CATEGORY: ROLL SURFACE INDICATIONS

TYPE: THERMAL PITTING

AFFECTS: WORK ROLL (HOT MILLS)

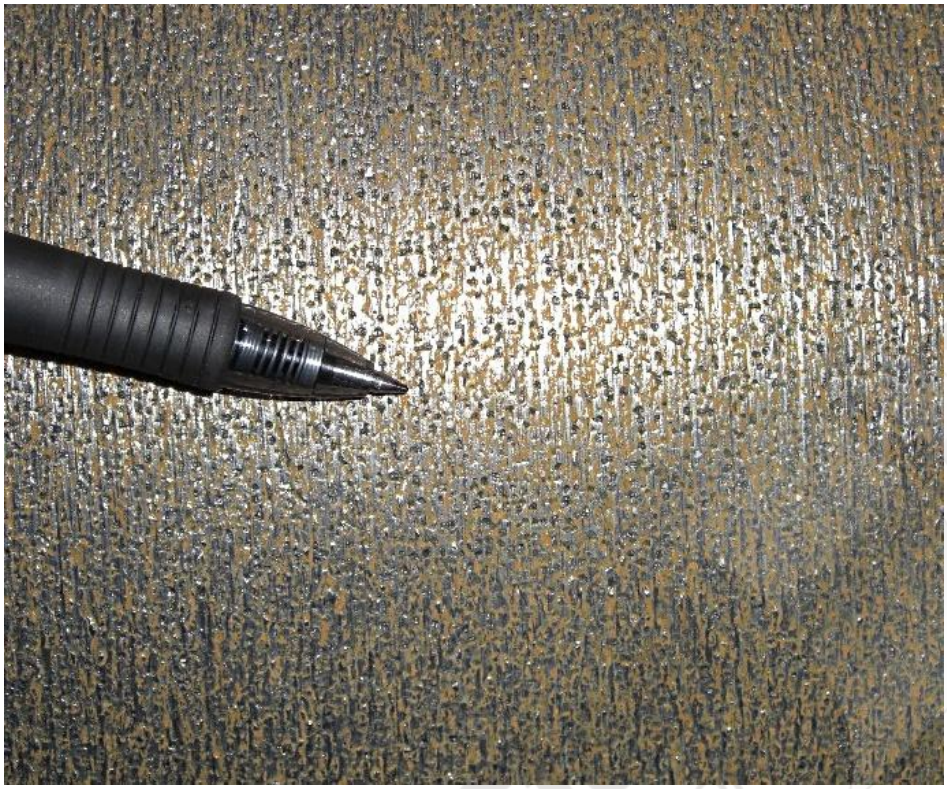
CHARACTERISTICS

Thermal pitting typically only occurs in hot applications and is a thermal/contact fatigue mechanism characterized by the presence of small, shallow spalls that appear as “holes” or “pits” located at the barrel surface in the area contacted by the bar or strip. The spalls generally have sharp angular corners, are cubic in form and can be regularly spaced or randomly scattered throughout the full strip contact width.

EXAMPLE

Example 1

Thermal pitting present at the barrel surface of a high speed steel hot mill work roll after grinding.



Example 2

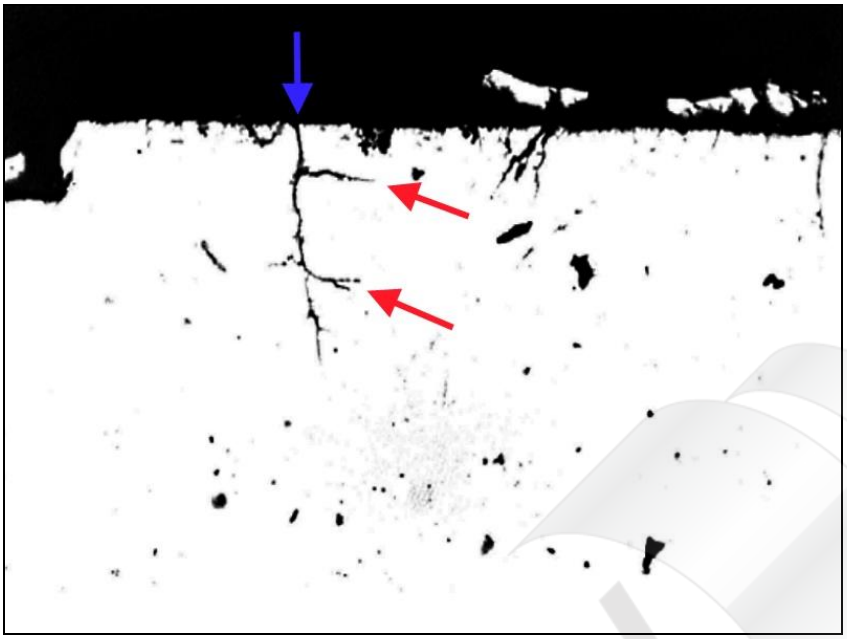
Thermal pitting at the barrel surface of a cast steel roughing work roll.

MECHANISM

Thermal pitting is a multi stage fatigue mechanism that results from the complex interaction of thermal and mechanical stress cycles on the roll surface during rolling. Due to the thermal fatigue cycle required, this mechanism typically only occurs in hot strip mill applications.

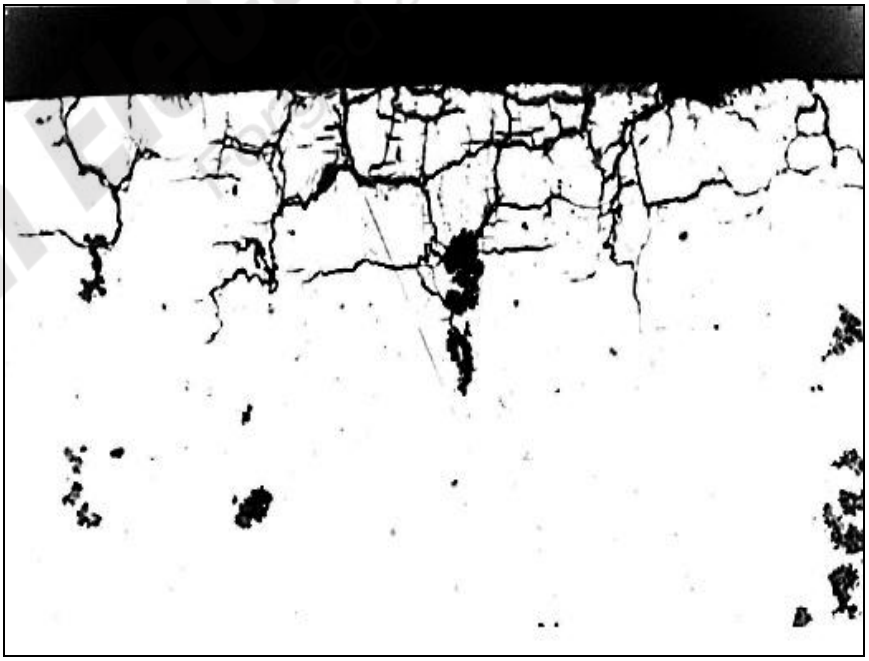
During the rolling process, the surface of a work roll forms a fire craze crack network via thermal fatigue in the area contacted by the hot bar or strip (see section II.A). This fire craze cracking is oriented in both the longitudinal and circumferential directions and extends radially inward from the barrel surface.

During rolling, the maximum resultant shear stress from contact pressure between the work roll and the back-up roll (Hertzian Stress) is oriented parallel to the tangent of the roll surface and is located a short distance below the roll surface (see section III.C – Contact Stress Spalling). With each rotation of the roll, the radial extension of the fire craze cracks (if deep enough) will be exposed to this Hertzian Stress which will then initiate secondary cracks at the location of maximum resultant shear stress that will be oriented parallel to the barrel surface tangent once the critical number of contact stress cycles is achieved (contact stress fatigue).



Cross sectional view of a work roll surface showing radial fire craze cracks (blue arrow). Early stage of contact stress cracks can also be seen developing parallel to the surface (red arrows). Magnification x 100.

With continued rolling the contact stress cracks will propagate parallel to the roll surface tangent until intersecting an adjacent crack. When this occurs a small cubic piece of the roll surface material will become detached from the parent material resulting in the formation of a small spall.



Cross sectional view of a work roll surface showing extensive interlinked craze cracking and contact stress cracking. Magnification x 100.

The size of these small spalls and rate at which they form is governed by the initial size and depth of the fire craze cells as well as the magnitude of the maximum sub surface contact shear stress (Hertzian Stress). In general terms the larger the fire craze cell size the deeper the cracks (depth is approximately half of the surface cell size). The greater the depth of the crack then the closer the crack tip will be to the zone of maximum sub surface shear stress and the higher the rate of crack propagation that will occur.

PREVENTION

Thermal pitting can be prevented by

- Ensuring sufficient stock removal during grinding after each mill campaign. Insufficient stock removal will result in an excessive number of stress cycles over several successive rolling campaigns at the same sub-surface zone of maximum resultant shear stress (Hertzian Stress). This is more commonly seen when using high performance rolls such as high speed steel in which average stock removals can be less than the radial depth of the fire craze cracking.

- Reducing the rolling campaign length and hence the total number of fatigue cycles.

- Review of the roll material specification including grade, heat treatment and hardness with the roll supplier to improve the shear strength of the roll material. Roll materials that exhibit a greater mechanical strength will therefore exhibit a greater fatigue strength (greater number of stress cycles required to initiate cracks).