# EXPERIENCE REPORT OF SURFACE QUALITY MANAGEMENT IN PICKLE LINES: IMPROVEMENT POTENTIAL OF PRODUCTIVITY AND QUALITY[1]

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**Summary**
In today's sellers market, one usually expects capacity to dominate quality, because nearly the complete produced steel can be sold. However, capacity and quality are not as conflicting as it might appear on the first glance: This paper shall examine how upstream quality measures at the pickling line can help increasing both quality and capacity for downstream processes. Describing a strip steel imperfection through both a quality and a capacity perspective requires parameters (features) to describe the defect characteristics such as size and shape. More features deliver better results. Therefore, Parsytec developed more than 800 features. This has caused a quantum leap in recognition accuracy and has finally made classification feasible. Software tools are needed to create classifiers effectively. The job is obvious: selecting the right features to distinguish the defects, which have been included into a process optimization-oriented defect catalog. The results of this new software approach will be discussed with field studies from leading US steel producers like USS POSCO: applying this classification technology at the pickling enabled USS POSCO to decrease the tandem breaks at the subsequent tandem line by more than 50% - leading to improved capacity and throughput by simultaneously higher quality.

**Key-words:** Surface inspection, surface quality

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## STEEL MAKERS' CHALLENGE: TAKING DECISIONS AS EARLY AS POSSIBLE IN THE PRODUCTION CHAIN

It is undoubted that today's steel market can be characterized as a seller's market: Industry analysts report a continuously increasing worldwide steel demand as well as global inventories to be far below the average. This lets them expect no downturn in the apparent consumption cycle in the near future, while, at the same time, they also notice only a flat growth of the global supply. In such a market environment, usually capacity dominates quality, because nearly the complete produced steel can be sold.

However, capacity and quality are not as conflicting as it might appear on the first glance: When thinking of quality, one usually focuses on the question how intermediate products approach final customer specification throughout several production steps. In this process, quality characteristics are transformed following precise process instructions of its order specific routing. The quality corridor – i.e. the bandwidth of the tolerable quality according to customer specification – becomes tighter from production step to production step: With production moving downstream, the commercial value of the intermediate material grows, and the degree of freedom for re-routing decreases. But at the same time, upstream opportunity costs due to delayed identification of missed quality characteristics increase. Consequently, if current surface quality does not meet the target characteristics in any stage of the value chain, decision processes must be triggered. Such decisions are mainly based on quality data, among which surface quality data turned to play a central role due to surface quality representing a key value driver in steel production. In this regard, Parsytec's leading surface inspection systems already today support the discussed decision universe.

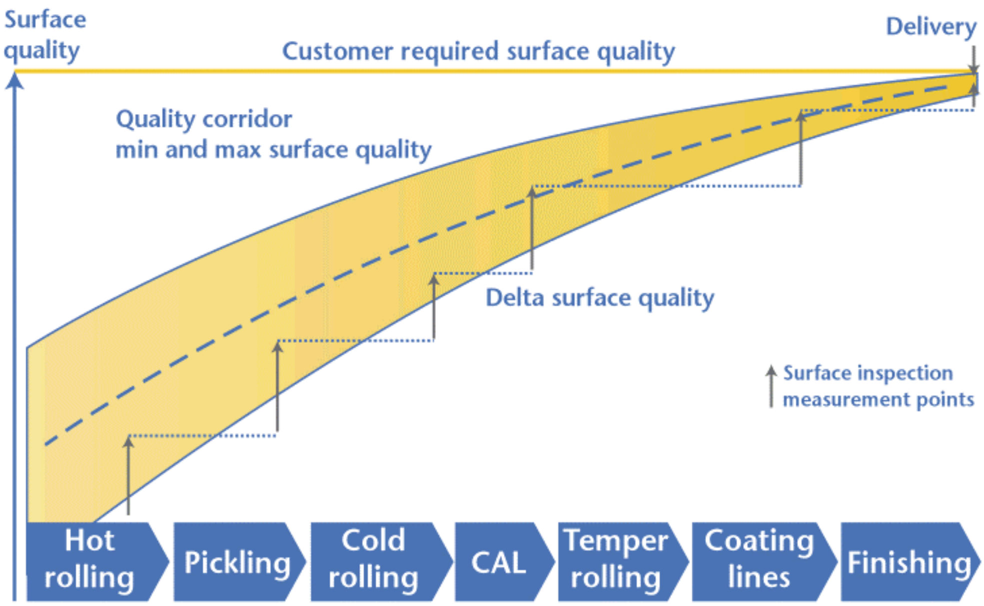


**Figure 1**. Optimizing capacity and yield means taking decisions as early as possible

But when it comes to capacity optimization considerations, more than pure surface inspection systems are needed: The customer-specific quality corridor must get enriched by a capacity-centered quality view. As the value per produced ton increases while processing the intermediate coils through the production chain, downstream bottlenecks have a high leverage on the yield. Controlling quality in the upstream processes with respect to the requirements of the subsequent process steps can enable steel producers to release downstream capacity bottlenecks.

This in turn requires a cross-line view of the quality corridor. One example may illustrate this: A Parsytec surface inspection system at the hot rolling mill reliably indicates the scale pit density. Assessing these quality data through the customer-oriented quality view may lead to the conclusion, that the produced material is not harmful with respect to customer requirements. Consequently, no action is triggered. However, looking at the same data with respect to the capacity of the subsequent pickling line may reveal the information, that the respective coil can get processed with a higher pickling speed. This in turn would immediately lead to better capacity utilization and increased output – while simultaneously securing high delivery quality through the customer-oriented quality view.

## THE TECHNOLOGICAL SOLUTION: CLASSIFICATION TECHNOLOGY AS CORE OF A SURFACE INSPECTION SYSTEM

Such process optimizations can only be achieved, if the applied surface inspection system does not simply “deliver defect images”. These images should get described through both a quality and a capacity perspective so that they deliver the appropriate information for downstream quality measures.

Parsytec AG for the first time ever has implemented this process in software for surface inspection: Describing an imperfection turns out to be the real challenge. It requires parameters (features) to delineate the defect characteristics such as size and shape. More features deliver a more precise description, consequently a better result, and as such a better basis for targeted productivity decisions and actions.

Based on its experience from over 150 worldwide installations in the metals industry, Parsytec utilizes more than 800 features. To handle these sophisticated analysis options, Parsytec has developed a set of software procedures, which take care that the best fitting set of analysis features is applied for the individually created defect classes. The best fitting set of features always follows the individual online-defect catalog of the specific production line like hot mill, pickling, cold rolling, coating or tinning. Each detected surface characteristic is then compared with the 800-features-set in this defect catalog. The analysis shows which specific set of features at this production line separates for example harmful and harmless defects for the subsequent production line. A specific defect label following the steel makers’ terminology is derived (cf. Figure 2).

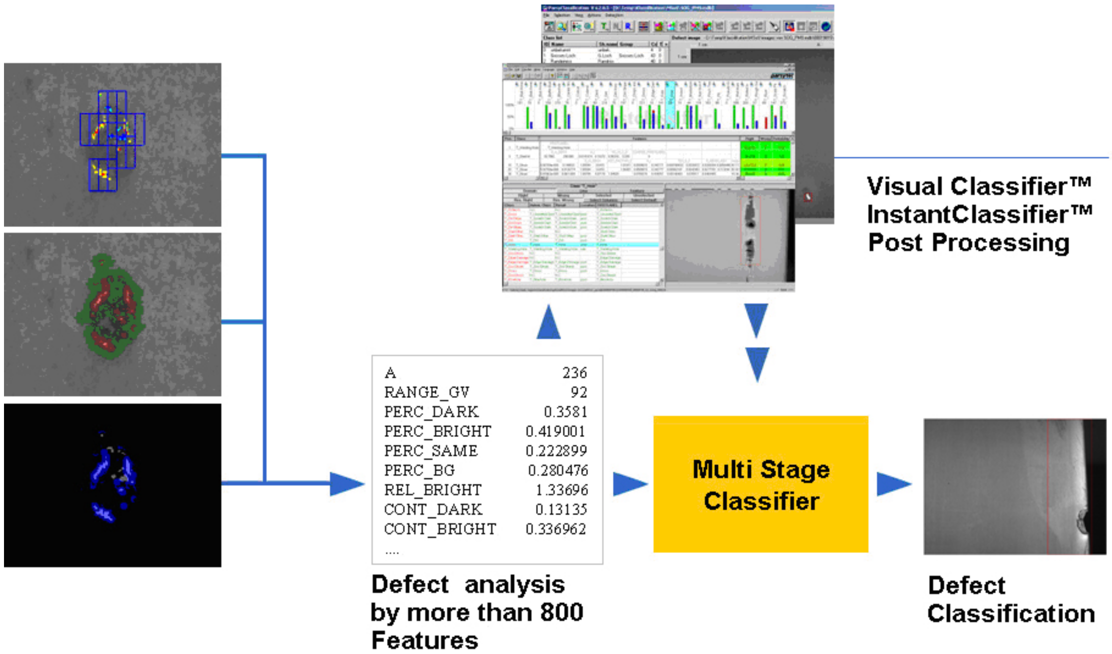


**Figure 2**. Classification technology

## CASE STUDY: SURFACE DEFECT CLASSIFICATION TO PREVENT STRIP BREAKS AT USS-POSCO

At Pittsburg, USS-POSCO operates a coupled pickling-tandem line processing 1.7 million short tons per year – of which 60% are sheet and 40% are tin. However, scrabs, edge cracks, inclusions and other pickling-related defects led to regular strip breaks at the subsequent tandem line. In 2002 and 2003, USS-POSCO had to face such strip breaks at its tandem line in average 25 times per month. The result were machine down times, roll shop costs and material loss. With such regular line still stands, capacity was not fully exploited and timely delivery was endangered. Consequently, for USS-POSCO it was essential to locate defects as early as possible to enable an in-time intervention.

Thus, USS-POSCO decided for a Parsytec surface inspection solution and jointly agreed the following objective: reduce tin product material strip breaks by 75%, which means from 25 strip breaks to 5 strip breaks per month in average. In order to achieve this challenging target, USS-POSCO started with the pre-configured pickling defect catalog already included in the standard Parsytec solution. This defect catalog was developed on the basis of Parsytec's broad experience from pickling inspection system installations. It contains the typical pickling-related defects and as such allows a jumpstart into a surface inspection project:

USS-POSCO placed the order for the Parsytec solution on July 27, 2003. The equipment was delivered on October 10, 2003. Commissioning started at November 3, 2003 and final acceptance was awarded at November 24, 2003. Already at this time – 8 weeks after delivery – USS-POSCO was able to prevent the first strip breaks at the subsequent tandem line. The next step was training the Parsytec classifier to the USS-POSCO-typical and -critical pickling line defects by putting emphasis on all types of edge defects. With defining defects, that were not in the initial catalog (like ship or rail abrasions stemming from receiving the hot band via ship and train), USS-POSCO delivered special tandem warning classifications and enabled the classifier to concentrate on the harmful defects.

This enabled a complete workflow between the pickling and tandem line – leading to surface quality-based upstream capacity optimizations. This workflow is shown in Figure 3:

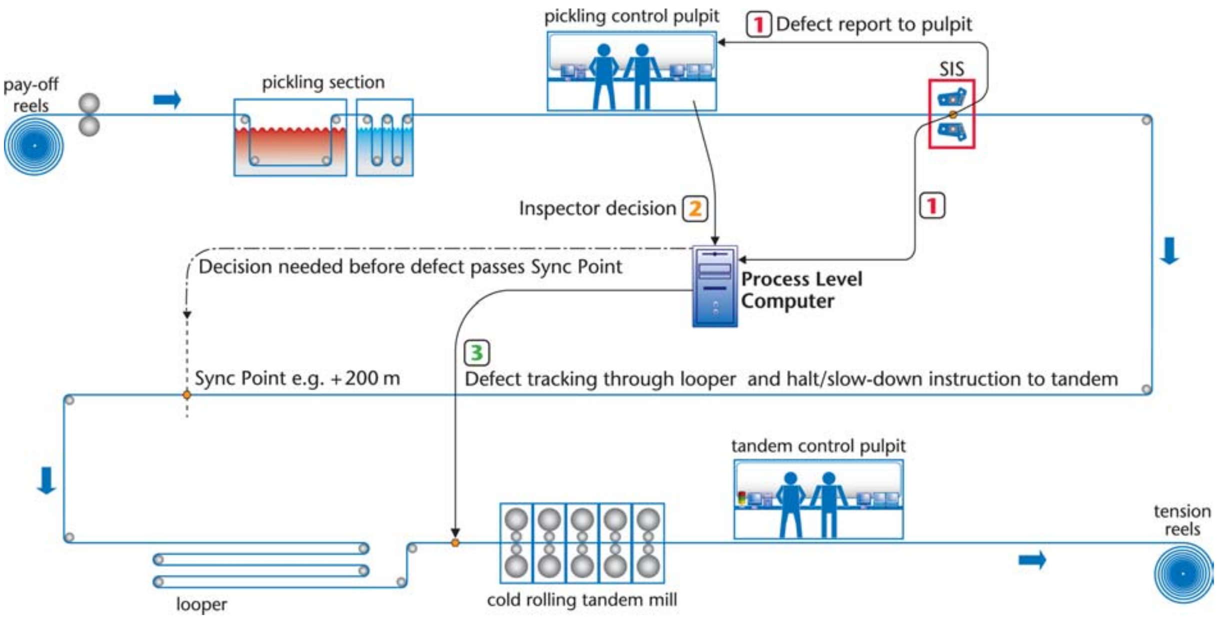


**Figure 3**. Surface quality-based workflow between pickling and tandem line

The surface inspection system is located after the pickling section. In case of critical defects, the defect is both directly reported to the pickling control pulpit (1) and sent to the process level computer (1). Based on the decision of the pickle line operator, the according command is then transferred also to the process level computer (2). If an action is required at the tandem mill, the process level computer autonomously generated the required machine control commands considering the status of intermediate sections including the looper (3). These commands can trigger actions like coil repairing, reducing roll pressure, tandem slow down, etc. Of course, timing is a serious issue: Both the defect reporting from the surface inspection system and the decision by the pickle line operators must be finished before the critical defect passes a defined synchronization point.

With this innovative approach, USS-POSCO managed a 55% reduction in tin material strip breaks in 5 months, and a 90% reduction in only 9 months time (cf. Figure 4)

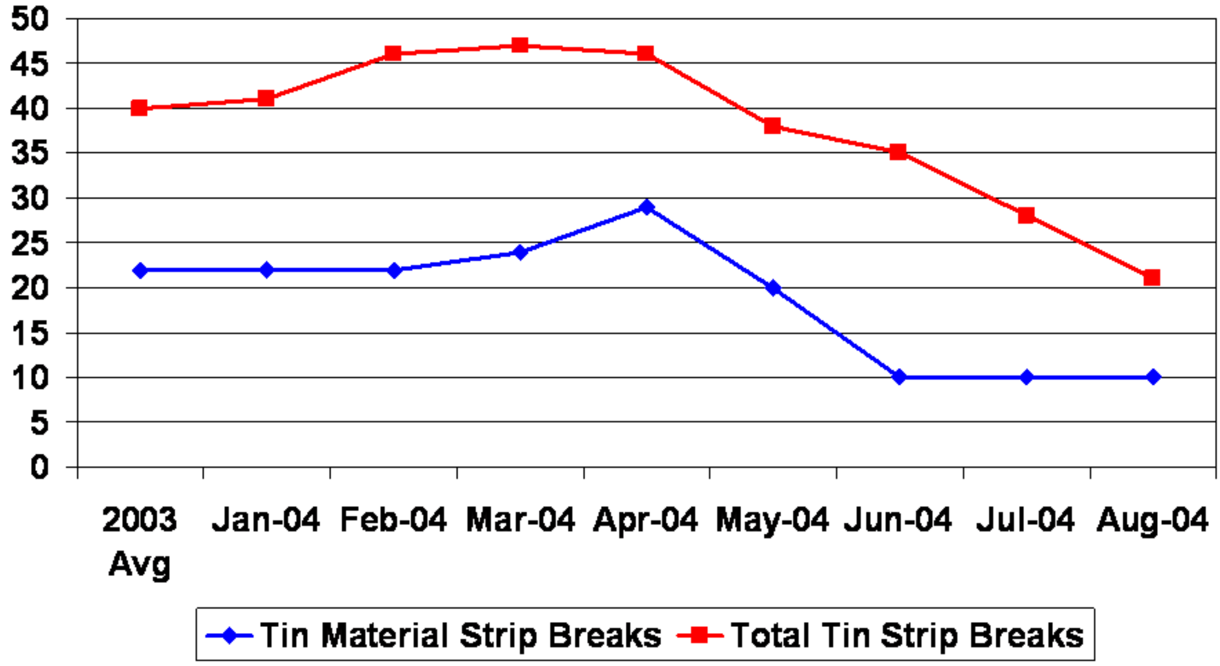


**Figure 4**. Achieved tin material strip breaks reduction

## CONCLUSION

The general economic conditions, stronger competition, and increasing customer demands force steel producers to simultaneously optimize quality and capacity. For both kinds of initiatives, classification-based surface quality information have proven as significant value creation catalyst. But such kind of quality data required to cope with today's challenges can no longer be delivered from traditional surface inspection systems. They need innovative classification technology and algorithms to become an efficient productivity weapon. With classification technology, steel producers can treat surface defects in a way they are used to – thus being enabled to take fast decisions. If defects are assessed through the "eyes" of the subsequent production step, relevant downstream process optimizations become feasible.

## Appendix - Harmful defects at USS-POSCO

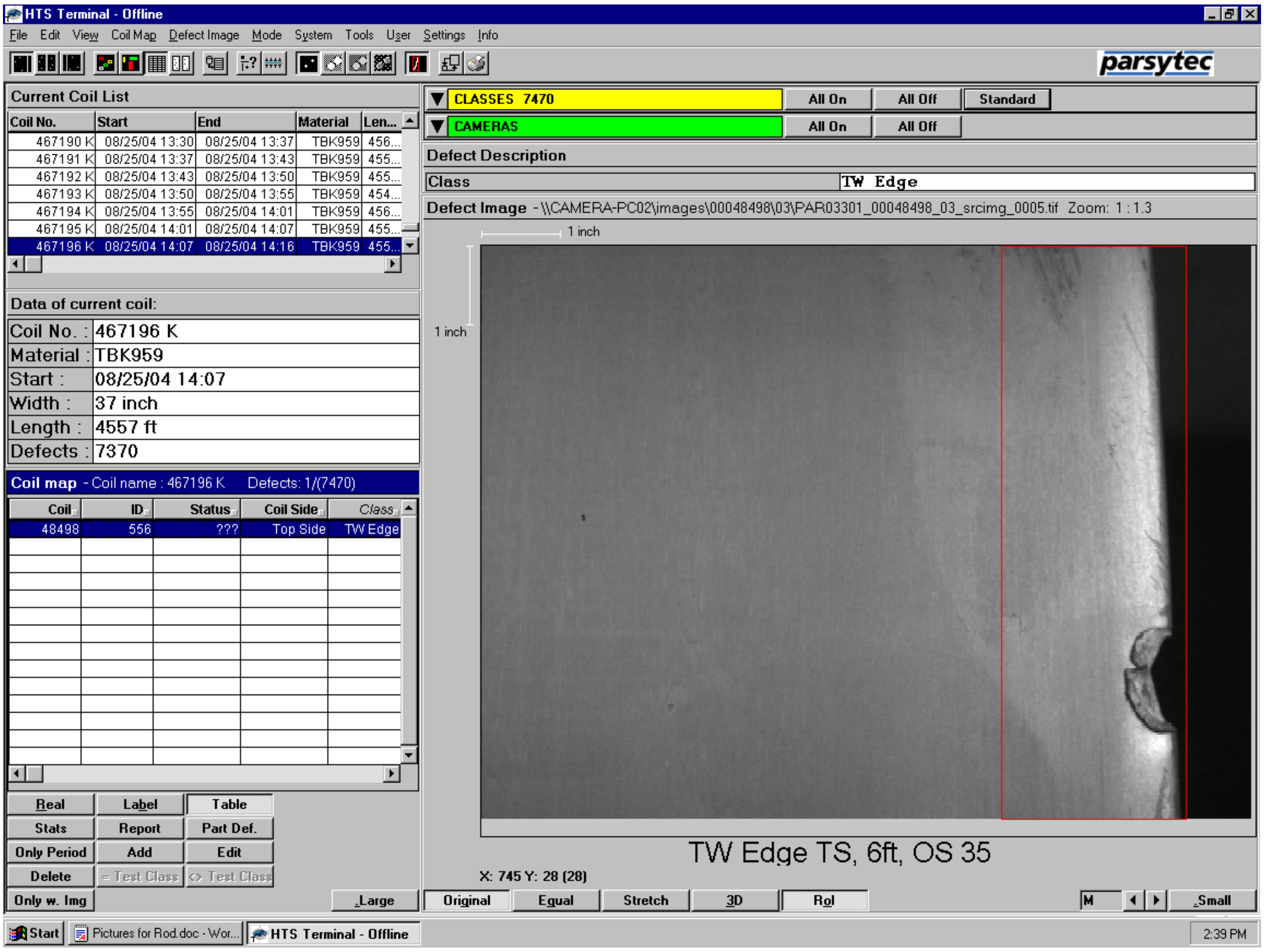


**Figure 5**. Edge damage

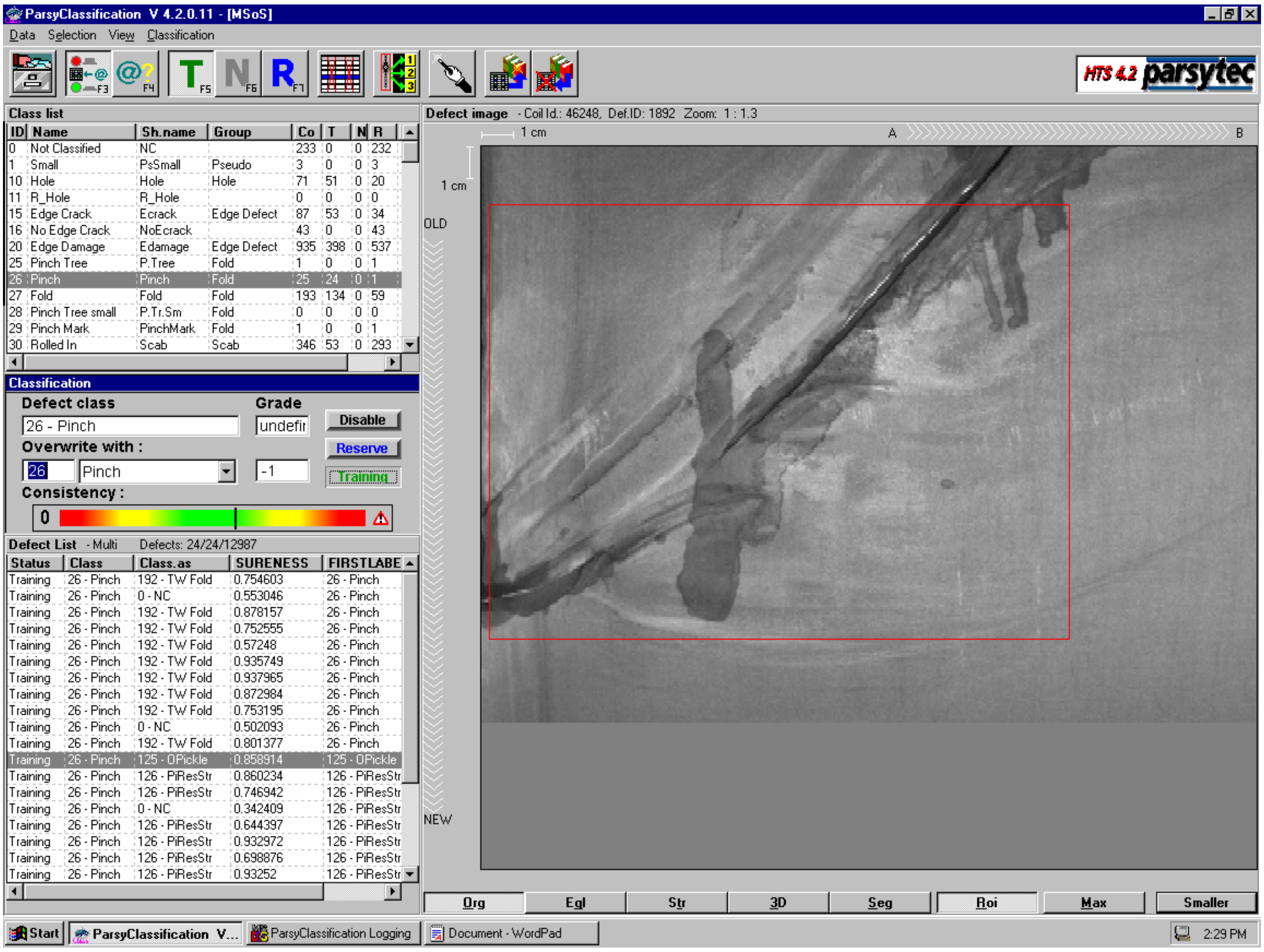


**Figure 6**. Hot mill pinch

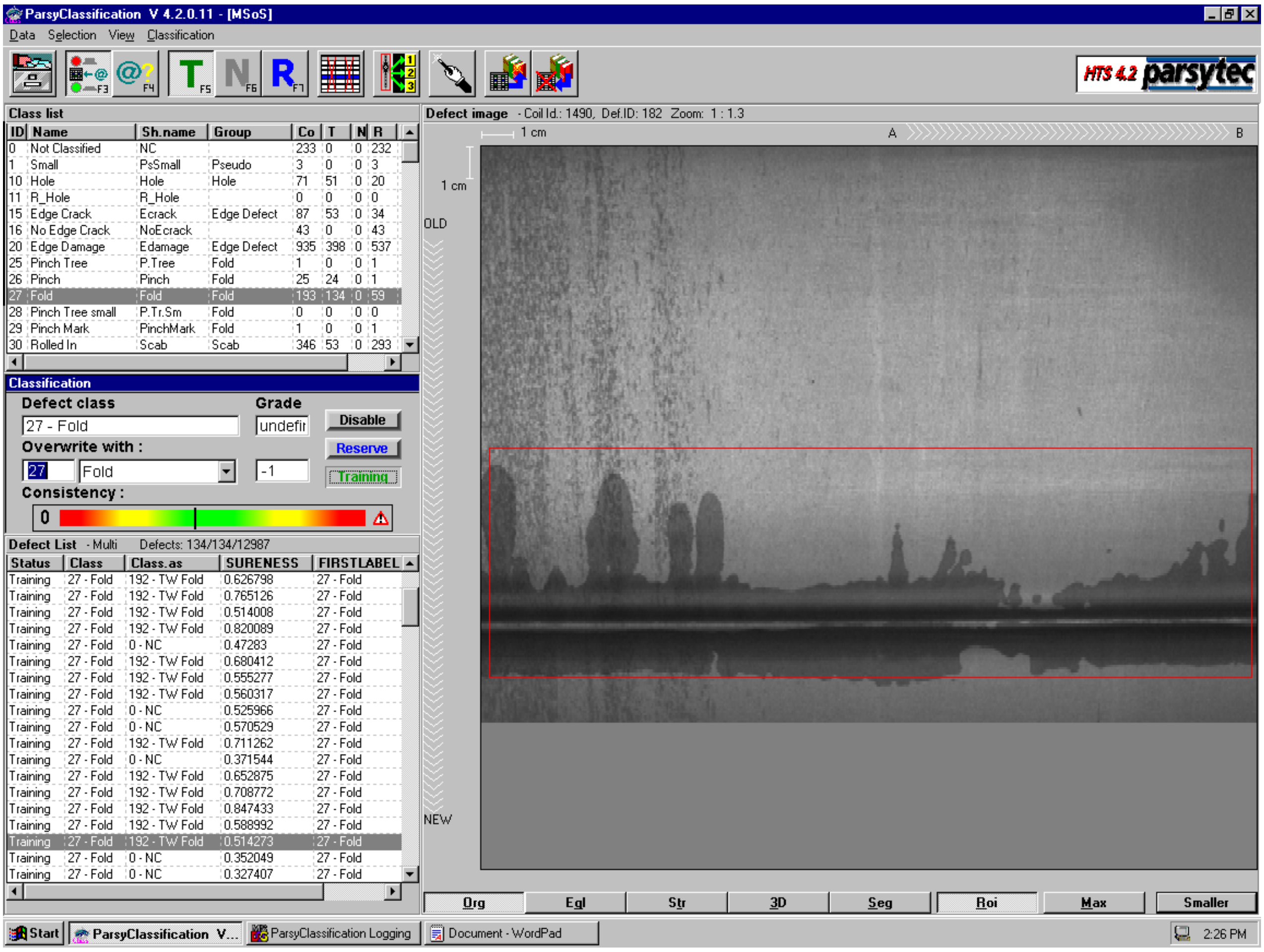


**Figure 7**. Fold

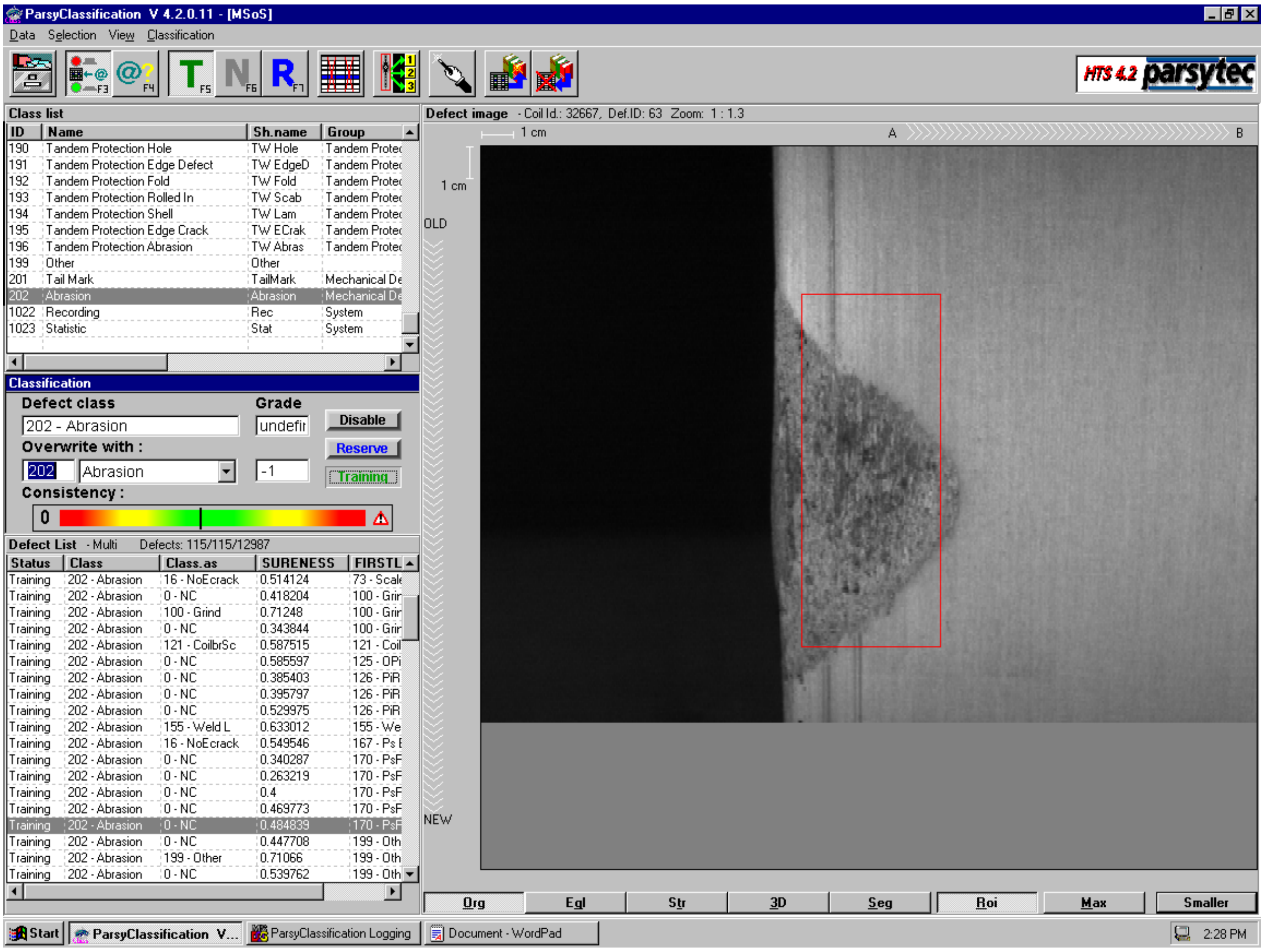


**Figure 8.** Abrasion