EVALUATION OF OPTICAL SIZING METHODS

BY

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PROBLEMS AND POTENTIAL

Operators are constantly searching for a method by which they can evaluate the results of varying blast designs. Past methods have involved eye ball estimates, production figures, counting oversize, etc., etc. The most effective method - screening of the muck - was rarely used and then on only a small scale. Recent developments have included photo analysis of muck piles for sizing. This was originally done by hand processing each image of broken muck. This was a time consuming method, but it did receive widespread acceptance.

The most recent methods are promoting edge defining software combined with image input hardware and software to automate the sizing function. Recognizing the "lost fines" problem, they also include a method for recalculating the distribution based on a calibration method to fill in the fines. The larger fractions in most cases are usually well recognized and defined by the software with very careful editing processes.

This "lost fines" problem seems to have been the most nagging difficulty with the current generation of analysis products. The basic fault claimed by the critics is that if you can't see a certain size, you can't measure it. Therefore the distance from the muck combined with the limits of the camera, cannot resolve down to the smaller pieces. For instance, if we take an image from 40 feet away and at normal magnification, the camera will not be able to distinguish pieces that are approximately 1 inch or less.

SIMULATED MUCK FOR EVALUATION

Simulated muck piles were created with 1 gallon (3.8 liter) to 5 gallon (19 liter) samples to approximate standard digging conditions to compare size distributions measured with the optical method versus actual screening. It was felt that this would supply a scaleable measurement method for much larger muck piles.

Each simulated muck pile was contained in an enclosure that would allow it to lay at it's normal angle of repose. Digging passes were made through the muck and each pass was imaged by the Wipfrag™ system. For each large image (macro) a zoom (micro) image was taken to attempt better fines definition.

The sample mucks were gathered and screened. The screen analysis for each was compared to average blasted muck relative per cent passing profiles and any sample mucks that were too heavy in fines or coarse were re-blended to more typically approximate average published screening data for blasted muck.

The typical division is of 7 to 9 size classifications with the following average cumulative percent passing in each:

Size 1 (fines)	6.7
Size 2 (fines)	11.9
Size 3 (fines)	18.2
Size 4	29.0
Size 5	43.8
Size 6	60.2
Size 7	79.7
Size 8 (coarse)	100.0

IMAGE AND EDITING PROCEDURES

Imaging was carried out in a controlled light and weather environment. Samples were not dried so as to give a typical muck appearance.

It was quickly noted that during the imaging process, particle definition could be easily distorted by lighting and image contamination.

Lighting effects are most severe when there is bright sun or artificial light at an oblique angle other than normal to the surface being imaged. The oblique light causes shadow effects that are easily read to be particles themselves or additions to existing particles.

Surface contamination can be a problem and are due to moisture, oils, or snow in northern climates. This contamination causes the same type of effects as from lighting. This is due to the differential reflectivity of the contaminants or their darkening effect on the muck. Individual pieces are created that aren't there, or extra dimension is added to or subtracted from existing particles.

The ideal conditions are of fresh dug muck without differential contamination and in a shaded condition to remove artificial shadows. Bright light normal to the face being measured is acceptable for minimizing shadow effects. In the absence of these controls, extraordinary editing controls have to be utilized to control this distortion.

Editing procedures are critical to size definition. Numerous examples of additional oversize were noted when checking data files. It was discovered that unusual and impossible oversize was created by lapses in editing images for size measurement. This was as a result of the program joining two or more particles into one and measuring that excess size.

The analysis of the auto imaged data used in this study showed potential results of incomplete editing. The large scale test mentioned here showed an extra upper size classification in the automated analysis from the actual screened data. This was probably due to incomplete edge closure as a result using one or very few resolution settings for the image gathering and edging. This is something that those trying to define the upper end of sizes for plant and equipment design must keep in mind.

CALIBRATION FROM SMALL TESTS

The raw data gathered from the small tests was compared to the actual screened data. The difference in each analysis was used to calculate a correction factor for the Slope (N) and Characteristic Size (Xc) for each Slope range. These corrected values were used in the Rosin-Rammler (R-R) equation to re-calculate the curve to better define the distribution.

True values for Slope and Xc were approximated from the Screened data. These were developed by a slope fitting to the Screen data.

LARGER SCALE TESTS

After the calibration corrections were calculated, larger samples of the same or similar type materials were analyzed. These larger samples were up to 5 gallons (19 liters) and of similar size distributions, color, and shape.

Optical analysis was done on each of these larger samples in the same manner as the smaller lots. After analysis, the correction factors developed in the small lots were applied by Slope degree to each of the larger samples. This was done to validate the method from a small scale to a somewhat larger scale with quantities that could be fairly easily handled and screened.

The analyses of the small and large lots confirmed the main criticism of optical methods. In nearly every case the fines portion was not measured adequately by the system. By fines I mean the lower 2 to 3 size classifications. Even careful attempts to include them by zooming in to acquire them or artificially multiplying the number of zoomed images was not adequate.

Most optical sizing also showed variance on the upper end of the size range, but correlation here was better than the fines range. The center of the size range tended to agree well with the screened information. (figures 1 & 2)

Corrections were made to the fines portion by applying the correction factors from the small lots to the larger lots with similar slope values for the raw data. These corrections were then applied to the lower 3 size classifications in each analysis.

For the middle sizes, the raw size data was retained. It has been commented by many observers that this size range tends to agree very well between screened data and optical sizing.

The upper size ranges were corrected for the weight of fines added to the lower sizes. This was done by distributing the weight of fines added to the 3 lower sizes evenly to the upper 4 sizes. (Figure 3 & 4)

Many suppliers seem to recommend the use of the full R-R curve for the complete range of sizes. In this study, the best fit was obtained with the slope correction in the fines, leaving the middle sizes as the raw data and correcting the larger sizes for the fines added.

Caution must be taken in the image analysis to carefully edit and define the particle sizes for many images to arrive at this good fit. Mistakes were easily made in the imaging of sample lots. Only careful editing and file checking avoided or eliminated these biases.

It can be seen that in most cases, this method supplied a very good way to resolve the fines problem that has haunted the optical sizing field. It indicates that recommended calibration methods will give reliable corrections for lost fines.

In addition, dependable methods of correcting across the entire curve are possible.

LARGE SCALE APPLICATION

The large scale tests done by U. S. Steel in 1991 screened approximately 7500 tons of blasted ore to make the comparison with auto imaged sizing. This data was evaluated and used with the developed correction factors for a new R-R curve. Figure 5 shows the excellent correlation obtained with this method.

In this instance, the optical measurement when corrected with calibration values described here gives a good tool for blast size distribution. It indicates that the optical analysis methods can be used to closely approximate the actual size distribution in a large scale.

More work is planned to use this method with historical published screening and optical studies. This will additionally confirm of disprove the detailed method described here.

USE OF SYSTEMS

These graduated measurement and comparison tests seem to confirm the usability of the optical fragmentation methods if carefully applied. As a usable method of fragmentation assessment, it allows decision making for blast modeling, equipment selection, mining methods, and economic planning.

FIGURE 1

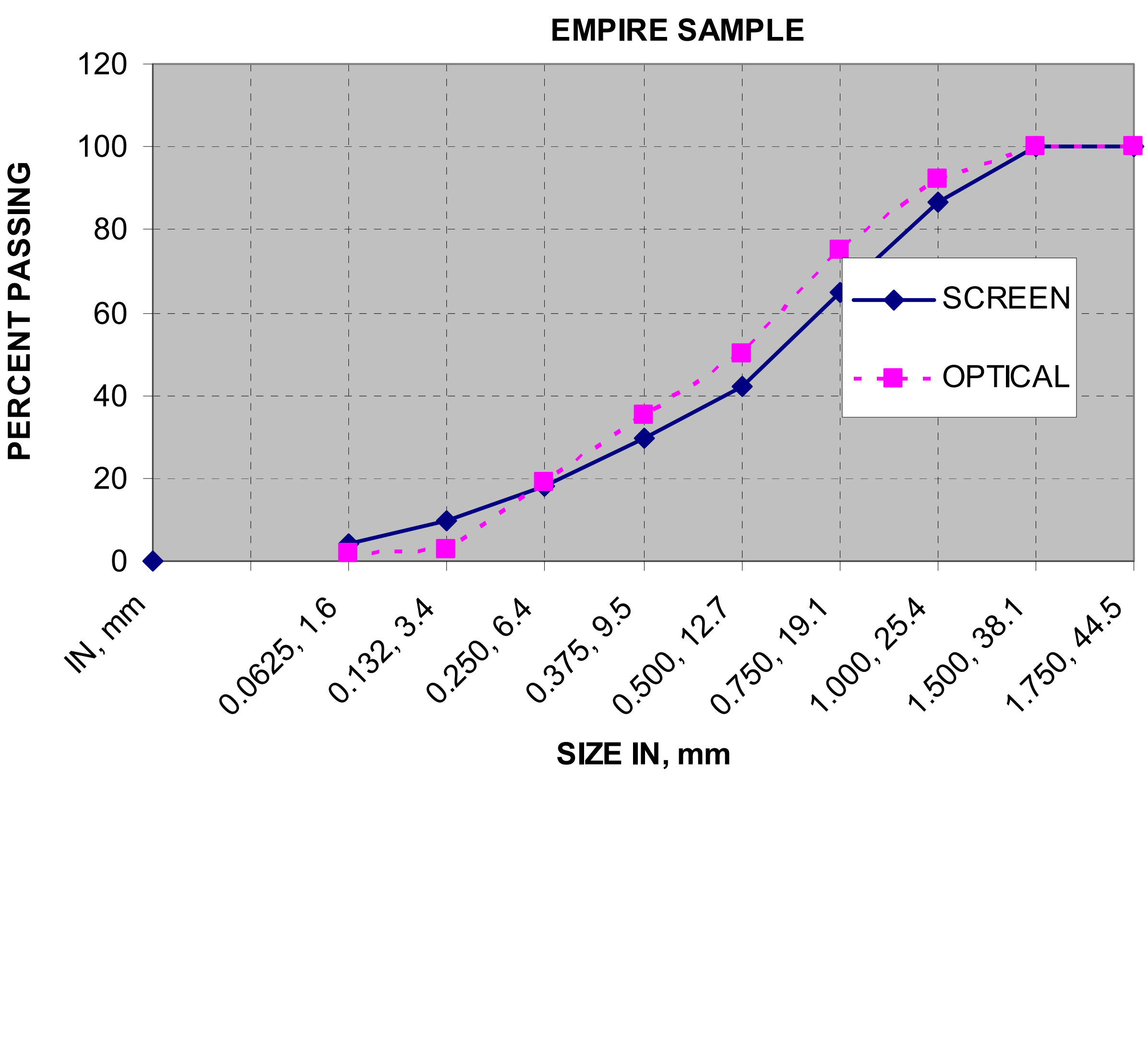


FIGURE 2

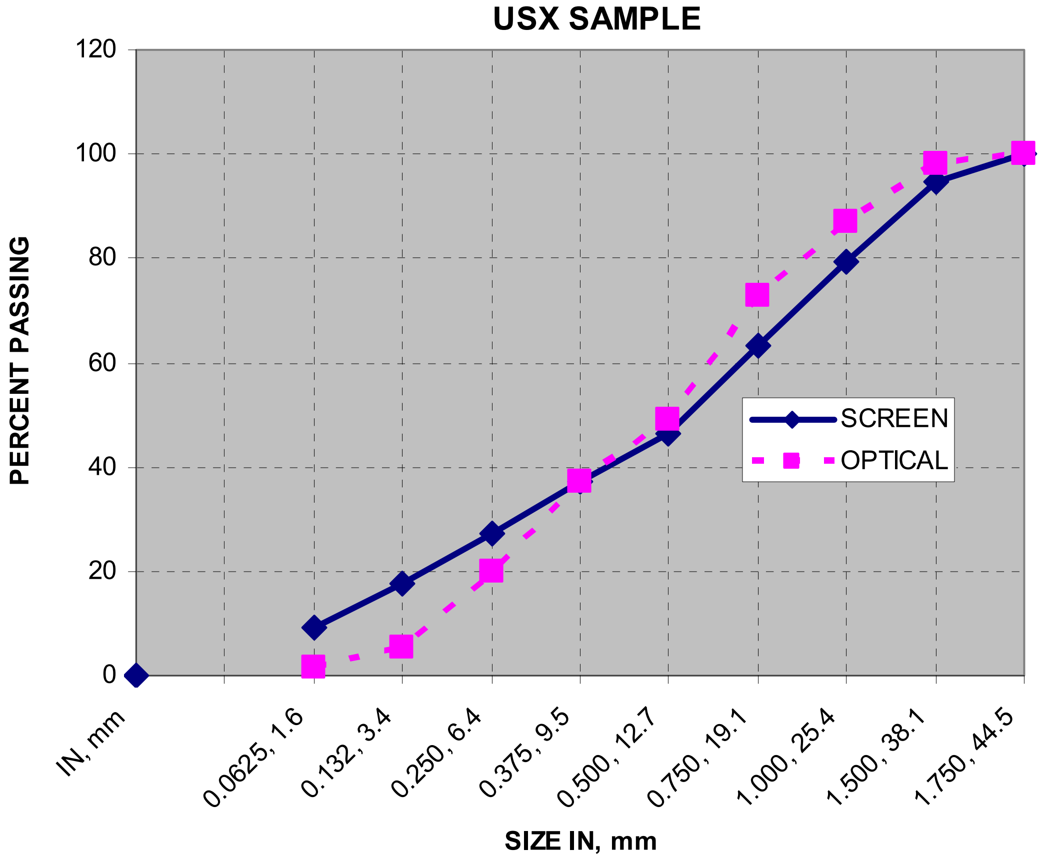

USX SAMPLE
120
100
80
60
40
20
0
PERCENT PASSING
SCREEN
OPTICAL
IN, mm
0.0625, 1.6
0.132, 3.4
0.250, 6.4
0.375, 9.5
0.500, 12.7
0.750, 19.1
1.000, 25.4
1.500, 38.1
1.750, 44.5
SIZE IN, mm

FIGURE 3

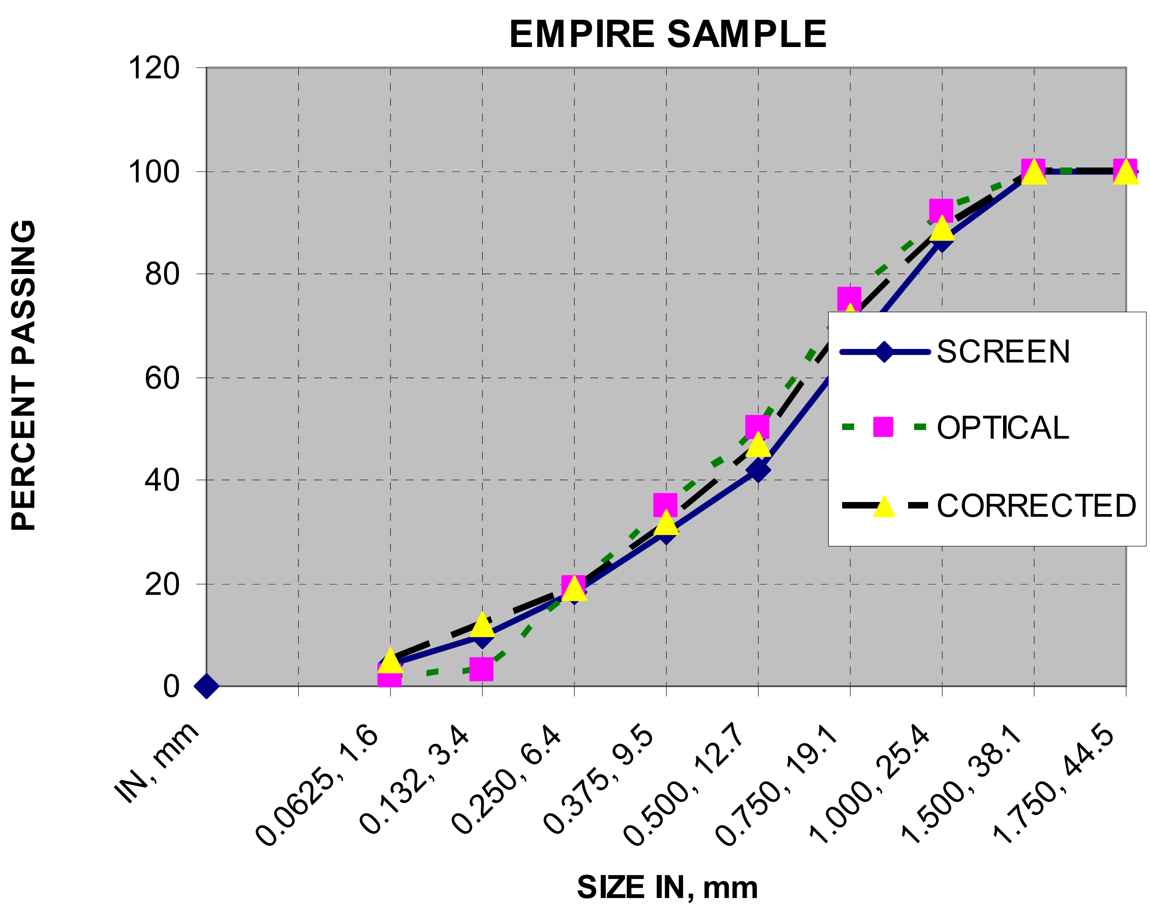

EMPIRE SAMPLE
120
100
80
60
40
20
0
PERCENT PASSING
SCREEN
OPTICAL
CORRECTED
IN, mm
0.0625, 1.6
0.132, 3.4
0.250, 6.4
0.375, 9.5
0.500, 12.7
0.750, 19.1
1.000, 25.4
1.500, 38.1
1.750, 44.5
SIZE IN, mm

FIGURE 4

USX SAMPLE

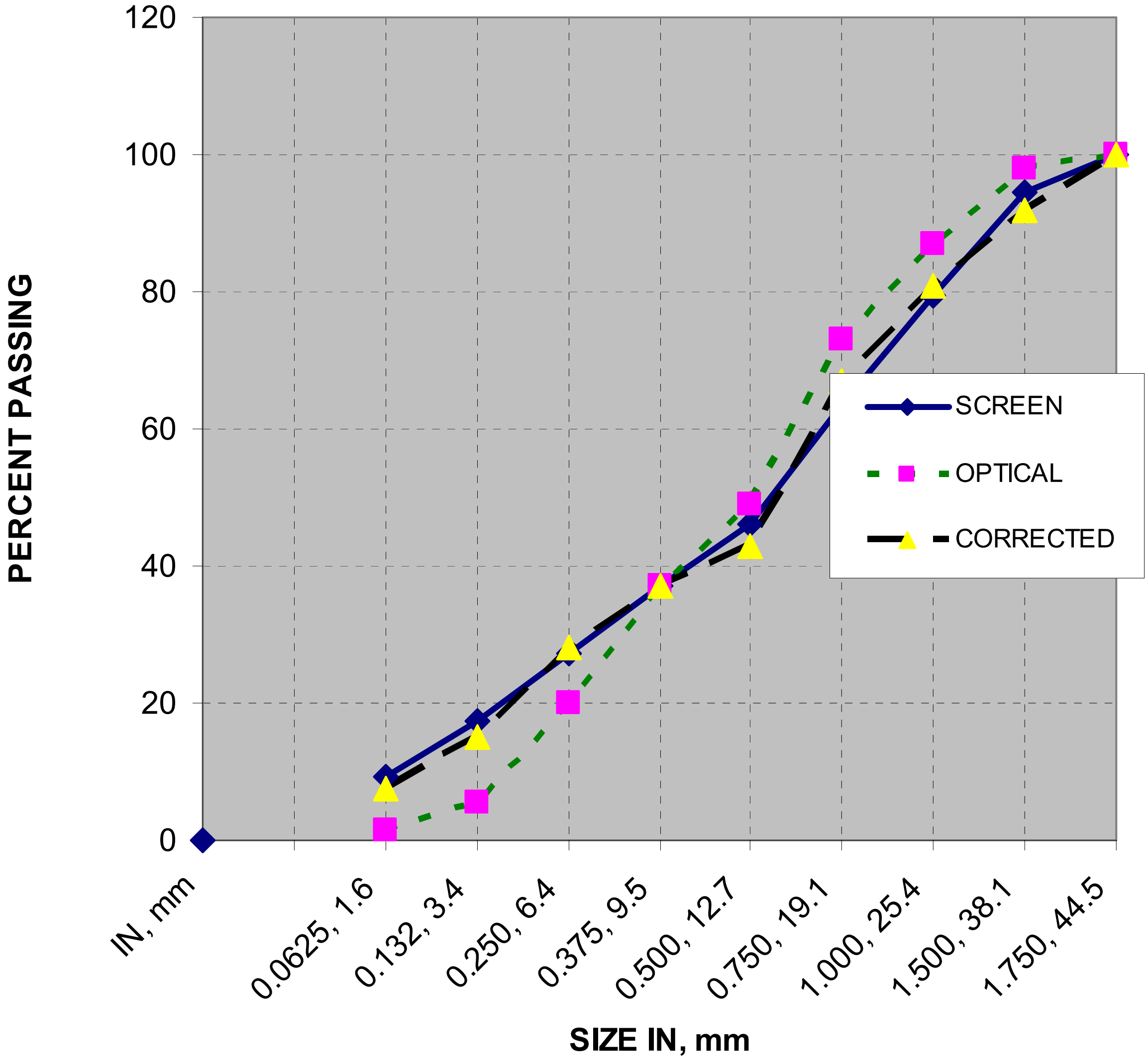
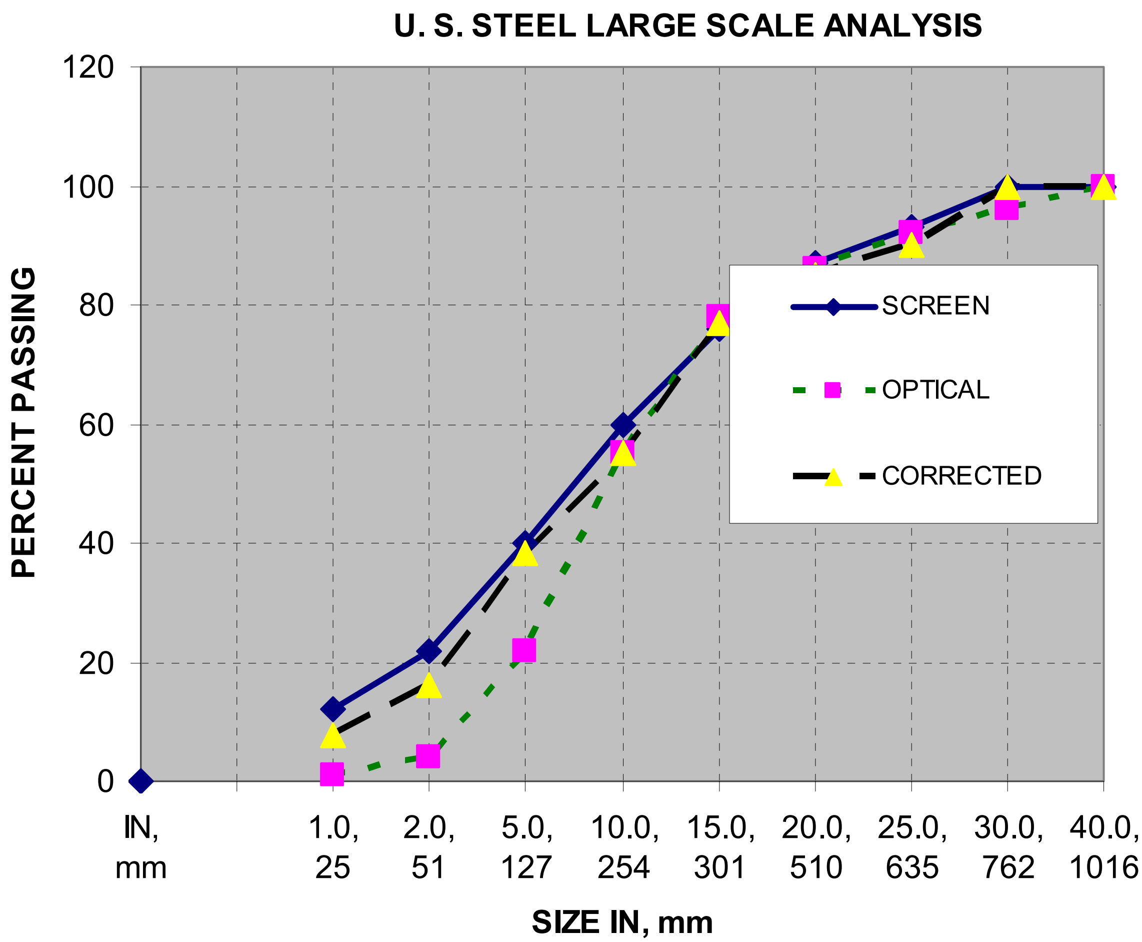


FIGURE 5


U. S. STEEL LARGE SCALE ANALYSIS
120
100
80
60
40
20
0
PERCENT PASSING
IN, mm
1.0, 25
2.0, 51
5.0, 127
10.0, 254
15.0, 301
20.0, 510
25.0, 635
30.0, 762
40.0, 1016
SIZE IN, mm
SCREEN
OPTICAL
CORRECTED