R-FACTOR

What it means and how to use it to roll the mill

R-Factor

- What does it stand for
  - Reduction Factor
- It is also known as (AKA)
  - E-Factor or Elongation Factor
- Because it is referred to as a “factor” it is unitless.
  - Meaning it can be applied equally in similar situations.

Reduction

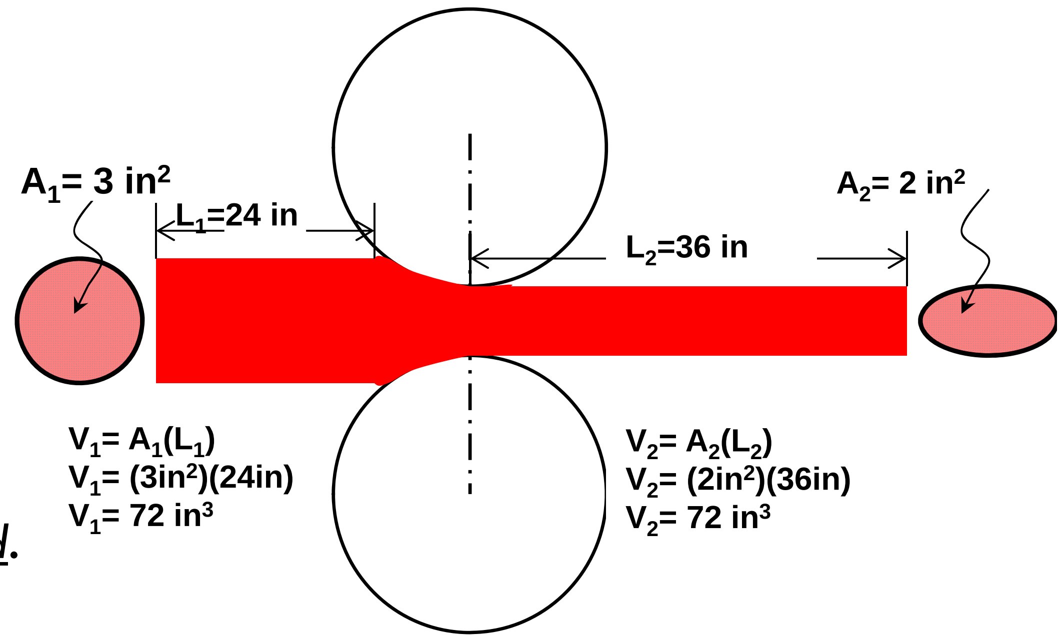
- When heated steel is passed between two counter revolving rolls where the incoming height is greater than the exiting height the change in Area of the two shapes is referred to as the reduction.
- R-Factor = Area in vs. Area out
  - R-Factor = Ain/Aout
- R-Factors will always be greater than 1
- The higher the number, the greater the reduction

Elongation

- The "reduction" in cross sectional area is directly proportional to the *change in length* because of the "Constant Volume Principle"
  - A 2 ton Billet yields 2 tons of product no matter the shape of the product (minus any yield lost to crops or scale)
- This is also directly proportional to the *change in speed* of the bar.

R- Factor/Elongation Factor

- Assuming the bar is rolled at constant volume.
- R-Factor represents the amount of change:
  - In the bars cross-sectional area
  - It's change in length
  - And the change in bar *speed*.



Ratio 3:2

R-factor =1.5

Working Diameter

- The working diameter of the roll is the diameter that that represents the speed of the bar
- The working diameter is calculated using the roll diameter and the Groove factor (G-Corr)
  - Roll Dia. – G-Factor = W-Dia
- Groove Factor is an empirical formula that uses pass area, bar width and roll gap
  - G-fact = Area/width-gap

Scheduled R- Factors

- Scheduled R-Factors are a blend of theoretical values and historically consistent rolling's.
- Variations from schedule have a variety of interpretations
  - Bar size at the stand in question is wrong
  - Bar size preceding the stand in question is wrong
  - Speed mismatch
    - Tension or Compression
  - Interstand looper settings are incorrect

Out of Range Remediation
(Bar size)

- R-Factor out of range due to size
  - R-Factor too high – bar is too small
  - R-Factor too low – bar is too large
- R-Factor out of range due to bar_{in} (*gazinta*) size discrepancy
  - R-Factor too high – bar_{in} is too large
  - R-Factor too low – bar_{in} is too small

Out of Range Remediation (Speed)

- R-Factor out of range due to speed
  - R-Factor too high - stands are considered “tight” Speed the mill up in back
  - R-Factor too low - stands are considered “soft” Slow the mill down in back

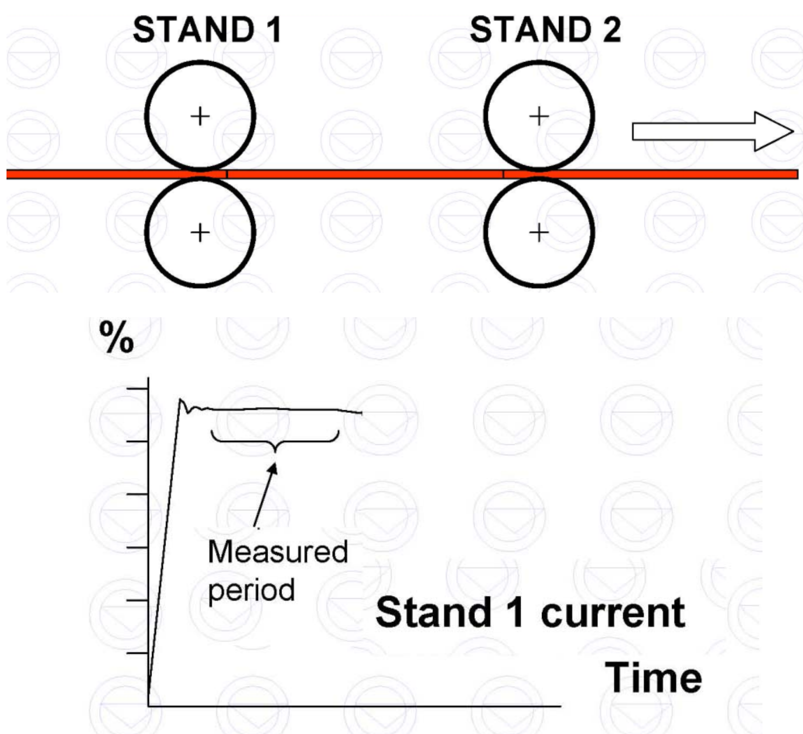
Other Indications of R-Factor fails

- Groove Factor
- Roll Diameter
- Gear ratio
- Schedule is wrong

Tension Control

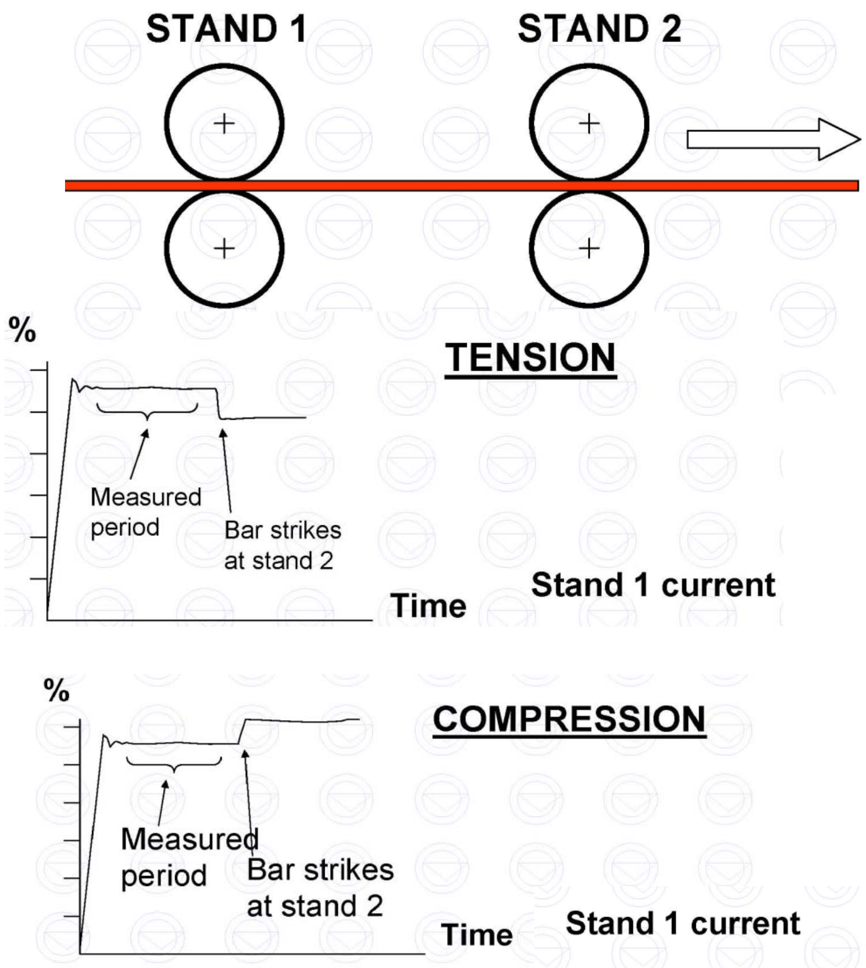
Rougher

- The mill is not rolling or between bars:
- A new bar arrives and bites at stand 1, the current taken by the motor is now being measured and averaged until just before the bar strikes stand 2.
- This is the measured period.



Tension Control

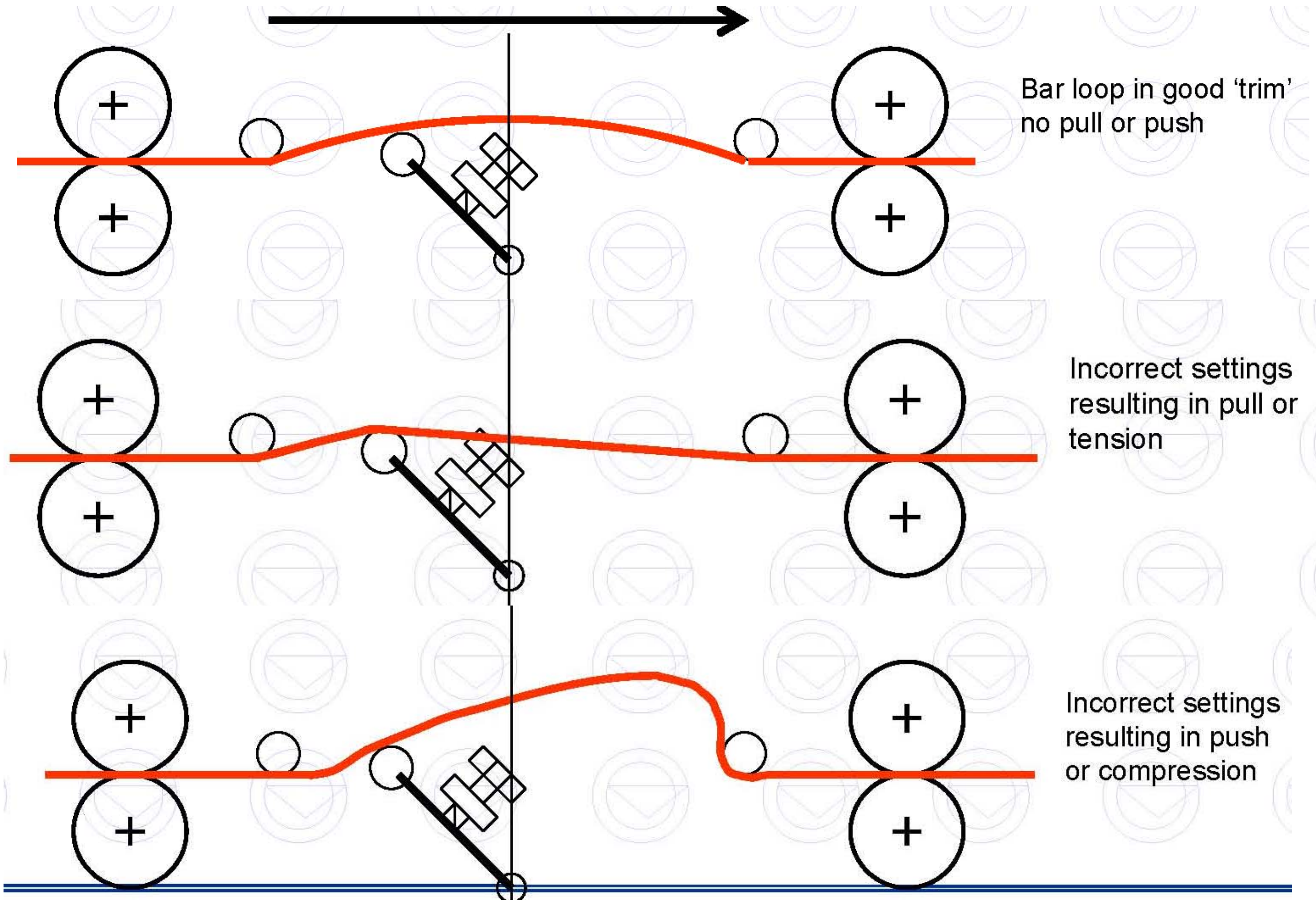
- The bar now bites at stand 2 and the current of stand 1 is monitored, any change in load pattern is acted upon through the speed control system.
  - If the current shows a decrease then tension is evident
    - The speed of stand 1 is increased.
  - So, an increase in current of stand 1 (at this exact time) indicates compression
    - The speed of stand 1 is decreased.



Scale Break

- The Scale Break is the part of the bar that does not touch the sides of the pass.
  - The appearance is rough and scaly
- If the mill is in tension the scale break
  - Gets wider
- If the mill is in compression the scale break
  - Gets smaller

Loop Profiles



Bar loop in good 'trim' no pull or push

Incorrect settings resulting in pull or tension

Incorrect settings resulting in push or compression

HOW DOES A CONTINUOUS MILL WORK ?

MILL CONSTANT IS BASED ON THE VOLUME CONSERVATION PRINCIPLE

MEASURED IN CUBIC INCHES PER SECOND

FORMULA : AREA x SPEED = THE MILL CONSTANT (in^3/sec)

AREA = PASS AREA (in^2)

SPEED = WORKING DIA x Pi x ROLL RPM/60 (in/sec)
Pi = 3.1412

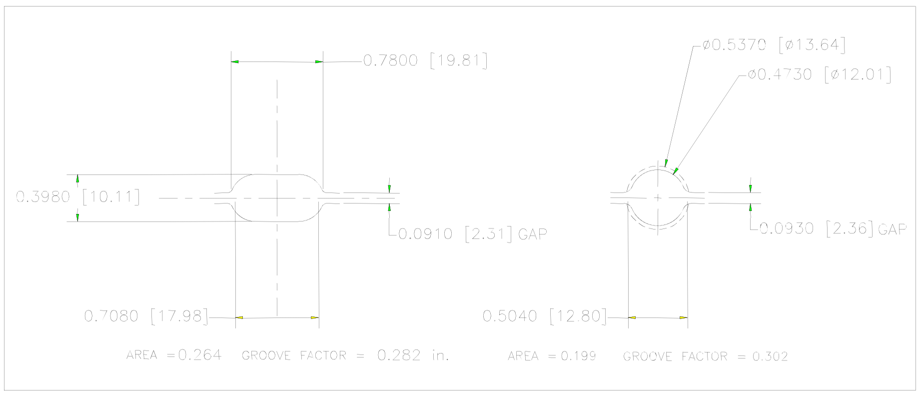
MILL CONSTANT

- Volume $_{entry}$ =Area $_{entry}$ x Speed $_{entry}$ =Area $_{exit}$ x Speed $_{exit}$ =Volume $_{exit}$

- Take 13mm for an example. Nominal Area is .199 in^2 , 5% light is .189 in^2
- Shrink factor for steel is 6.5×10^{-6} per inch per degree Fahrenheit. Delta t is 1830° (1900-70). This works out to 1.012, or .012" shrink per inch.
- The hot area is .191 in^2. We are finishing at 2264 FPM or 452.8 inch/sec.
- The volume in in^3/sec is: .191 x 452.8 = 86.62 in^3/sec. This is the hot volume going through each stand.
- How does this translate into TPH?
- A 1in^3 piece of steel weighs .277# (hot).
- 86.62 x .277 x 3600 / 2000 = 43.19 full groove TPH.

MILL CONSTANT

- Working Diameter = Roll diameter – Groove Factor
- Groove factor = pass area / bar width – roll gap



LEADER
Roll dia = 13.400”

FINISHER
Roll dia = 13.400”

GROOVE FACTOR (GF) FOR FINISHER

GF = 0.191 in^2 / 0.504 - .093 = 0.286

GROOVE FACTOR (GF) FOR LEADER

GF = 0.264 in^2 / 0.708 – 0.091 = 0.282

CALCULATE ROLL RPM FOR THE FINISHER AND LEADER FOR 13mm Rebar

CALCULATE ROLL RPM FOR THE FINISHER FOR 13mm Rebar

$$\text{WE SAID THAT VOLUME} = \text{AREA} * \text{SPEED}$$

$$\text{IF WE DEFINE SPEED IN THIS EQUATION WE REWRITE :}$$

$$VOLUME\,\frac{in^3}{\sec} = AREAin^2 * \left(ROLL\ DIAMETER\ in - GF\ in\right) * \pi * ROLL\ RPM\ /\ 60\,\frac{\sec}{\min}$$

$$\text{EXTRAPOLATE 'ROLL RPM'}$$

$$\text{ROLL RPM} = \frac{VOLUME\ in^3 * 60\sec}{AREAin^2 * \left(ROLL\ DIAMETER\ in - GF\ \text{in}\right) * \pi}$$

$$ROLL\ RPM = \frac{86.62 * 60}{0.191 * \left(13.400 - 0.268\right) * \pi}$$

$$ROLL\ RPM = 659.6$$

CALCULATE ROLL RPM FOR THE LEADER FOR 13mm Rebar

NOW CALCULATE THE ROLL RPM FOR THE LEADER

IF WE DEFINE SPEED IN THIS EQUATION WE REWRITE :

$$VOLUME\,\frac{in^3}{\sec} = AREA\,in^2 * (ROLL\ DIAMETER\ in - GF\ in) * \pi * ROLL\ RPM\ / 60\,\frac{\sec}{\min}$$

EXTRAPOLATE 'ROLL RPM'

$$\text{ROLL RPM} = \frac{VOLUME\ in^3 * 60\sec}{AREA\,in^2 * (ROLL\ DIAMETER\ in - GF\ \text{in}) * \pi}$$

$$ROLL\ RPM = \frac{86.62 * 60}{0.264 * (13.400 - 0.282) * \pi}$$

$$ROLL\ RPM = 477.7$$

GEAR RATIO & MOTOR SPEED

- **Roll RPM * Gear Ratio = Motor RPM**
  - **(motor RPM/Roll RPM = Gear Ratio)**
- **For Stand 16V Gear ratios are 2.2 and 4**
- **Motor RPM Stand 16V 1000min/2000max**
  - 659.6 * 4.0 = 2638 (too high)
  - **659.6 * 2.2 = 1451**

- **For Stand 15H gear ratio is 3.3**
  - **477.7 * 3.3 = 1062**

Expectations for Running on Schedule

- Consistency of operations
- Faster more repeatable start ups
- Better quality product