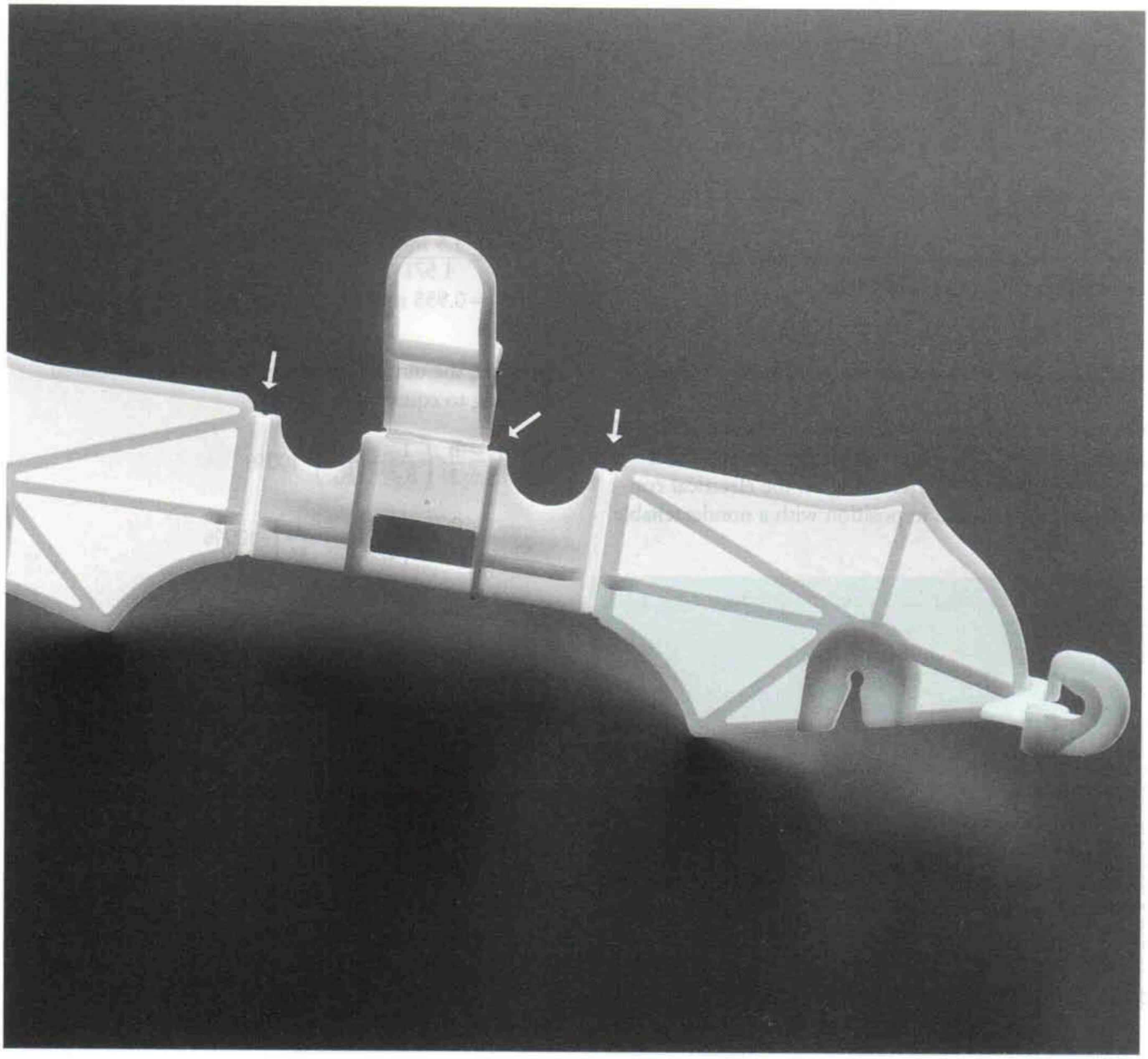
$$\varepsilon_b = \frac{h}{2}\left(\frac{1}{R_2} - \frac{1}{R_1}\right) \cdot 100\,\%$$

$$= \frac{0.75}{2}\left(\frac{1}{0.955} - \frac{1}{\infty}\right) \cdot 100\,\%$$

$$= \underline{\underline{39.3\,\%}}$$

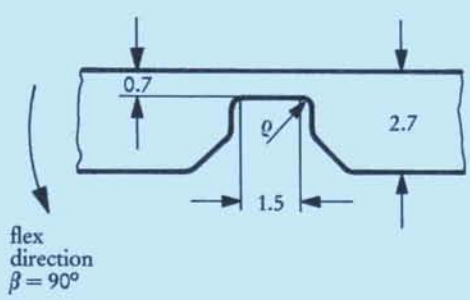
The outer fibre elongation occuring is less than the elongation at break of $\varepsilon_R = 50\,\%$ quoted in table 2 for Hostacom G2 N01.

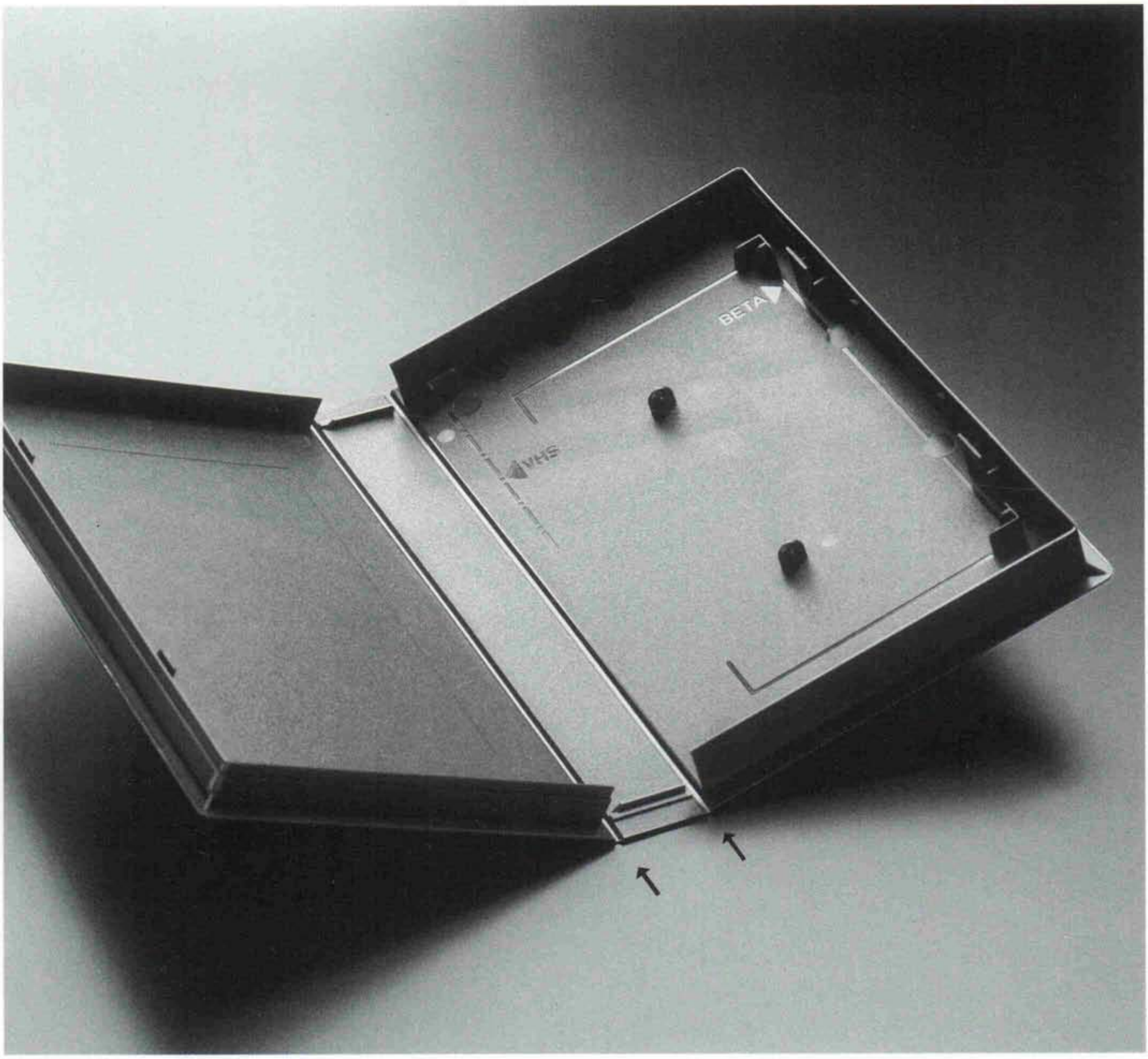
8. *Typical applications*



8.1 Fastening device for greenhouse shading

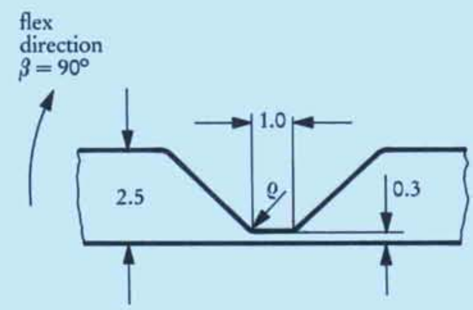
This fastening device with three integral hinges is produced from Hostaform S 9064. The thickness of the integral hinges is h = 0.7 mm and the length is L = 1.5 mm. The flex angle is $\beta = 90°$. The moulding is centrally gated via a pinpoint gate.

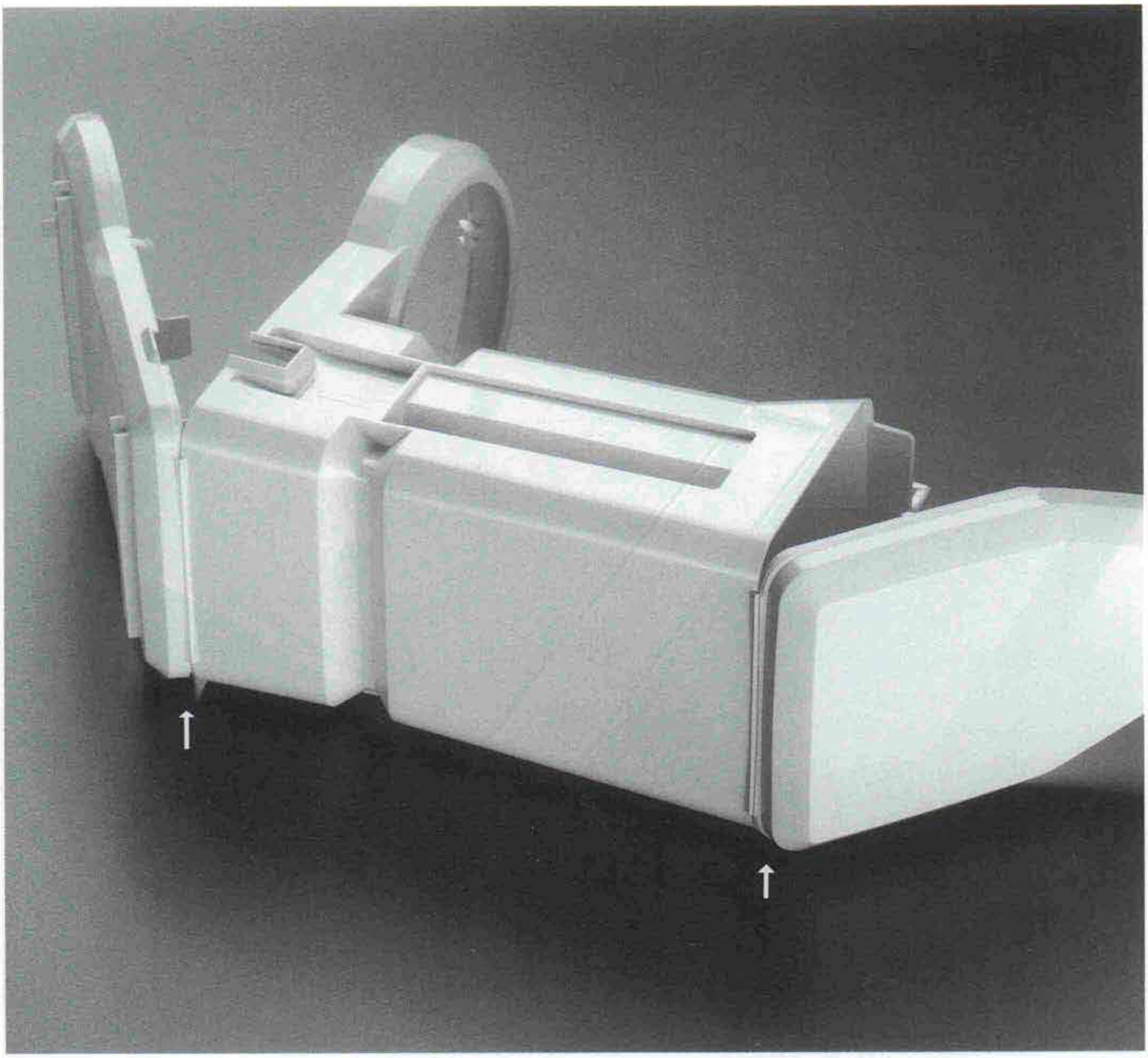




8.2 Video cassette box

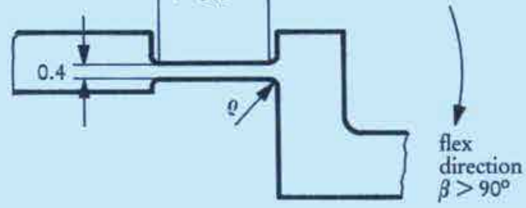
This box is injection moulded from the easy-flowing, antistatic-modified copolymer Hostalen PPW 1752 S 1 ASTL. The moulding is gated in the centre via two pinpoint gates. There are similar designs with just one central pinpoint gate.

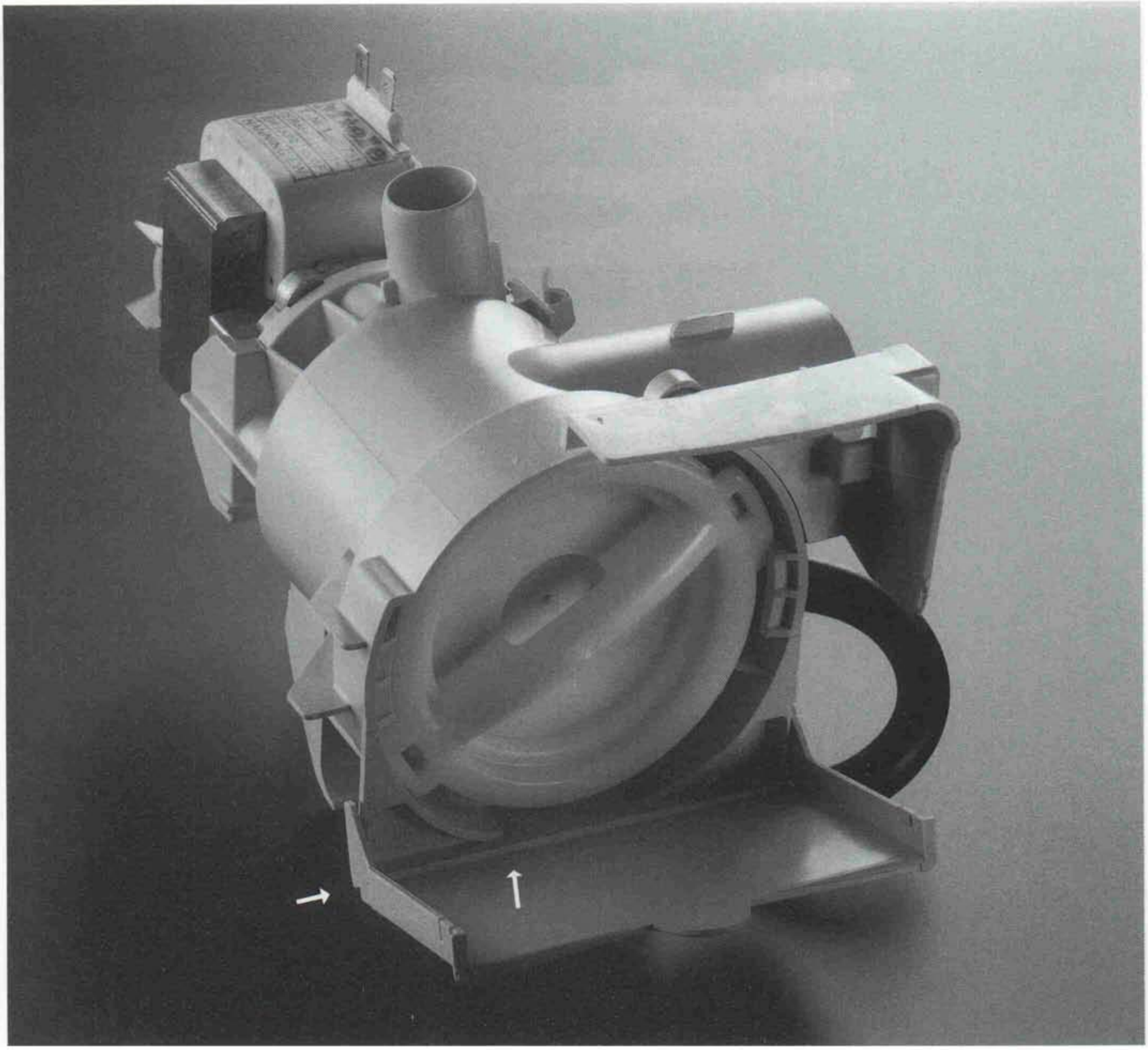




8.3 Coffee maker housing

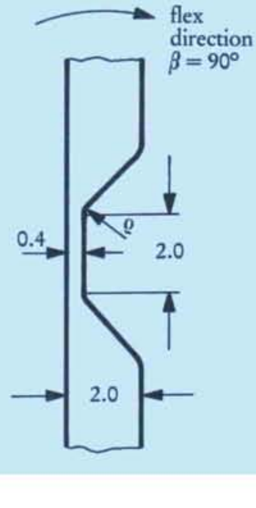
In this example, the lid and base are connected via integral hinges to the main housing. The materials used are Hostacom M1 U 01 and unreinforced polypropylene. While the integral hinge with the base is only flexed during assembly and in the possible event of repair, the lid hinge is flexed every time the coffee maker is used.

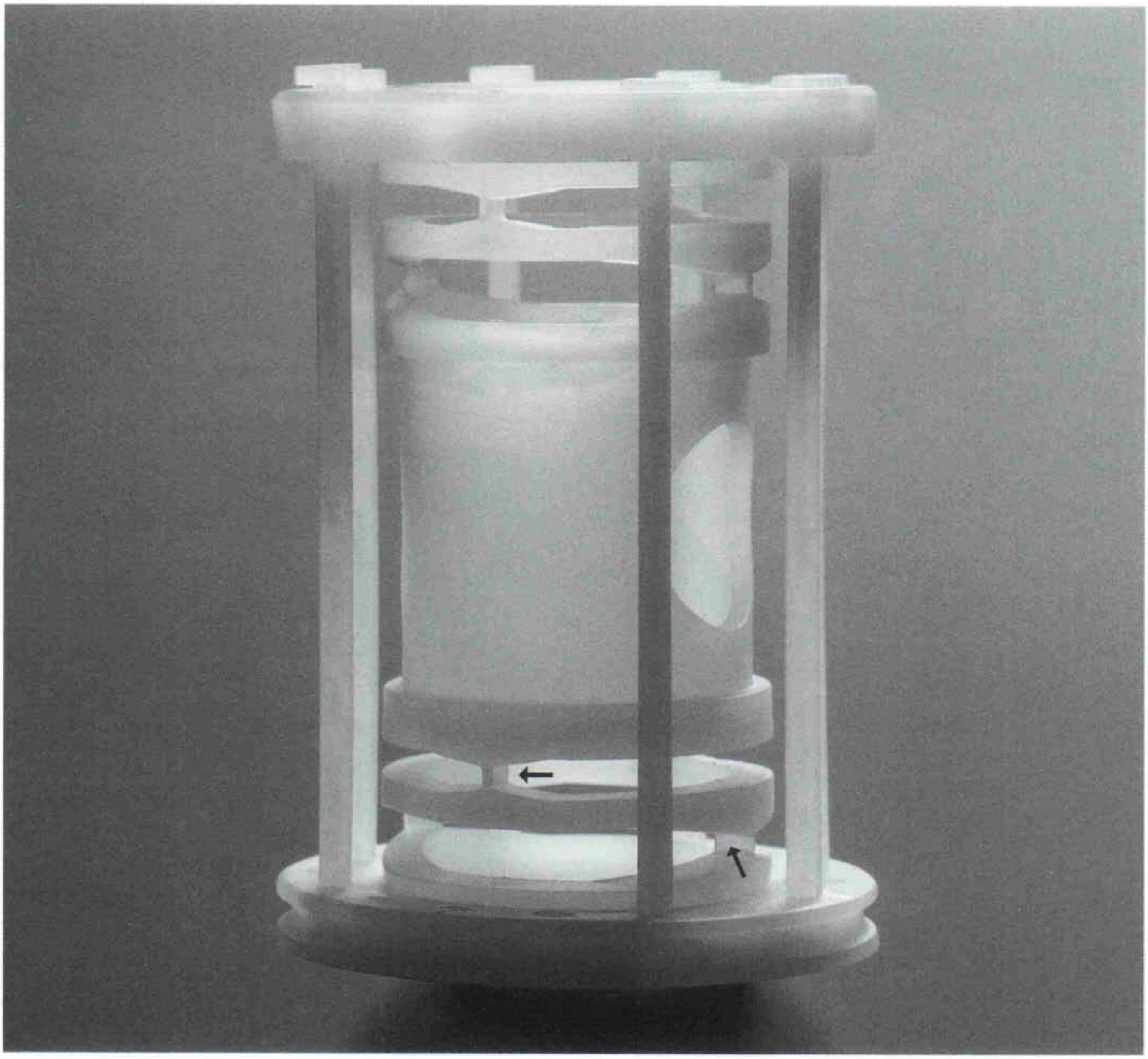




8.4 Filter housing for a washing machine

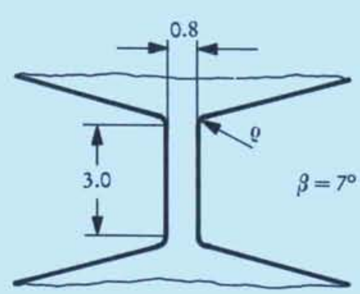
This filter housing is made from Hostacom M 4 N 01. To clean the filter, the integrally hinged flap is pulled down. This enables any residual water to be collected without any problem. The cylindrical section of the housing is gated via four tunnel gates.

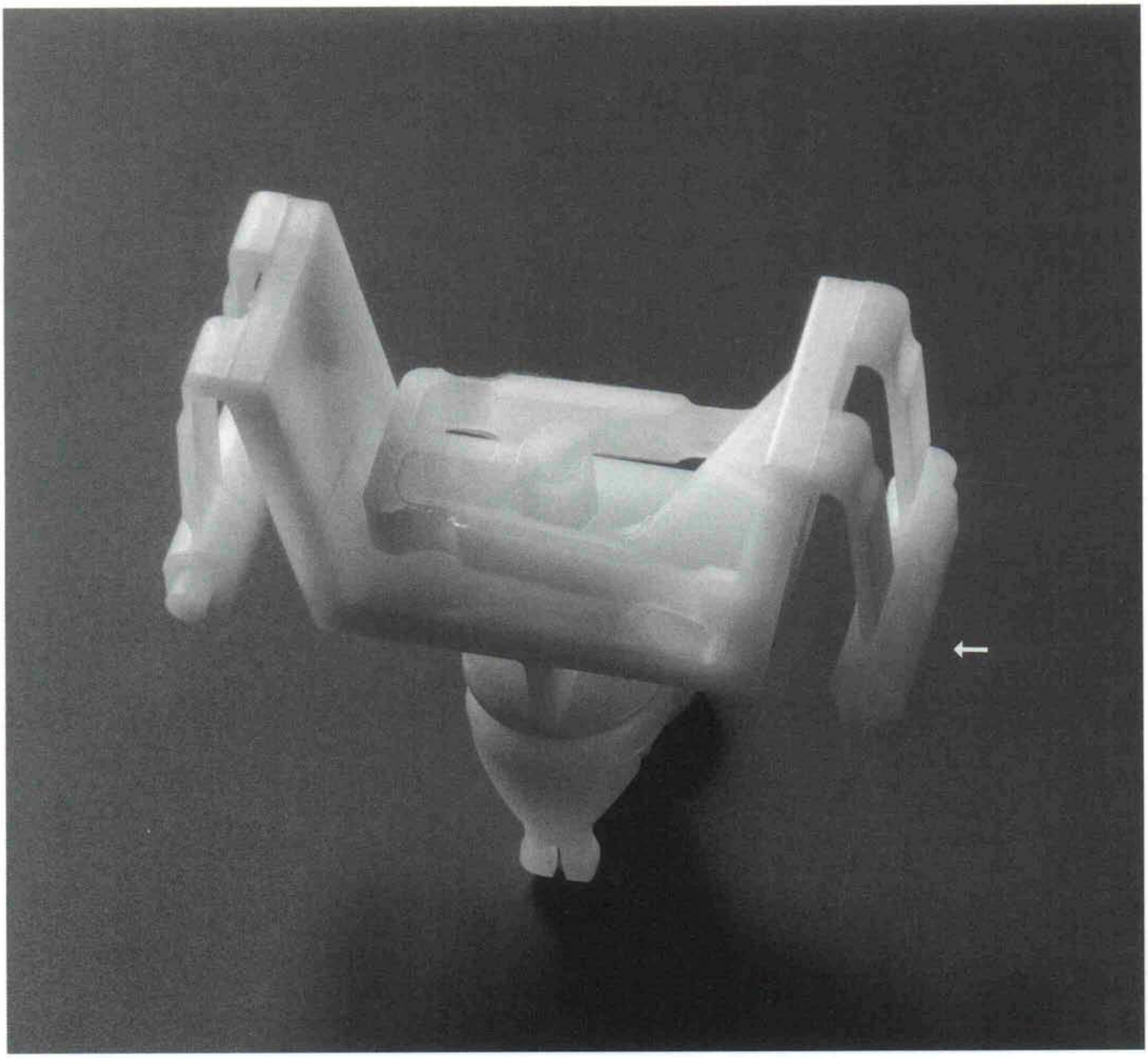




8.5 Cardan mounting

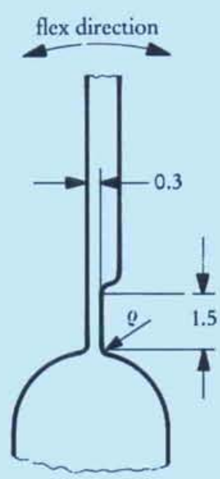
This Cardan mounting for the baseplate of an orbital sander is made from Hostalen PPR 1042. A total of eight integral hinges ensure the mobility of the baseplate parallel to the housing in all directions. The integral hinges are stressed by high flex numbers and oscillating frequency with relatively small flex angles.

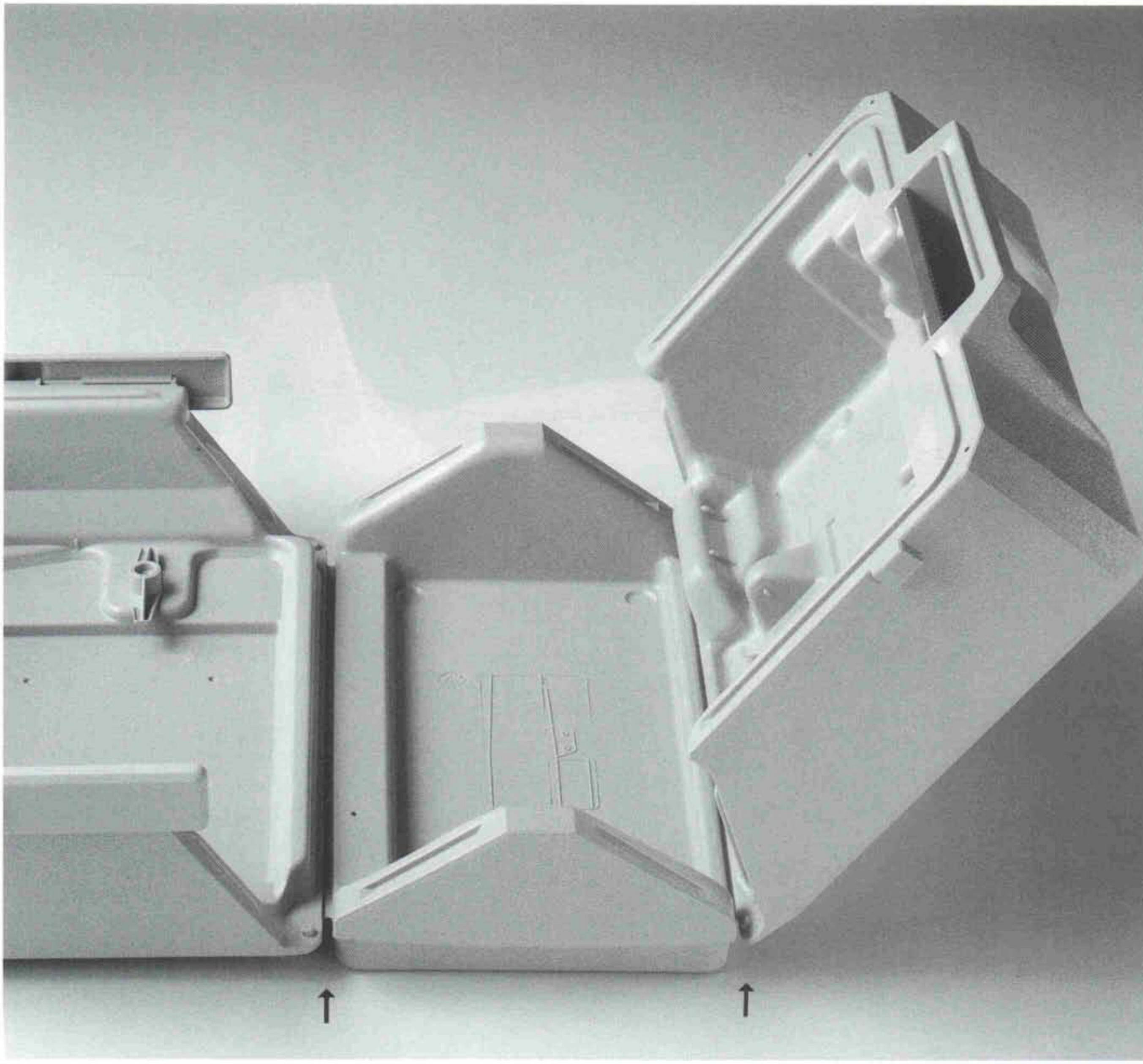




8.6 Transmission head of an electric razor

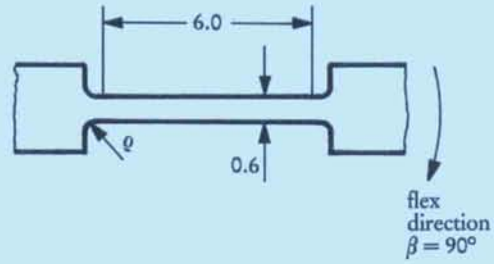
This transmission head made from Hostaform S 27063 has the function of converting the drive motion imparted by the drive motor into a reciprocation movement of the razor cutter. High oscillating frequency and a small flex angle characterize the stress to which the twelve integral hinges are exposed.

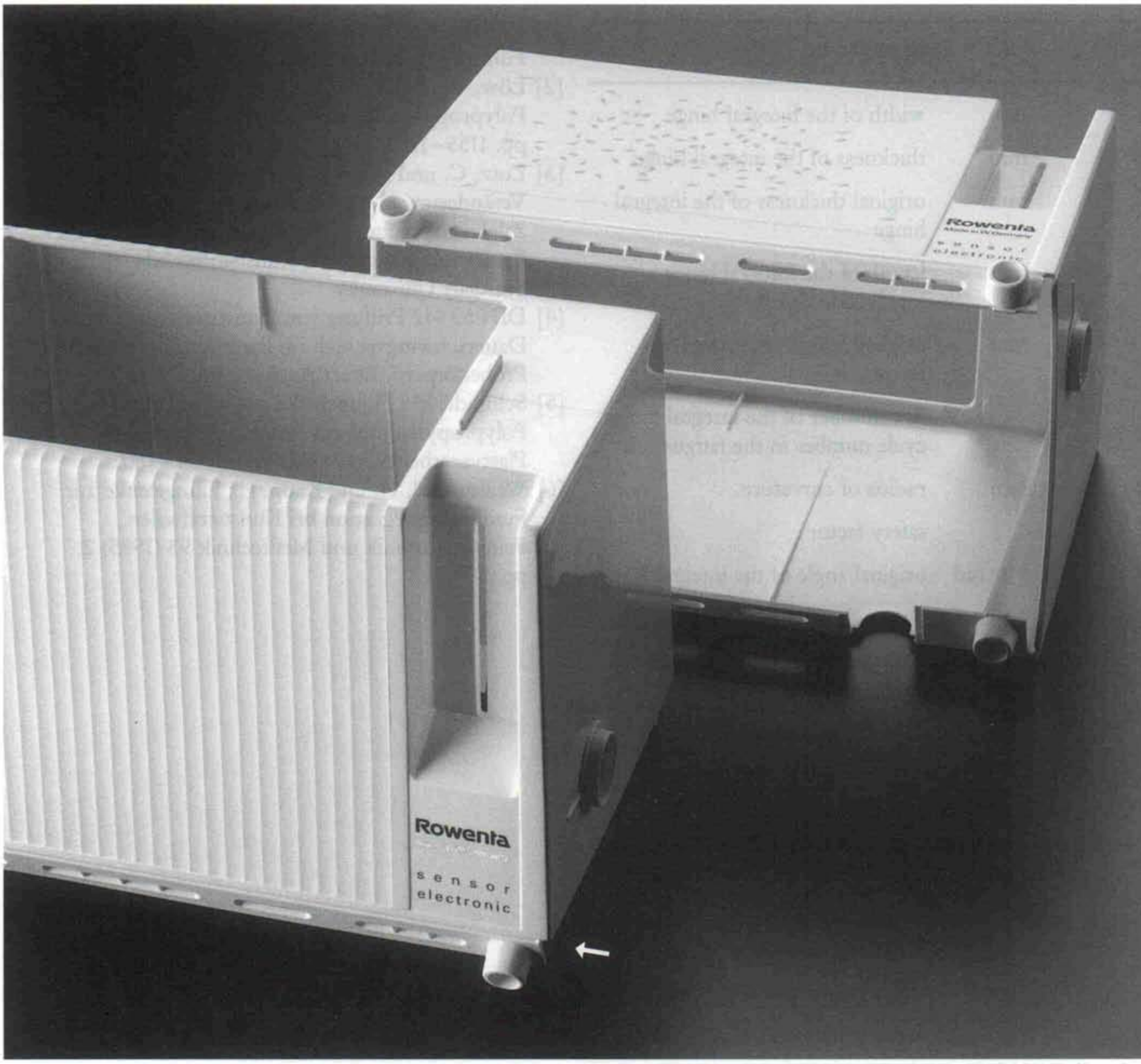




8.7 Sewing machine box

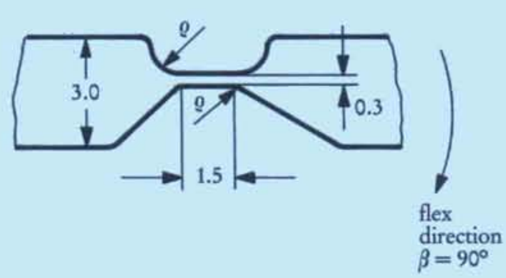
This box is extrusion blow moulded from Hostalen PPG 1022. To confirm the stress-bearing capacity of the integral hinge, flexing trials were carried out at room temperature and at –20 °C. After 20 000 flex cycles at –20 °C and $3 \cdot 10^6$ cycles at room temperature, no changes in the integral hinge could be detected except for slight white fracture.





8.8 Toaster housing

This toaster made from Hostacom M1 U01 is very easy to assemble. Two fixing strips with moulded-on feet are connected to the toaster body via integral hinges. When the toaster chassis has been inserted, the fixing strips are bent inwards through 90° and screwed to the chassis.



9. *Explanation of symbols*

Symbol	Unit	Explanation
b	mm	width of the integral hinge
h	mm	thickness of the integral hinge
h_0	mm	original thickness of the integral hinge
L	mm	length of the integral hinge involved in flexure
L_0	mm	original length of the integral hinge
N		flex number of the integral hinge cycle number in the fatigue test
R	mm	radius of curvature
S		safety factor
$\measuredangle \alpha$	° or rad	original angle of the integral hinge
$\measuredangle \beta$	° or rad	flex angle
ε_a		deformation amplitude in the fatigue test
ε_b		outer fibre deformation in the integral hinge
λ		degree of stretching $\lambda = \frac{h_0}{h} = \frac{L}{L_0}$
ϱ	mm	fillet radius of the transition from the integral hinge to the moulding
σ_a	N/mm²	stress amplitude in the fatique test
σ_b	N/mm²	flexural stress in the integral hinge

10. *Literature*

[1] VDI/VDE 2252, Blatt 9: Feinwerkelemente; Führungen, Federgelenke (draft October 1987)

[2] Löw, W.: Blasformen von technischen Teilen aus Polypropylen. Kunststoffe 78 (1988) 12, pp. 1155–1160

[3] Lutz, C. und Polsack, A.: Morphologische Veränderungen von i-Polypropylen bei einachsiger Zugbeanspruchung. Mitteilung aus dem Inst. für Kunststoffprüfung und Kunststoffkunde (IKP), Stuttgart University

[4] DIN 53 442 Prüfung von Kunststoffen, Dauerschwingversuch im Biegebereich an flachen Probekörpern. Draft August 1988

[5] Schmidt, H.: Filmgelenke aus verstärktem Polypropylen und aus Acetalcopolymerisat. Plastverarbeiter 34 (1983) 9, pp. 774–780

[6] Weißmantel, H. und Kapp, L.: Filmgelenke zur Funktionsintegration bei Kunststoffteilen. Feinwerktechnik und Meßtechnik 93 (1985) 2, pp. 89–91

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