Selection and Use of Steels —SAE J401

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[SAE Specifications for automotive steels are developed cooperatively by steel producers and users.]

Introduction—Steel compositions included in SAE Handbook are considered adequate for practically all parts made of wrought ferrous materials that are necessary for the production of automotive apparatus, and include grades that have been found commercially available and technically adequate for the service required of such parts. (SAE steel compositions should not be confused with specifications, of which composition is only a part.)

Only general applications of the SAE steels are indicated; definite applications are not shown, because—as it will be readily appreciated—the selection of a steel for a given part must be based upon an intimate knowledge of a number of important factors such as the severity of the service to be imposed, the detailed design of the part, the method of fabrication, its machinability, and the cost and availability of the material. It is only after a careful consideration of these factors that steels for the great variety of automotive and other mechanical parts can be selected properly.

Heat Treating—It is important to bear in mind that the information pertaining to typical heat treatments is based on the tests and experience of steel manufacturers and users and is intended only as a guide in selecting steels and their heat treatment. Care has been taken to provide reliable data, but steel users should supplement these data with suitable inspection tests and practices in order to be assured that each lot of material purchased will respond in a normal manner to the heat treatment generally applied in their particular practices.

Variations in the effect of the usual forms of heat treatment may be due to personnel, variations in the steel composition or manufacture, and to changes in local conditions such as control and precision of heat treating equipment. In order to minimize the effects of such variations, steel users should keep the product of each mill heat of steel separate in the stock room and during processing so that necessary adjustments of treatment can be made.

Frequently the necessity for drastic quenching can be avoided by the proper selection of a steel from a hardenability, or depth of hardening, standpoint. Plain carbon steels, unless their section size is very small and uniform, normally will not develop their maximum hardness throughout the section even with the most drastic quench. If depth hardness is an important factor, the user should consider an alloy steel of the proper carbon and alloy level which will meet his hardenability requirement with a less drastic quench and less chance of distortion and/or cracking. When selecting a steel, the user should bear in mind that the surface hardness obtainable by quenching is mainly a function of the carbon content and that depth hardness, or hardenability, is dependent upon the presence of alloying elements in addition to the carbon content of the steel.

Filleting—Another detail of greatest importance to the designer and the producer of heat treated steel parts is correct filleting. Sharp corners and inadequate fillets are the primary cause of most fatigue failures. In parts subjected to dynamic stresses, sharp corners and inadequate fillets produce serious stress concentration, causing the actual service stresses to build up to a point where they may amount to several times the normal working stress calculated by the designer. The use of generous fillets is especially desirable with all high strength alloy steels.

While adequate fillets may reduce the weakening effect of abrupt changes in section, they will not appreciably reduce the serious distortion which inevitably develops when parts of widely varying section are quenched during heat treatment. Whether oil or water quenching is required, heavy sections cool less rapidly than light sections, and, therefore, variations in section size tend to produce distortions. Consequently it is desirable to minimize variations in section as much as practicable.

Elastic Deflection—The steel user should also remember that the elastic deflection under load of a given part is a function of the section of the part rather than of the composition, heat treatment, or hardness of the particular steel that may be used. In other words, the modulus of elasticity of all the commercial steels, both plain carbon and alloy types, is the same so far as practical designing is concerned. Consequently if a part deflects excessively within the elastic range, the remedy lies in the field of design, not in the field of metallurgy. Either a heavier section must be used, the points of support must be increased, or some similar change made, since under the same conditions of loading all steels deflect the same amount within the elastic limit.

High Tensile Low Alloy Steels—In addition to the standard list of SAE steels, there is a specific class of High Strength Low Alloy Steels. In this category, materials are normally furnished to mechanical property requirements rather than chemical ranges, and various steel makers produce these grades under specific trade names. These steels have high mechanical properties, higher abrasion resistance and, in some cases, better resistance to atmospheric corrosion than plain structural or copper bearing steels. These steels are not intended for quenching and tempering. They have better welding properties than quenched and tempered structurals of similar strength. Applications are usually for untreated high strength parts made from hot or cold rolled structural shapes, plates, bars, sheets, and strip.

The ϕ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.