Energy Savings for the Metals Industry

Flying Gage Change Technology for Hot Strip Mills

by Bill Turowski and Paul Blaiklock

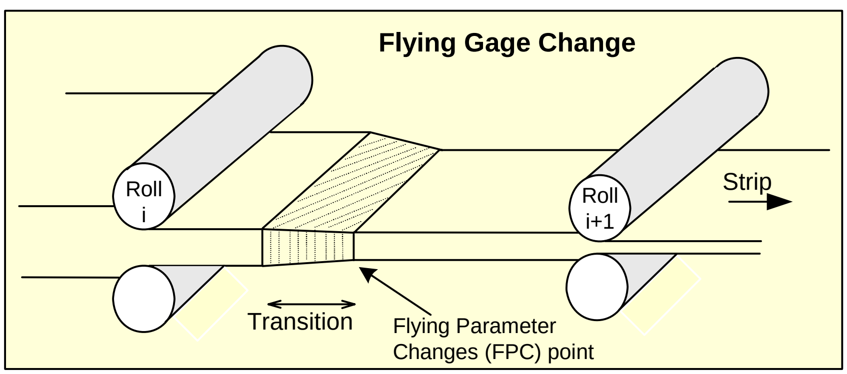
Rolling mill technology is continually advancing, driven by the need for increasing productivity and lower costs. This article gives an overview of a new control technology applied to hot strip mills producing light and ultra-light gage strip. These mills work with very long slabs and produce many coils from one slab, changing the gage at beginning and end, and sometimes requiring to change gage part way through. Flying gage change (FGC) is an advanced technology used in these mills to change the strip thickness on the fly.

The first implementation of the constant exit strip mass flow type FGC was by TMEIC GE at a plant in the Europe, shown here.

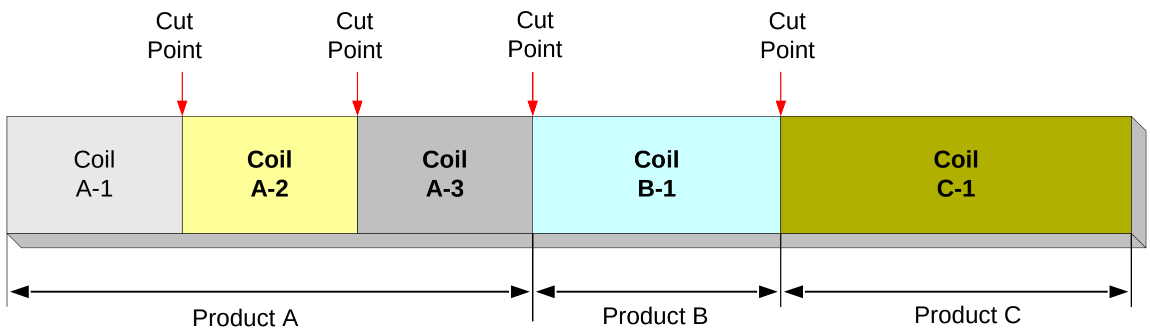
This mill is fed from a continuous caster and produces strip with a gage of 1 mm and below.

Background

Changing the strip gage is illustrated opposite. The FGC produces a tapered section with a transition length, which is determined by the rolling speed, the system response time and equipment capabilities.



The diagram (top of next page) shows three products continuously rolled from one slab without de-threading strip from the stands. In the case of a hot mill, the mill cannot be slowed down to make changes, so FGC is a highly coordinated control procedure involving the actuator regulators. The first hot mill FGC systems were implemented by TMEIC GE in 2000.



Semi-Endless Rolling: 1 Slab, 3 Products (3 unique setups), 5 Coils

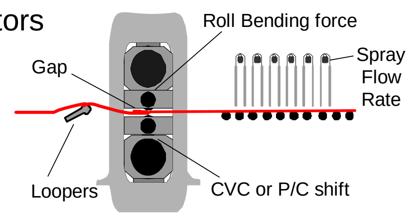
To implement FGC, the following regulators must be closely and accurately coordinated:

Regulators:

- Loopers
- Gaps
- Speeds

- Continuously variable crown shift or pair cross shift
- Roll bending force
- Spray's flow rate

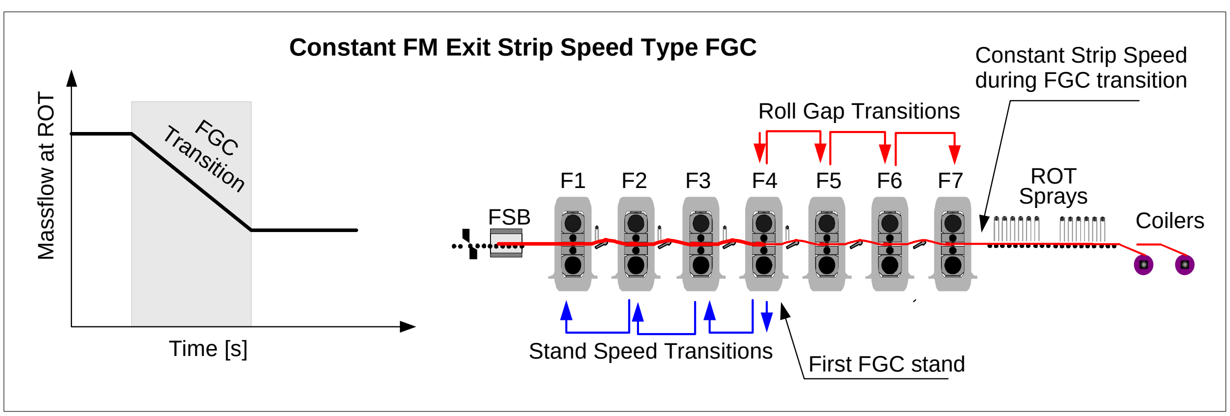
Actuators



Two types of hot mill FGC have been applied as discussed in the following sections.

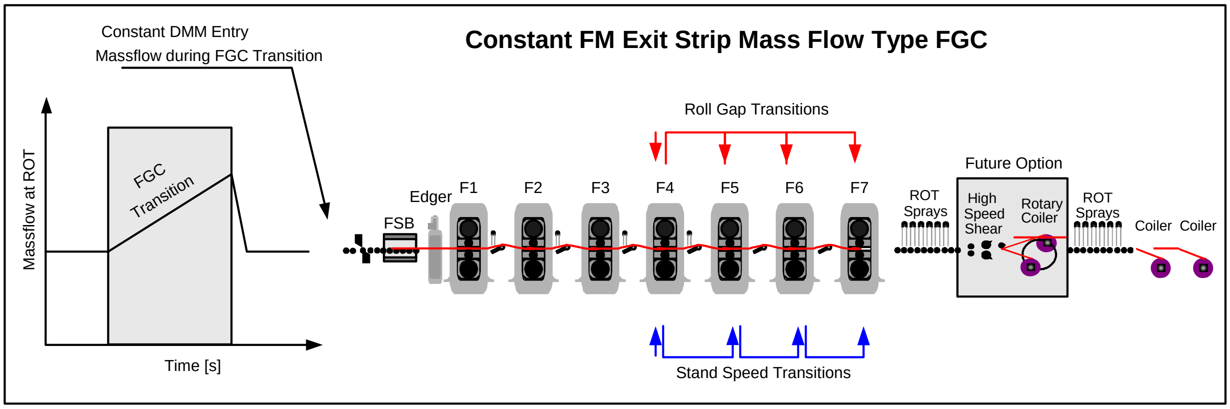
Type 1. Constant Finishing Mill Exit Speed

With this strategy, the mill speed is raised to the target level prior to the transition, then the gap and up-mill stand speeds are transitioned using a ramp. During the change, the looper, speed, gap, and profile adjustments are tracked and tightly controlled, and the finishing mill exit speed is held constant. There is also a flying profile change affecting the roll bending force with minimum changes to either the pair cross (P/C) angle or continuously variable crown (CVC) control. So far there have been four applications of this type system in Japan and China.

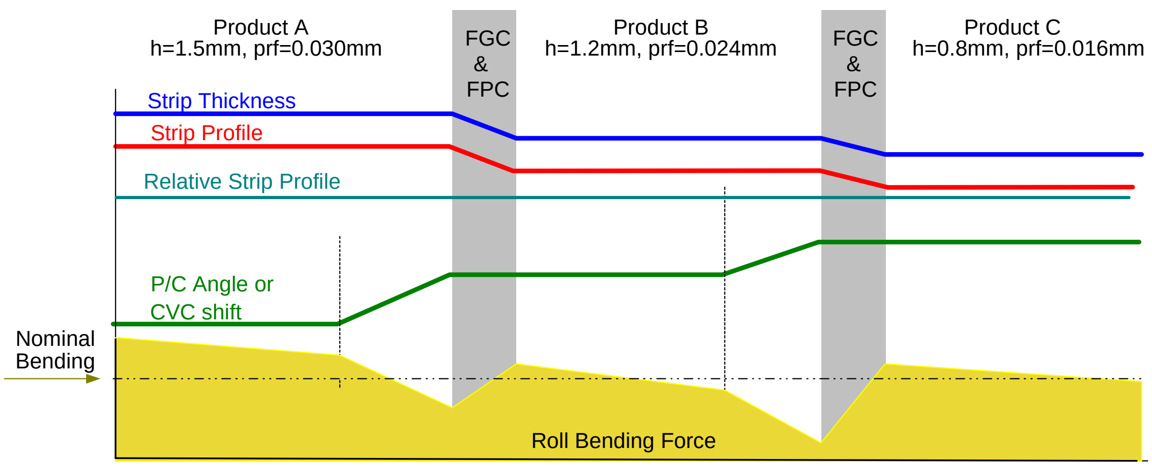


Type 2. Constant Finishing Mill Exit Strip Mass Flow

With this strategy, control of strip speed at the run-out table requires high acceleration torque, and the mass flow control is challenging. The gap and stand speeds are progressively transitioned down-mill using a ramp. The looper, speed, gap, and profile adjustments are tracked and tightly controlled, and the finishing mill entry speed is held constant.



During this change, there is also a flying profile change to maintain flatness. In the following example, the requirements are to maintain a constant relative profile of 2%.



Flying Profile Change (Constant Relative Profile of 2%)

Summary

Implementation of FGC has been shown to be an effective strategy to produce ultra-thin product in hot strip mills. The control system has to make many model-based process parameter calculations at high-speed and accuracy, with tight coordination. A critical element is control of strip profile and flatness.

At present the Constant FM Exit Mass Flow type of FGC has longer transition times causing higher strip yield losses than the constant speed type. This results from mechanical and electrical equipment limitations. However, with advances in equipment, it is expected this of type FGC will be required in mills where casting and rolling are in tandem.