Steel Production

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10 January, 2012

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Introduction

High quality steel typically has the following components:

- **96.5% iron**
- **2% carbon**, which acts as a hardening agent
- **1.5% manganese** to provide tensile strength.

For this study these percentages will be considered to be the necessary components of steel.

For this study it is assumed that iron ore [magnetite (Fe_3O_4) and hematite (Fe_3O_3)] is about 70% iron.

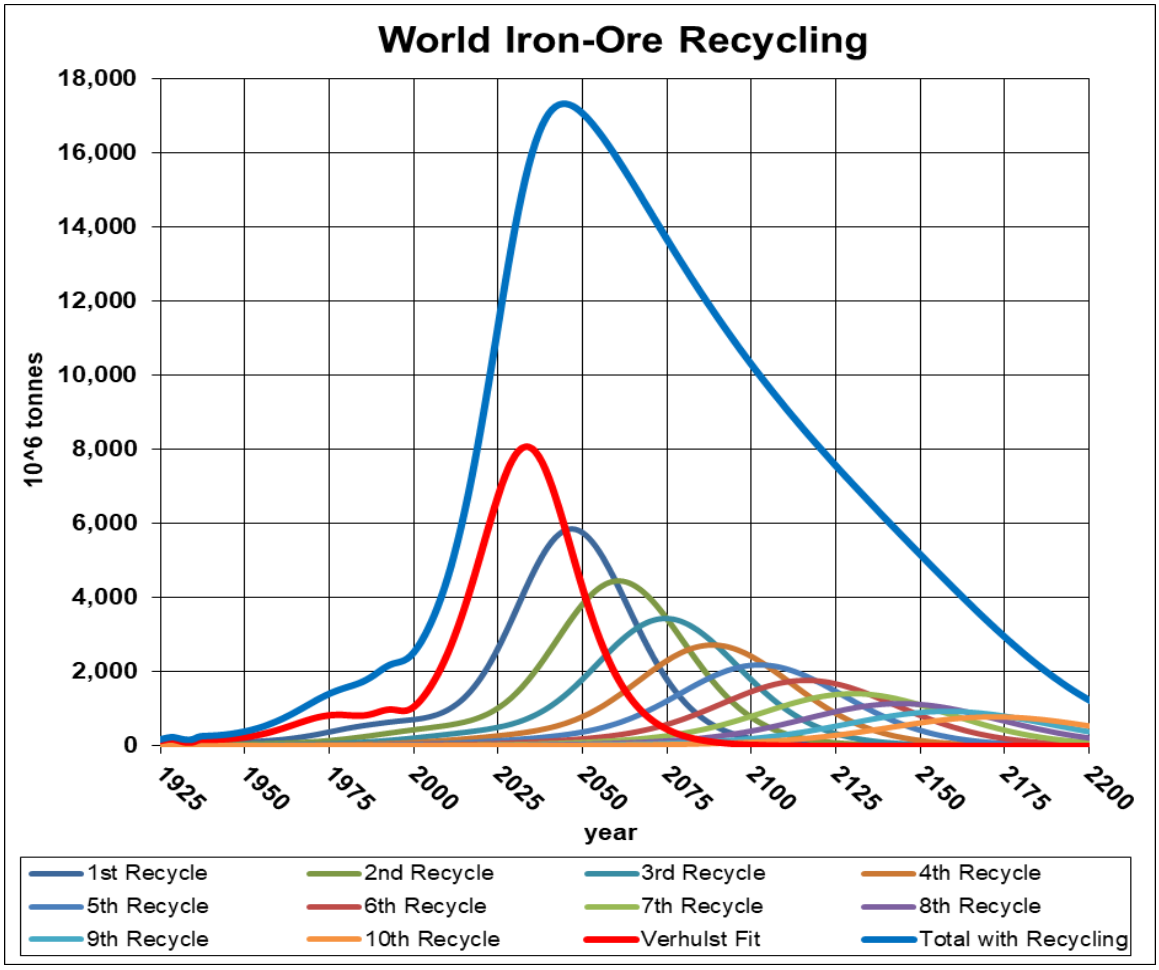
Stainless steel, invented in early twentieth century, is highly corrosion resistant. The anti-corrosion is due to ~11% by mass of chromium which forms a layer on the steel. For this study it is assumed that stainless steel has the following components:

1. **85.5% iron**
2. **11% chromium**
3. **2% carbon**
4. **1.5% manganese**

This study will consider the world depletion situations for iron ore, chromium and manganese and the impacts those depletions will have on the production of steel in the future. It is assumed that any limits on the availability of carbon are negligible compared to the iron-ore, chromium and manganese limits.

Iron-Ore Depletion

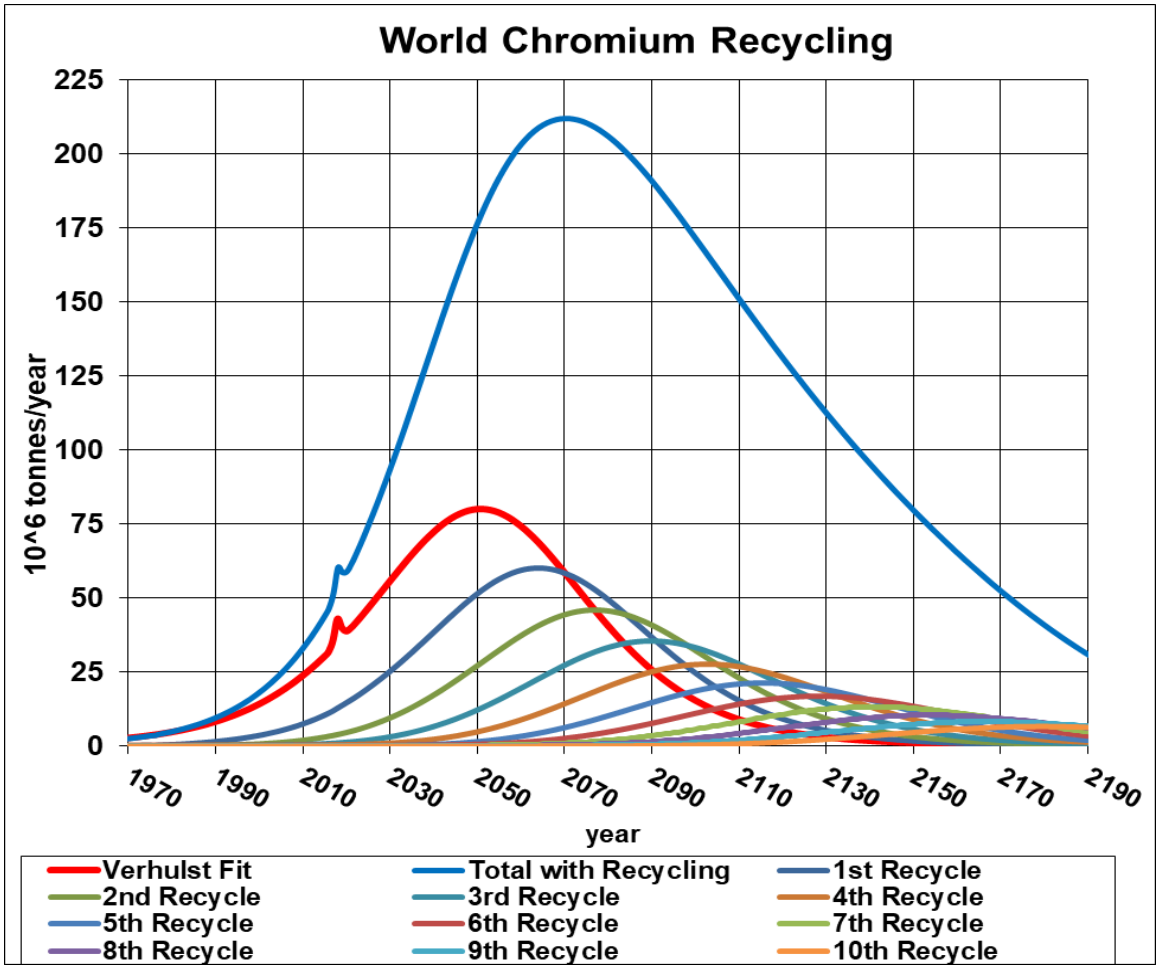
In a previous study (Ref. 1) the author has dealt with iron-ore depletion. Making some assumptions about reserves and recycling, the following curve was obtained for iron-ore depletion:



It will be assumed below that iron ore contains 70% irons.

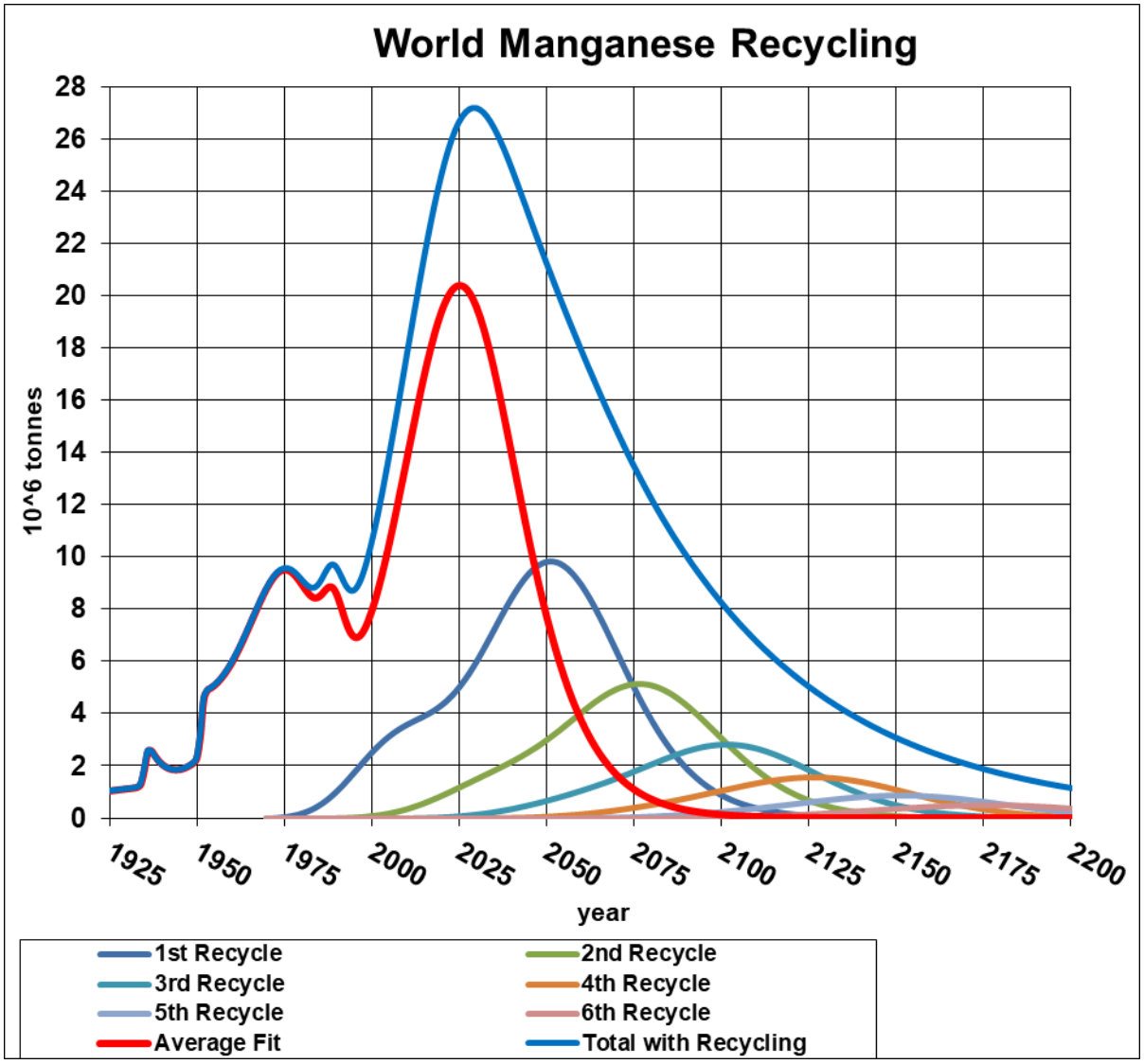
Chromium Depletion

In a previous study (Ref. 2) the author has dealt with chromium depletion. Making some assumptions about reserves and recycling, the following curve was obtained for chromium depletion:

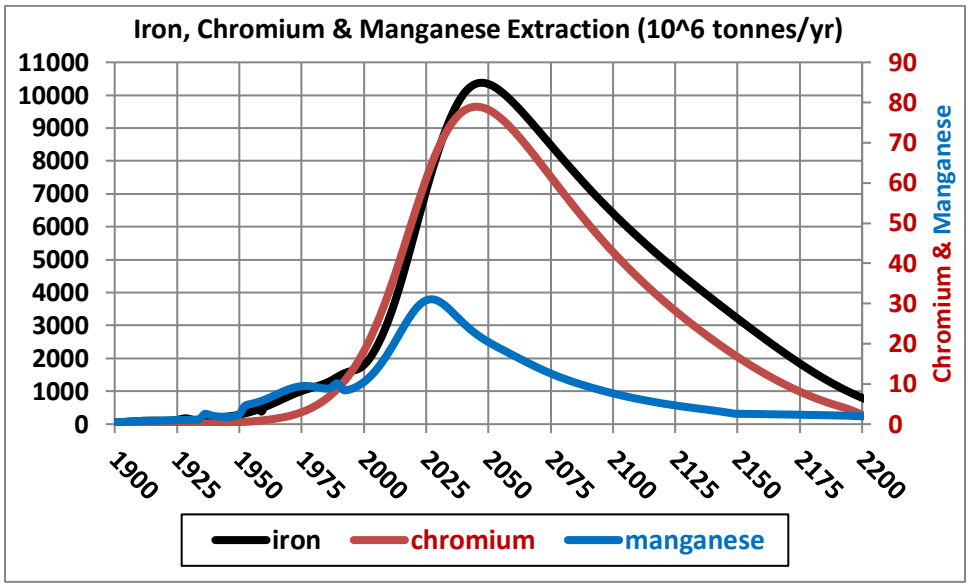


Manganese Depletion

In a previous study (Ref. 3) the author has dealt with manganese depletion. Making some assumptions about reserves and recycling, the following curve was obtained for manganese depletion:



The yearly availability rates, including recycling, for iron, chromium and manganese plotted together are:



Note that the chromium and manganese curves are measured by the much-lower-value right axis.

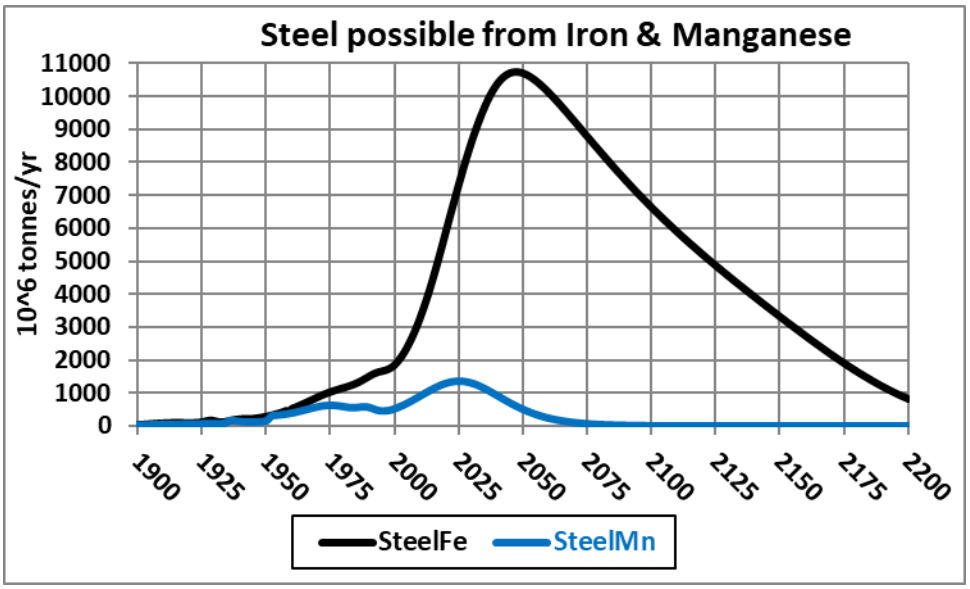
Steel Production

For this study it is assumed that iron ore [magnetite (Fe_3O_4) and hematite (Fe_3O_3)] is about 70% iron.

The maximum steel production possible for the two metals, Fe and Mn, is calculated by:

$$\mathbf{SteelFe = Fe/0.965 \text{ and } SteelMn = Mn/0.015}$$

The following graph shows the result of the calculation:



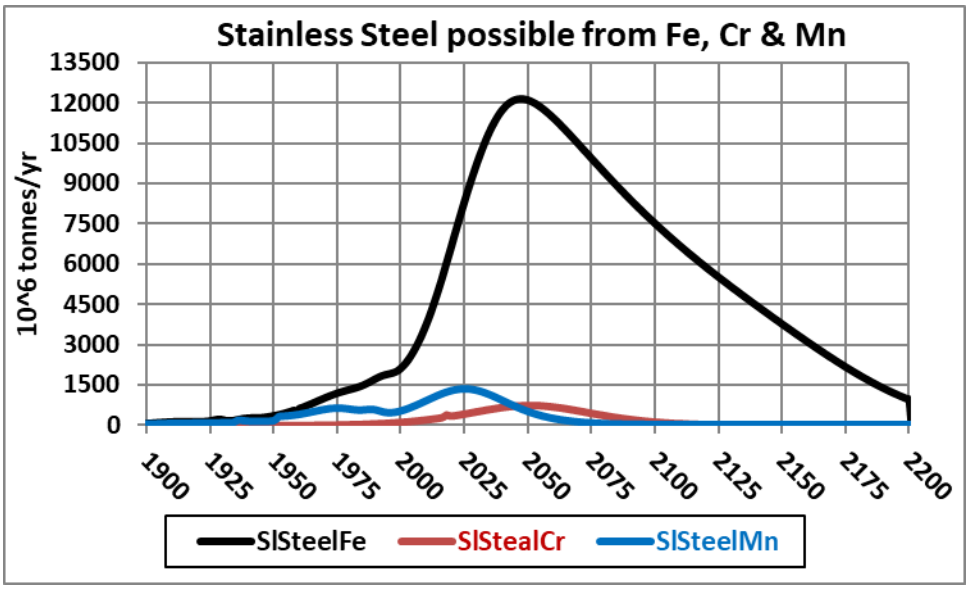
Obviously, manganese is the limiting factor in producing steel.

Stainless Steel Production

The maximum steel production possible for the two metals, Fe and Mn, is calculated by:

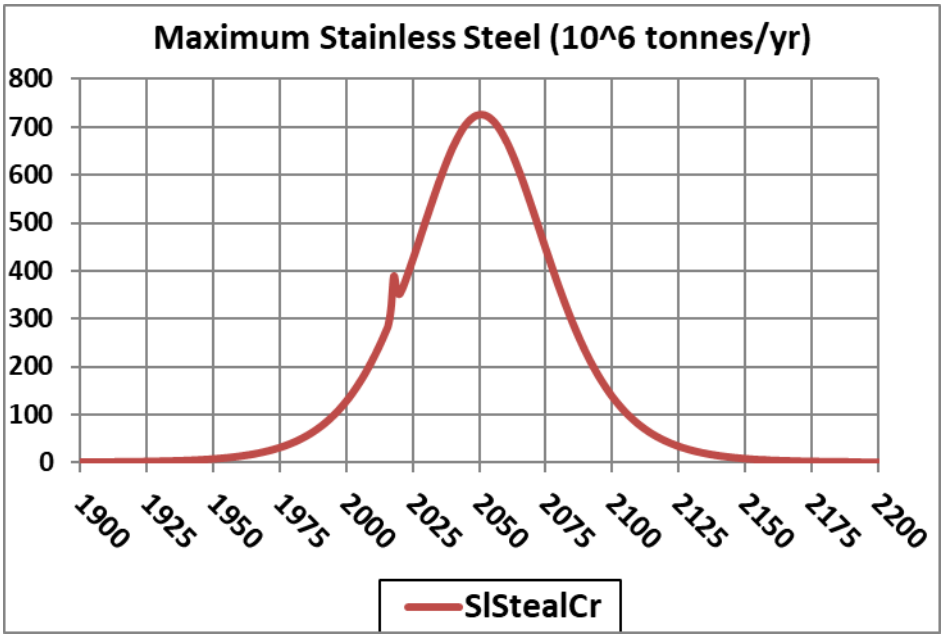
SlSteelFe = Fe/0.855, SlSteelCr = CR/0.11 and SteelMn = Mn/0.015

The following graph shows the result of the calculation:



Obviously, chromium is the limiting factor in producing stainless steel.

This graph shows the possible stainless-steel for chromium:



References

1. Iron (http://en.wikipedia.org/wiki/Iron)(http://www.roperld.com/science/minerals/iron.pdf)
2. Chromium (http://en.wikipedia.org/wiki/Chromium)(http://www.roperld.com/science/minerals/chromium.pdf)
3. Manganese (http://en.wikipedia.org/wiki/Manganese)(http://www.roperld.com/science/minerals/manganese.pdf)
4. Steel (http://en.wikipedia.org/wiki/Steel)
5. Stainless Steel (http://en.wikipedia.org/wiki/Stainless_steel)

Note that minerals are “extracted” from the Earth, not “produced”. Steel is produced from extracted iron, chromium and manganese ores.

This is http://www.roperld.com/science/minerals/StainlessSteel.pdf.