2.2 STEEL MAKING

Figure 2.2-1 is a block diagram of the steel making process from iron making through cold reduction. Most of the steel for automotive applications is produced in basic oxygen furnaces (BOFs), deoxidized, and continuously cast into slabs. These slabs are reheated and hot rolled into coils that can be used in heavier gage (≥1.83 mm [0.072"]) automotive structural applications or processed into lighter gage (0.4 – 1.5 mm [0.015 to 0.060"]) cold rolled coils for use in auto body applications.

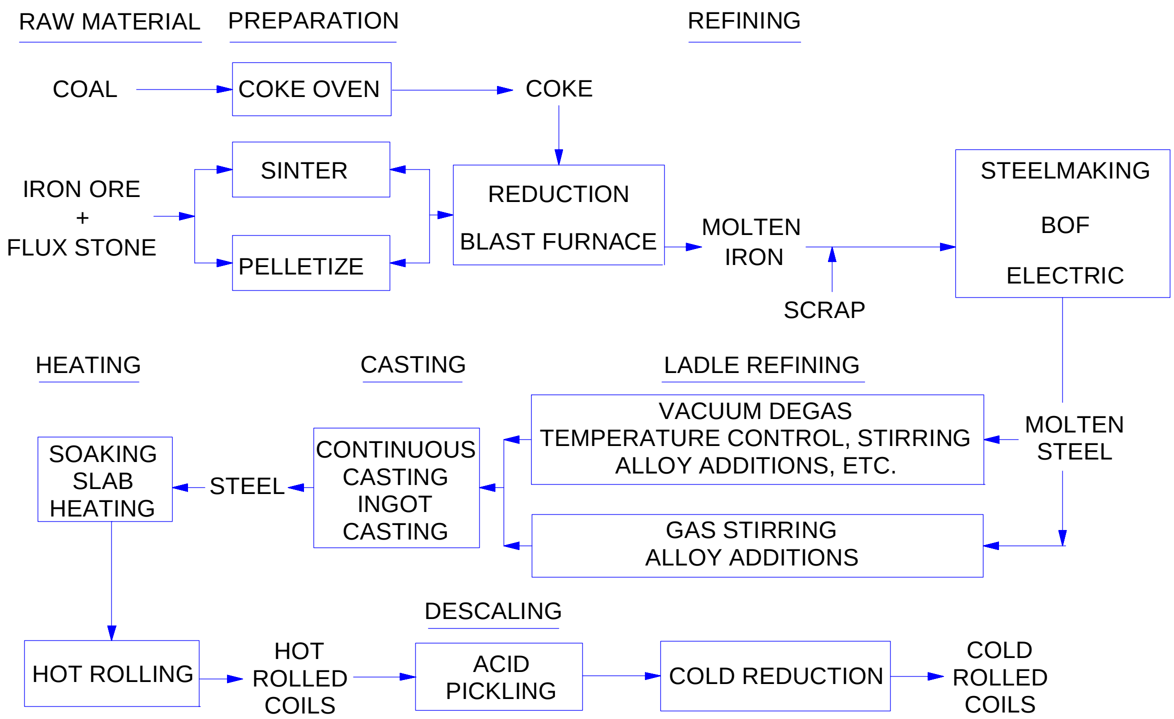

Figure 2.2-1 Steel making flowline

2.2.1 DEOXIDATION PRACTICES

Currently all of the steel for automotive applications is deoxidized. Deoxidization with aluminum is performed during and after pouring of the steel from the BOF into a ladle. Other alloying elements can be added to the ladle to produce compositions necessary to attain specified properties in a flat rolled sheet such as higher strength and improved corrosion resistance. Ladle treatments are available to further modify the steel characteristics, such as calcium treatment to reduce sulfur and modify sulfides, gas stirring to improve uniformity of the alloy additions, or vacuum degassing to lower carbon levels <0.01%. Additions of titanium and/or columbium in a vacuum degassed heat are used to produce interstitial free (IF) stabilized steels.

2.2.2 STEEL CHEMISTRY

Sheet steels used in the automotive industry are available in the following types:

- Commercial Quality
- Low Carbon –Drawing quality
- IF stabilized – Deep drawing quality
- Dent Resistant
- Bake Hardenable
- Non-Bake Hardenable
- High Strength Low Alloy
- High Strength Solution Strengthened
- Ultra High Strength
    - * Dual Phase
    - * Martensitic
- Laminated Steels
- Stainless Steels

The low carbon steels are generally less than 0.13% carbon, 0.60% manganese, 0.030% phosphorus, 0.030% sulfur, and greater than 0.02% aluminum. The drawing quality steels have carbon level in the 0.02 to 0.04% range. The Interstitial free (IF) steels are stabilized with Ti, Cb, or Cb + Ti, and are normally ultra low carbon (0.005% max). While most IF steels are produced as drawing quality, solid solution strengthening with P, Mn, and Si can be utilized to produce a higher strength formable steel (with higher **n** values and **r** values). (See Section 2.5)

Bake hardenable steels utilize carbon in solution to provide an increase in strength during the paint bake cycle due to carbon strain aging. Therefore these steels can be produced in a relatively low strength condition and easily formed into parts. However, after forming and paint baking, a significantly stronger part is produced.

The dent resistant steels contain increased levels of phosphorus (up to 0.10%), and possibly manganese and silicon to low carbon steels and IF steels. The high strength solution strengthened steels contain increased levels of carbon and manganese with the addition of phosphorous and/or silicon.

The high strength low alloy steels (HSLA) contain the addition of the carbide forming elements Cb, V, or Ti singularly or in combination to a low carbon steel, providing strength through precipitation of fine carbides or carbonitrides of Cb, Ti, and/or V. Microalloying to these grades does reduce the ductility.

The dual phase, ultra high strength steels rely on a microstructure of ferrite and Martensite to provide a unique combination of low yield strength and high tensile strength as well as a high **n** value. This combination results in a high level of formability in the initial material and high strength due to work hardening in the finished part. The unique combination of properties is achieved by alloy additions of C, Mn, and Si, and possibly Cb, V, Mo, and/or Cr , coupled with continuous annealing for cold rolled steels. It is possible to produce a hot rolled product with a combination of alloying and a selected thermal practice on the Hot Mill.

The martensitic, ultra high strength steels are produced by alloying and continuous annealing followed with a rapid cool to produce a low carbon, martensitic structure.

Stainless steels are classified into austenitic, martensitic or ferritic steels. The major divisions are the 300 series steels, with nickel stabilized austenite, and the 400 series, which are nickel free but contain 10% or more chromium. Some of these are hardenable by quenching and tempering. The 200 series are special austenitic steels where portions of the nickel are replaced with manganese and nitrogen. The 500 series are low chromium steels (4-6%) but with small additions of molybdenum.