Centrifugal pumps are fabricated of almost all the known engineering materials, from simple thermoplastic polymers through metals ranging from cast iron to the various nickel-based alloys to composites and ceramics. The conditions of service and the nature of the pumped liquid finally determine which among this wide range of materials will be the most suitable. A specific choice is based first on past experience with the same liquid or a similar liquid. When past experience is lacking, material properties and known performance must be used. Listings of the materials commonly recommended for various liquids can be readily found in the Standards published by the Hydraulic Institute [1.1], in API-610 [3.1] and in the catalogs and bulletins of pump manufacturers, particularly those who specialize in centrifugal pumps for chemical service, the field that presents the greatest variety of material selection problems. Note, in this connection, that the plant owner is ultimately responsible for the performance of the specified materials, because the precise nature of the pumped liquid is solely under his or her control. It is the pump manufacturer’s responsibility to furnish the specified materials (provided, of course, they are mechanically suitable).

The principal service conditions that affect the selection of materials are

1. Operating pressure
2. Pumping temperature
3. Head per stage (affects both the peripheral velocity of the impeller and the liquid velocity in the waterways)
4. Corrosiveness of the pumped liquid (can vary markedly with traces of halogens, halides, or compounds of hydrogen)
5. Concentration and abrasiveness of any suspended solids
6. Load factor (fraction of time running) and expected life.

In selecting the material for any part of a pump, the material properties to be considered are

1. Strength: tensile, impact and endurance or fatigue.
2. Stiffness
3. Thermal expansion and thermal shock resistance
4. Corrosion resistance, considering the effects of velocity and stress
5. Erosion resistance (both abrasion and cavitation)
6. Feasibility of fabrication into the required component.

Table 17.1 gives a qualitative ranking of these properties for the usual pump materials.

In developing general guidelines for material selection, we first concentrate on the materials most commonly used for individual parts. Table 17.2 summarizes these materials for the three major parts: casing (plus inner casing where applicable), impeller, and shaft.

Table 17.3 lists the specification and chemical composition of the metals commonly used in centrifugal pump construction.

CASING MATERIALS

The foremost requirement of the material of a centrifugal pump casing is that it be strong enough, given the sections employed in the design, to safely contain the maximum working pressure. Next, the material or combination of materials must be stiff enough to limit distortion of the casing under pressure and imposed nozzle loads to that which will enable the pump to operate as intended. Finally, the material must provide an economical balance between service life (determined by loss of wall thickness due to corrosion or erosion or both) and cost.

Injection-molded polymers are viable materials for the casings of small, mass produced pumps for low pressure, 1.0 to 1.4 bar (15 to 20 psig), at ambient temperature. Limited strength, low stiffness, and the cost of molds generally preclude their use above these limits.

Cast iron has higher strength and stiffness than polymers, yet is still economical to produce. For these reasons it is the material used for the casings of most centrifugal pumps. Its strength and stiffness are limited, however, which places a practical upper limit on the pressure for which cast iron casings can be built. This limit varies with size, being around 35 bar (500 psig) for small pumps and falling to 10 bar (150 psig) for large pumps. Cast iron has poor resistance to thermal shock, and therefore is generally not used at pumping temperatures above 175°C (350°F), nor for services where the pumped liquid is flammable or toxic. In the latter case, the concern is that should the pump be involved in a fire, attempts to extinguish the fire may quench and fracture the heated casing.

Ductile iron offers higher strength, stiffness, and thermal shock resistance than cast iron, with the degree of improvement depending on the grade specified. Many chemical pumps have high-elongation ductile-iron casings to allow their use for flammable or toxic liquids. Larger pumps have ductile iron casings, usually of lower elongation, to increase their pressure rating.

Carbon steel is stronger, stiffer, and more ductile than ductile iron. Beyond mechanical properties, carbon steel has the advantage that it can be welded, thus enabling ready repair in the field, something that is not feasible with either iron or ductile iron. Given its mechanical properties, carbon steel is the usual material for medium- and high-pressure casings: in cast form for medium pressure and forged for high pressure. Carbon steel is the standard casing material for pumps handling flammable or toxic liquids in petroleum refining service, a practice related to the material’s strength and thermal shock resistance. Because they can be readily repaired by welding, carbon-steel casings are frequently used in mildly erosive mineral processing services.

Chrome steels offer higher strength than carbon steel, superior corrosion resistance in some services (e.g., boiler feed) and marginally better erosion resistance. When taking advantage of the higher strength of chrome steels, the casing design must be able to accommodate the higher deflection that will occur