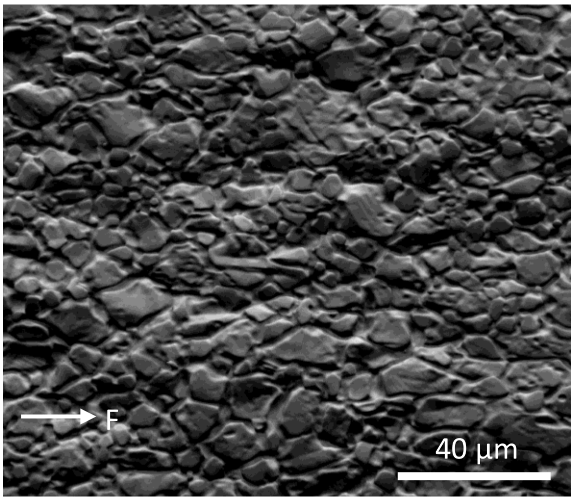
A popular science summary of master thesis, Division of materials engineering, Faculty of Engineering, Lund university

Surface roughness in stainless steel derived from strain

- A surface- and microstructural characterization of deformed stainless steel.

When deforming a metal at room temperature, the surface is affected. It might not be obvious to the naked eye, but on a micrometre scale, large changes occur on a surface when a material is strained. For the equipment produced at Tetra Pak processing systems, it is of relevance to study these changes in order to understand the interface between food products processed, and the equipment.

Most liquid food products that you consume are in some way processed. It may be homogenization to ensure that the oil and the water of your mayonnaise do not separate, or pasteurization to ensure there are no bacteria in your juice. Either way, to optimize the processing equipment, it is important to understand the interface between food and equipment. This interface would be the surface in contact with the food. At Tetra Pak, for some equipment stainless steel tubes of an alloy type named 316L is used. During the production process, these tubes are occasionally deformed. It is known that deformation at room temperature (cold deformation) induce roughening of a metal surface [1-3]. The goal of this thesis has been to develop an understanding for this roughening and to derive a relationship between surface roughness and strain for 316L steel. Just as all metals, steel is crystalline, meaning that the atoms are ordered in a repeatable manner. It is often the case that metals consist of several crystals, where each crystallite is referred to as a 'grain'. This is the case for the metal studied in this thesis. Important to know is that metal surfaces tend to form oxide layers. For steel it can be a chromium oxide layer, which is what protects your car from rust. To understand the mechanism of roughening, it is important to distinguish between effects deriving from oxide layer, and grains of the underlying bulk material. To do this, both polished and unpolished steel sheet samples were elongated to different extents and the surface roughness measured. What was found was that these two specimen types differed significantly, both in appearance and in the surface roughness - strain relationship. From electron imaging and roughness data it was found that for polished sheets, surface roughness was localized at the grain boundaries due to rotation of the grains when the material is strained. The surface roughness increased with strain until reaching a maximum, then decreased to a point at which roughness was no longer affected by strain. This behaviour is thought to be because that the grains rotate towards a steady state. However, when reaching this point, they slightly rotate past it before going back. Unpolished sheets contained a scale-like oxide layer and obtained a linear, positive relationship between strain and surface roughness. The slope of the relationship was directional dependent, in relation to the direction in which the sheets had been rolled. The mechanism of surface roughening was more complex and is believed to originate both from underlaying grain rotation, but also from a lack of ductility in the oxide layer, inducing cracks.



Unpolished sheet elongated by 30%, with the force direction indicated by arrow.

A linear model was developed correlating strain and surface roughness of steel tubes deformed by an indentation process. The results showed that the model was accurate with some restrictions on size of indentation.

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References

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