Quantitative Characterization of Microstructure Features for 1st Generation Advanced High Strength Steels

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Pacific Northwest NATIONAL LABORATORY
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Introduction

The role of Advanced High Strength Steels (AHSS) in the automotive industry is important because of its affordability and excellent mechanical properties. The 1st generation of AHSS achieves its preferred combination of strength and ductility by embedding harder martensite grains into softer ferritic matrix. Ductility and strength of these steels are important to safety, formability, application and life. However, a noticeable degree of inconsistent forming behaviors has been observed in the 1st generation AHSS in production, which seems to be related to the microstructure-level inhomogeneity.

DP980 A DP980 B

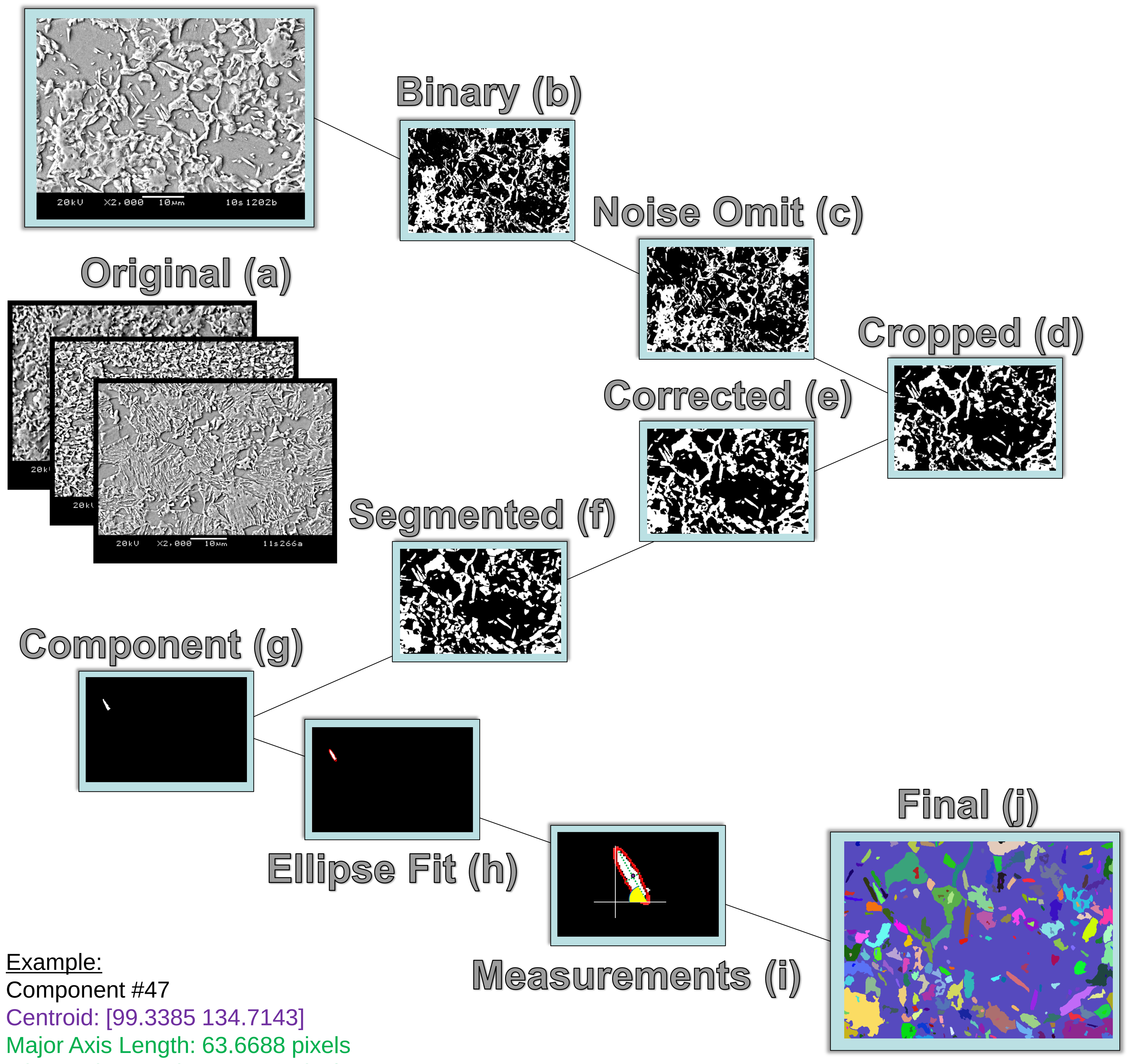
Figure 1. Markedly different forming behaviors for two commercial DP980 steels.

The objective of this project is to gain fundamental understandings on how different microstructure level features of AHSS can influence the behaviors of these steels subjected to deformation paths similar to those experienced in automotive forming operations. The ultimate goal is to accelerate the cost-effective vehicle weight reduction through increasing use of these steels. In this study, microstructure characterization has been performed on nine different DP980 grade steels. SEM (Scanning Electron Microscope) pictures are first taken from the DP steels.

About Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory, located in southeastern Washington State, is a U.S. Department of Energy Office of Science laboratory that solves complex problems in energy, national security and the environment, and advances scientific frontiers in the chemical, biological, materials, environmental and computational sciences. The Laboratory employs nearly 5,000 staff members, has an annual budget of more than $1 billion, and has been managed by Ohio-based Battelle since 1965.

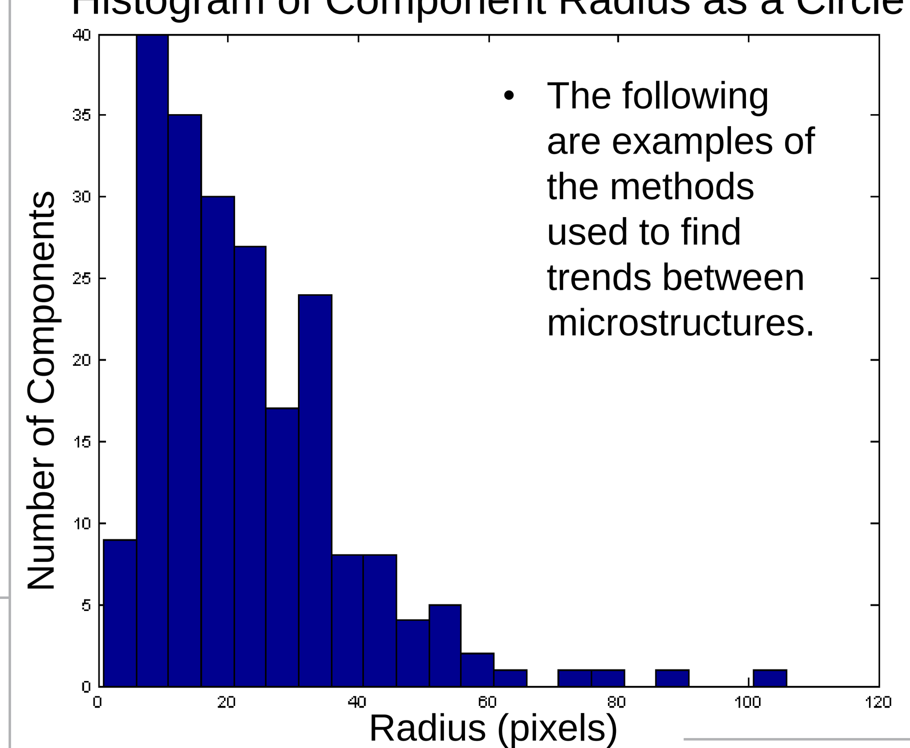
Methods



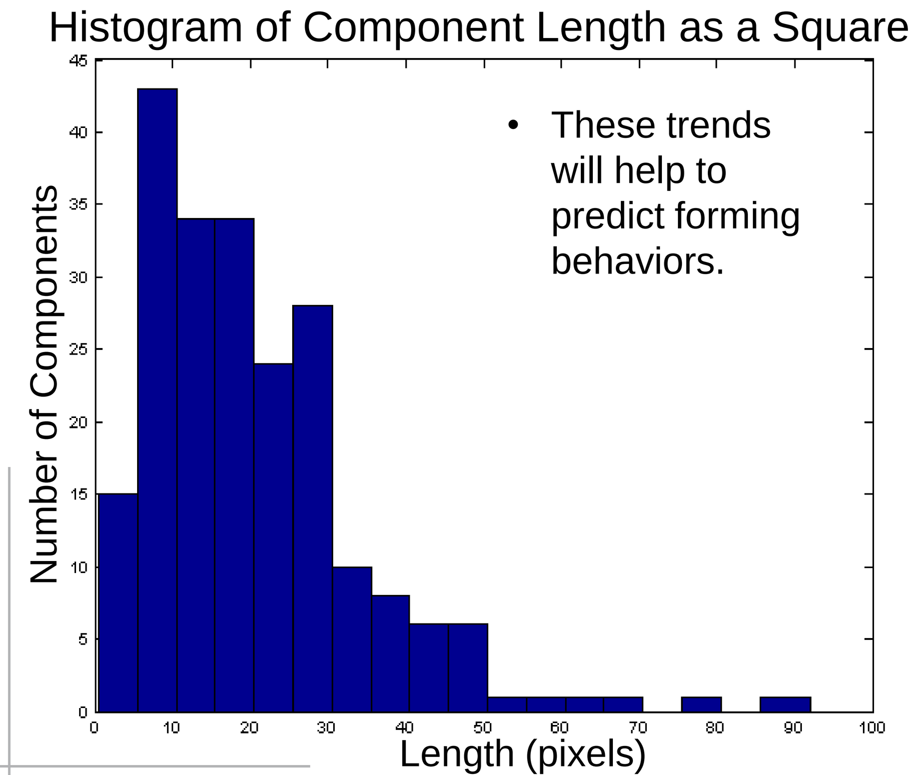
Example:
Component #47
Centroid: [99.3385 134.7143]
Major Axis Length: 63.6688 pixels
Minor Axis Length: 14.3799 pixels
Eccentricity: 0.9742
Orientation: -60.0731 degrees

(a)	Info	(b)	(c)	(d)	(e)	(f)
10s1202b	Volume Fraction	0.35	0.35	0.31	0.35	
In Pixels	Grain Size in X-direction				17	18
	Grain Size in Y-direction				18	17
	Aspect Ratio (Y/X)				1.06	0.94

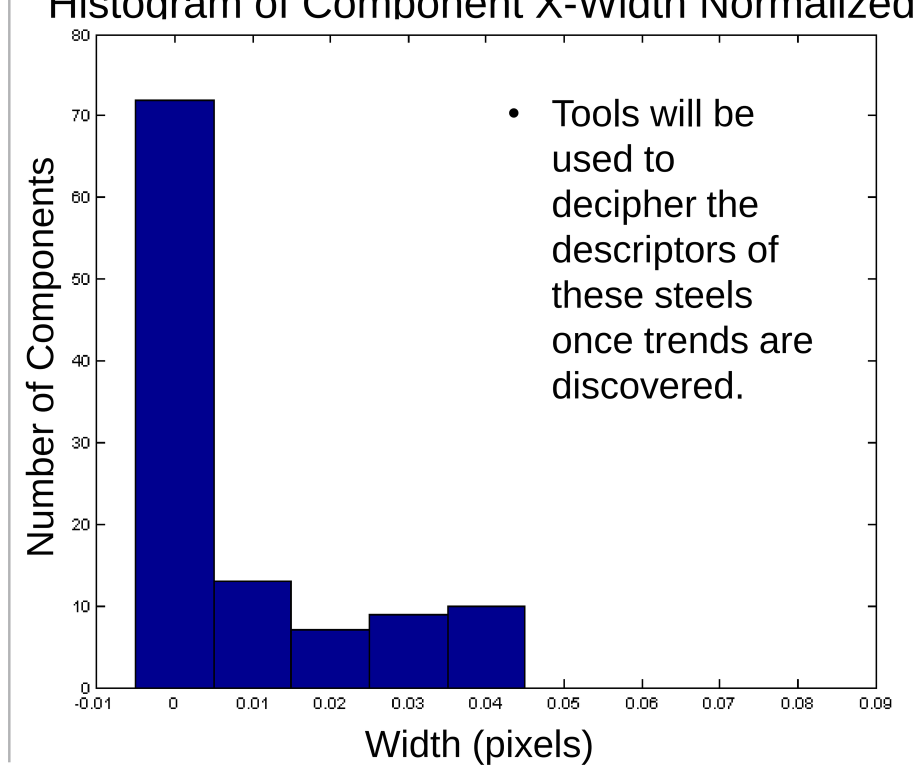
Histogram of Component Radius as a Circle



Histogram of Component Length as a Square



Histogram of Component X-Width Normalized



Histogram of Component Y-Length Normalized

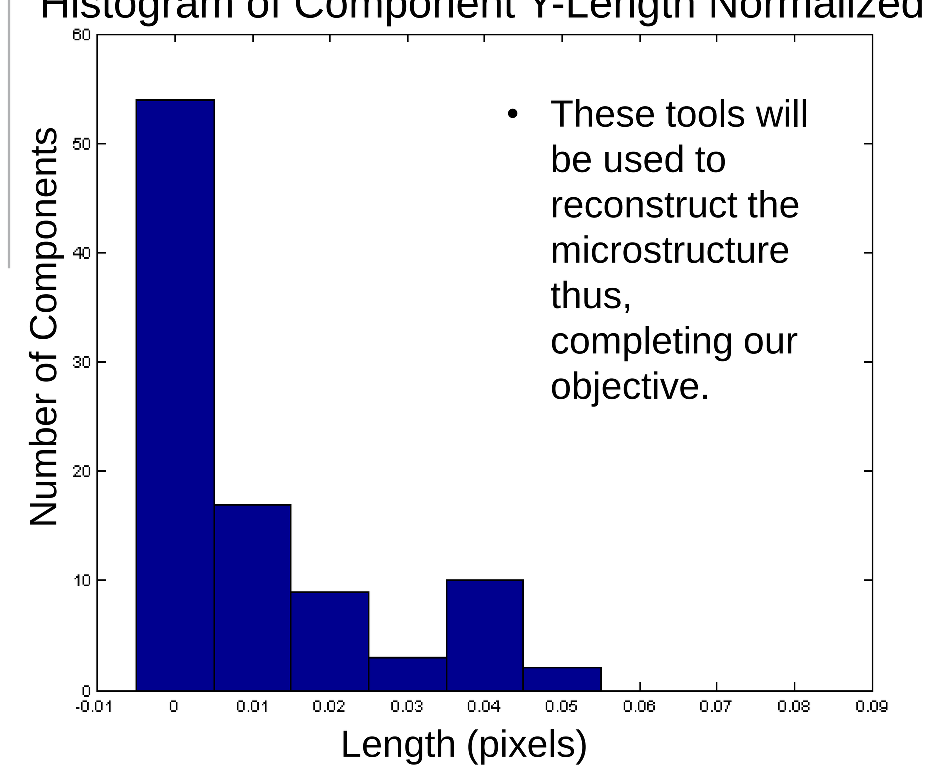


Image processing tools in MATLAB and Photoshop were adopted to mathematically quantify the microstructural features of these different steels.For the image analysis, the SEM pictures of the microstructures were first converted into binary images using MATLAB by adopting an appropriate threshold to obtain reasonable range of martensite volume fractions. Here, the binary image is one composed of a matrix of ones and zeros, and was used to distinguish ferrite from martensite. This binary image was then used to find the volume fraction of martensite to the entire image by complete identification of the phase attribution for each pixel using a threshold algorithm and following island removal i.e. noise or not existing data. Photoshop is also used to ensure authenticity of the photograph due to MATLAB misinterpreting components of ferrite with martensite or vice versa. MATLAB was then used in creating ellipses to fit the martensite components in the final binary images in order to find the volume fraction, grain size, component area, the number of components, size of the components in the x and y directions, grain orientation and other specifics of the images.

Figure 2. Characterization work flow:
(a) The original SEM image,
(b) The binary image of (a),
(c) The noise of (b) is removed,
(d) The bottom right-hand corner of (c),
(e) The Photoshop corrected image of (d),
(f) The segmented image of (e),
(g) One component of (f),
(h) The ellipse fit of (g),
(i) Measurements taken in Matlab of (h), and
(j) The final image of (f) with all components in a multicolor mapping.

Future Research

The results obtained in this study are expected to correlate with the macroscopic deformation behaviors observed in various experiments.

References

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