6 – Springs and Living Hinges

Springs of DuPont engineering resins have been successfully used in numerous applications where intermittent spring action is required. Among unreinforced plastics, DELRIN® acetal resin is the best material due to its high degree of resiliency. Springs under constant load or deflection should be designed in spring steel.
Plastic materials, other than special composite structures, will not function well as constantly loaded springs due to creep and stress relaxation.

Integral, light-spring actions can be provided inexpensively in moulded parts of DELRIN® acetal resin by exploiting the fabricability and the particular properties of these resins, which are important in spring applications. These include, in addition to resiliency, high modulus of elasticity and strength, fatigue resistance and good resistance to moisture, solvents, and oils.

In the design of springs in DELRIN® acetal resin, certain fundamental aspects of spring properties of DELRIN® acetal resin should be recognized.

- The effect of temperature and the chemical nature of the environment on mechanical properties must be allowed for.
- Design stresses for repeatedly operated springs must not exceed the fatigue resistance of DELRIN® acetal resin under the operating conditions.
- Sharp corners should be avoided by provision of generous fillets.

Springs of a design based upon constant strength beam formulae operate at lower levels of stress than springs of other shapes for a given spring rate and part weight. Fig. 6.01 is a comparison of various spring shapes which produce an equivalent spring rate. The upper spring *A* has a constant rectangular cross section and an initial spring rate calculated from the deflection formula for a cantilever beam ($W/y = EI/L^3$) where W is the load and y is the deflection of the end of the spring. The other springs were designed to provide an identical spring rate using formulas for constant strength beams. This results in lower stress level and, in some cases, a reduction in weight. For example, in spring *C* the stress is two-thirds of that developed in spring *A*, and weight is reduced by 25%. This weight reduction can be of equal importance as a cost savings factor when large production runs are contemplated. An important fact to keep in mind is that tapered springs are reasonable to consider for production by injection moulding. Metal springs made by stamping or forming operations would be cost prohibitive in shapes such as *D* or *E*.

For a special application of plastic springs, see: “Assembly Techniques”, “Snap-Fits”.

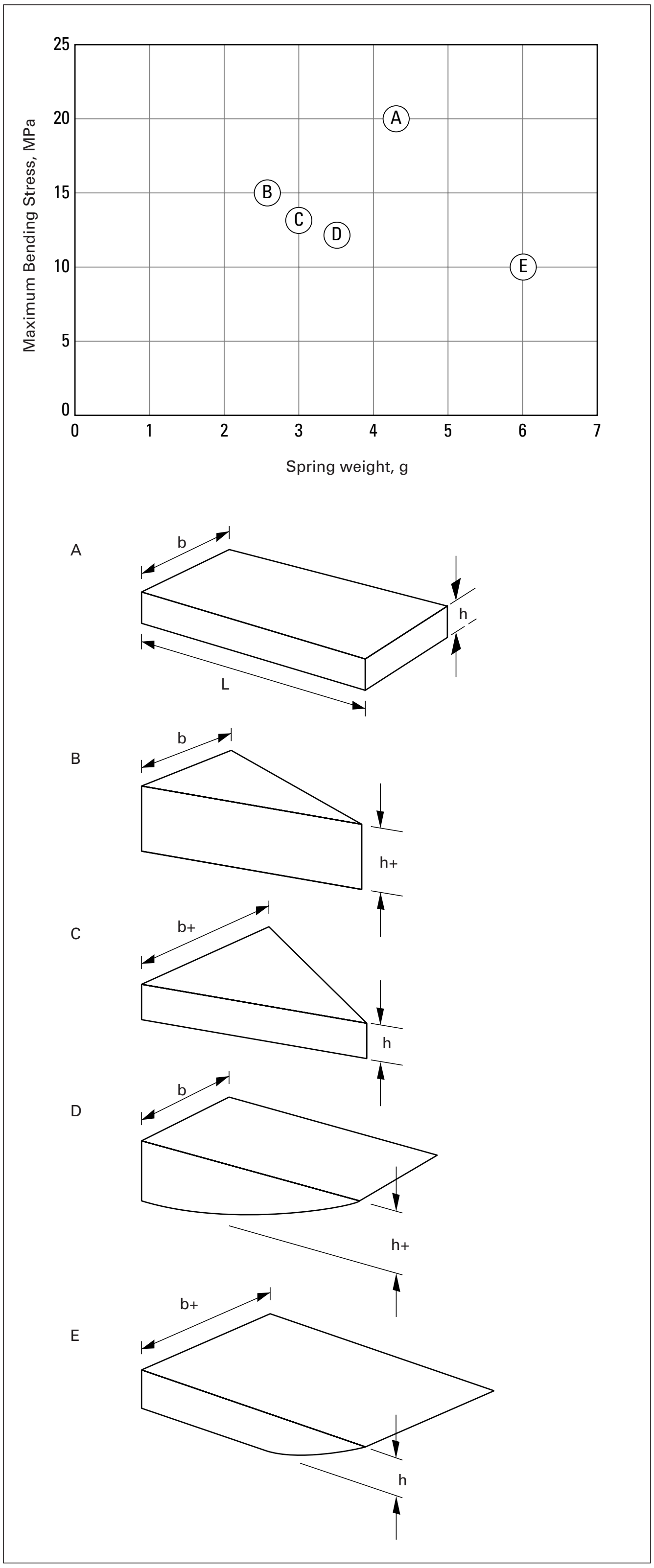

Fig. 6.01 **Bending stress versus spring weight for various spring designs (23° C)**

Design of Living Hinges

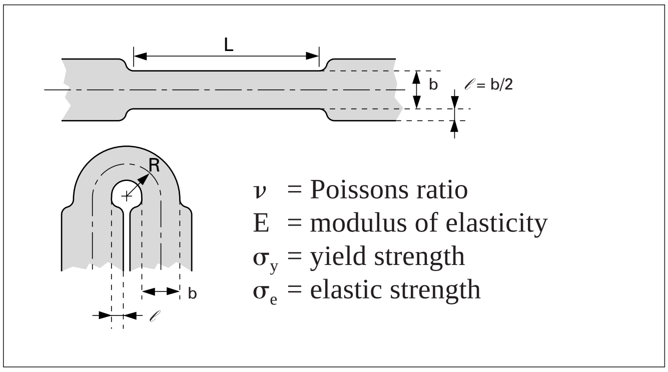

Fig. 6.02 **Recommended shape of living hinge**

In case of 180° bending: $R = \frac{L}{\pi}$

Strain in extreme fibre : $\epsilon = \frac{\pi\, b}{2\, L}$

Stress in extreme fibre : $\sigma = \frac{\pi\, b\, E}{2\, L\, (1 - \nu^2)}$

For elastic behaviour, the following should be satisfied:

$$\frac{b}{L} < \frac{2\, \sigma_e}{\pi\, E} (1 - \nu^2) \qquad (1)$$

For other closing angles than 180°, adjust π in the above equation.

Living hinges, designed for elastic behaviour will have rather big dimensions, which may make them less practical.

A certain amount of plasticity can be allowed before failure occurs, which modifies equation (1) to:

$$\frac{b}{L} < \frac{2\, \sigma_y}{\pi\, E} (1 - \nu^2) = \frac{2\, \epsilon_y}{\pi} (1 - \nu^2) \qquad (2)$$