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Publication Date
1981-12-01
Submitted for the International Corrosion Forum, sponsored by the National Association of Corrosion Engineers, Houston, TX, March 22-26, 1982

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December 1981
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SURFACE DEGRADATION OF METALS IN SIMULATED SYNTHETIC FUELS PLANT ENVIRONMENTS

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Abstract

The erosion behavior of candidate steel alloys for liquid-solid particle slurry service in coal conversion equipment was determined over a range of testing conditions. It was determined that relative erosion resistance of the carbon, low alloy, chromium, and austenitic steels tested could not be readily related to their composition, morphology, or mechanical properties. Higher solids loading and larger particles in the coal-kerosene slurries used resulted in greater erosion. The greater the lubricity of the carrier liquid is, the lower is the erosivity of the slurry. Low elevated temperatures can cause a decrease or an increase in the erosivity of the slurry, depending on the alloy tested and the test temperature. The mechanism of erosion was determined to be of a platelet formation type, similar to that observed in gas-solid particle stream erosion of ductile metals.

I. Introduction

The flow of particle laden, non-aqueous liquids in the passages of coal liquefaction systems causes erosion degradation of the containment metal surfaces. The degradation is similar in mechanism to that experienced on ductile metals exposed to streams of solid particles in gases. In the relatively low velocity regimes in coal conversion equipment, the erosion mechanism knowledge gained in one fluid media can be used to understand the mechanism of metal removal in the other. The effects of several test variables such as flow velocity, particle size, solids loading, and temperature on the erosion of steel alloys also provide evidence to establish the behavior of steel containment materials in slurry flow service. This paper will present data on the performance of several steel alloys exposed to coal-kerosene slurry flows.

II. Experimental Conditions

Various test devices were used to determine the effect of erosive streams of coal in kerosene on the surface material loss of a group of steel

This work was supported by the Assistant Secretary for Fossil Energy, Office of Coal Research, Materials and Components Division of the U.S. Department of Energy under Contract Number W-7405-ENG-48, through the Fossil Energy Materials Programs, Oak Ridge National Laboratory, Oak Ridge, TN.
alloys that are commonly used in the flow passages of chemical process equipment. The steels tested are listed in Table I. The devices simulate various aspects of the environment of the slurry flow in a coal liquefaction system in the region where the pulverized coal is mixed with the heated process solvent. The principal condition that is not simulated is the pressure of the slurry, which is not felt to be a significant consideration in the erosion process. The chemical activity of the liquid in the tests that will be described is considerably different from that of process solvent. The once-through aspect of the particles in the actual process flow is also not simulated; however, very little comminution of particles occurs in the tests. The principal variables that affect the erosion process, i.e., velocity, impingement angle, solids loading, particle size, and the combination of viscosity and temperature are simulated in the tests described.

The test device used in this study, the slurry pot tester, directs a flow of coal particles in a liquid kerosene carrier at 3 mm diameter cylindrical specimens 5 cm long by rotating the vertically oriented test cylinders on the end of arms attached to a motor-driven rotating shaft in a controlled environment pot of slurry of 3 liters capacity. A vortex is prevented by placing metal baffles around the inside periphery of the pot and settling of the coal particles is prevented by a small propeller that is mounted near the bottom of the rotating shaft. The slurry pot operating temperature is controlled by cooling or heating from 25°C to 250°C. Figs. 1 and 2 show the exterior appearance of the slurry pot tester and its design cross section.

III. Data Reproducibility

The slurry pot tester is used to compare materials erosion behavior by determining the weight loss of the cylindrical test specimens after rotating in slurry for incremental times up to 5 hours. The angle of impingement of the slurry's particles on the cylinder varies around the front half of the cylinder; so the weight loss is an integration of weight losses over the spectrum of impingement angles from 0 to 90°.

The reproducibility of the slurry pot test device is shown in Fig. 3 for two alloys, A53 mild steel and 304SS. Their overlapping erosion behavior is consistently observed over a large variation in test conditions.

IV. Effect of Alloy Composition

Figure 4 shows how a number of alloys eroded in a cumulative plot of erosion loss over a two-hour exposure period. The near-straight lines of each curve indicate that little change in the erosivity of the particles is occurring as the result of comminution of the particles. The A53 and 304SS alloys had the highest erosion. As chromium was added to the ferritic alloys in the test series, the amount of erosion was reduced with the 410SS containing 12% chromium having the lowest amount of erosion. The reason for this behavior variation is being investigated. It should be noted that hardness, long thought to be a direct indication of erosion resistance, does not relate to erosion behavior. The softest alloy, 2-1/4 Cr1Mo steel, had the second lowest erosion rate.

Figure 5 shows the variation in erosion behavior of several austenitic stainless steels compared to A53 mild steel. It can be seen that the A53 and 304SS eroded similarly along with the 321SS, which is a stabilized version of the 304SS. A higher chromium content steel--310SS--eroded less, and a steel containing 2-1/2% molybdenum, 316SS, eroded the least. The hardnesses of the
stainless steels were comparable, so the variation in behavior—over 50% among the four stainless steels tested—is due to a more subtle variation in composition, structure, and properties.

V. Effect of Particle Size and Solids Loading

The effect of velocity plotted in ft/sec (fps) on the erosion of steel as a function of coal solids loading in the carrier liquid and the particle size distribution of the coal are shown in Figs. 6-8. Figure 6 shows that both A53 and 304SS behave similarly. The greater solids loading of the 50 wt% coal slurry results in a significantly greater amount of erosion, even though its effective viscosity is higher than that of the 20 wt% coal slurry. This indicates that it is the viscosity of the liquid constituent primarily and not that of the slurry that can reduce the amount of erosion as it increases.

Figure 7 plots the amount of erosion when -30 mesh coal is used in the slurry. The particle size distribution of the -200 mesh coal and the -30 mesh coal were determined using a Tyler sieve analysis, and are shown in Table II. It can be seen that the larger size coal grind results in a considerably greater amount of erosion at the higher velocities, and that the difference between the two solids loadings is much less for the larger size coal. The effect of velocity on the erosion rate is also markedly increased when the coarser coal grind was used. Table III shows the velocity exponents for the two grinds of coal. The differences between the two coal grinds can be seen more graphically in Fig. 8 for the 20 wt% coal slurries. Four times as much erosion occurred on the samples exposed to the larger particles of coal than to the smaller particles at 40 fps velocity. The difference is markedly less at the lower velocities.

VI. Effect of Lubricity of Liquid

In order to determine the effect of the lubricity of the carrier liquid on the erosivity of coal containing slurries, an oil was selected whose lubricating properties could be varied by means of a small addition that did not affect its viscosity appreciably. A hexadecane solvent was used in these tests. The addition of 1/2 mole percent of hexadecanoic acid to the solvent is known to have a major effect on the solvent, increasing its lubricity without changing its viscosity. The acid group polarizes the hydrocarbon chain, making it attach to the metal surface, imparting lubricity. Shorter chain hydrocarbons and their acids cause a similar effect but at lower viscosities.

Figure 9 compares the erosion of A53 mild steel in hexadecane without acid addition to that of kerosene in a 30 wt%-200 mesh coal slurry. It can be seen that the hexadecane-coal slurry is more erosive than the kerosene-coal slurry. Figure 10 shows the effect of the addition of the hexadecanoic acid addition to increase the lubricity of the solvent in room-temperature tests of A53 and 304SS metals. The increased lubricity decreased the amount of erosion in a 120 min exposure by 3 times. Both alloys behaved in a similar manner. In a test series performed at 94°C (200°F), the difference was more pronounced. Figure 11 shows the 94°C (200°F) curves where the erosion in the hexadecane plus acid slurry was one quarter that in the straight hexadecane for the A53 mild steel. A greater difference in erosion occurred between the two metals in the hexadecane slurry at 94°C (200°F) than occurred at room temperature.
VII. Effect of Temperature

The elevated temperature tests in a slurry pot tester at 94°C (200°F) for a number of steel alloys resulted in a behavior pattern that has been observed at low elevated temperatures for ductile metals in gas-solid particle erosion tests. In general, the erosion rate initially decreased with the increasing temperature. Figure 12 shows the effect of temperature on six alloys tested. The A53 and 304SS alloys behaved in a similar manner, as they have for all tests performed in the slurry pot. Their rates of erosion were markedly higher than those of the other four alloys tested, particularly at room temperature and 94°C (200°F), and they did not show a decrease at the 94°C (200°F) test temperature.

The four, more erosion-resistant alloys had lower erosion rates at 94°C (200°F) than at 25°C (75°F). The A106 alloy is a finer grain size mild steel of the same nominal composition as the A53 pipe steel. Its lower erosion rate can probably be attributed to its finer grain size. The order of erosion rates with the 410SS having the lowest rate and the mild steel having the highest rate has been generally observed. The significant increase in erosion for all alloys at 177°C (350°F) is probably more the result of changes in the nature of the slurry than of changes in the erosion resistance of the alloys. A marked reduction in the viscosity of the liquid that generally occurs at elevated temperatures could cause the increase to occur.

Figure 13 plots seven alloys' cumulative erosion vs time of exposure curves at 94°C (200°F) for a slurry velocity of 20 fps. At the five-hour test time, the spread in amount of erosion ranged from 2 to 6 gm/cm² x 10⁻⁴, the highest eroding material having three times the erosion of the lowest. This is a considerably greater spread than occurs at room temperature. The reasons for the relative amounts of erosion of each alloy are being studied. The straight line curves show that the steady state erosion condition is reached near the beginning of the test. This has also been observed in gas-solid particle erosion.

Figure 14 shows the cumulative erosion vs time curves for six of the alloys at a higher velocity, 40 fps, at 94°C (200°F). It can be seen that the erosion rate markedly increases as the velocity of the slurry is increased, the A53 steel eroding five times more at 40 fps than at 20 fps after five hours of exposure. It is also interesting to note that the order of erosion rate changed among the alloys tested, and that the A53 and 304SS rates separated from those of the other alloys that were bunched together in a far lower erosion rate range.

The effect on the erosion of the test alloys at 177°C (350°F), the temperature at which slurries are prepared in the SRC coal liquefaction process, is shown in Fig. 15 for a slurry velocity of 20 fps. The same type of spread in performance as occurred at 94°C (200°F) and at 25°C (75°F) was observed. However, the order of the alloys was different. Again, the greatest amount of erosion occurred in the A53 mild steel. As the erosion time increases, the spread in the amount of erosion between the alloys increases significantly. At the higher temperature, the difference in erosion between the A53 mild steel and the 304SS begins to reflect the higher strength of the stainless steel at elevated temperatures.

Increasing the erosion velocity to 40 fps at 177°C (350°F) test temperatures (Fig. 16) has an interesting effect on the erosion behavior. All of the curves are essentially straight, which indicates that no comminution of the eroding particles is occurring. Also, the amount of erosion increases up to eight times greater at the higher velocity, as can be seen in Fig. 17.
VII. Metallography

The eroded surfaces of the steel specimens exposed to coal solvent slurries show very little surface deformation compared to that which occurs in gas-solid particle erosion. Figure 18 shows a typical slurry eroded surface at a relatively high magnification in an SEM for 316SS in a 30 wt% coal-kerosene slurry at 40 fps. Figure 19 shows a typical eroded surface of mild steel in a SiC-air mixture at 100 fps. The great difference in the amount of surface deformation can be readily seen. The type and amount of deformation in the specimen exposed to the gas-solid particle stream makes it relatively easy to discern the mechanism of erosion that is occurring. It is much more difficult to determine the mechanism in the slurry eroded material.

Cross sections of each of eight alloys tested in the slurry pot are shown in Fig. 20 at their positions of greatest erosion around the periphery of the cylinder, 40° from the stagnation point. It can be seen that in only half of the specimens can any evidence of erosion of the surface be observed. The 9Cr-1Mo steel and the 410SS show evidence of the formation of platelets on the surface that are the same as those observed in gas-solid particle erosion.

Figure 21 shows the 9Cr-1Mo steel surface area cross section at a high magnification. Careful observation of the immediate surface area shows the presence of some thin platelets and some crater areas. Figure 22, of an A53 steel specimen at a higher magnification, shows additional evidence of platelet formation and cratering. The platelet in the lower left side of the figure appears to have broken off part way across the crater it is over, and to have a separation in it at the left edge of the crater. Careful metallographic analysis of many specimens of each alloy resulted in the observance of thin platelets and craters on almost all of the alloys, however hard they were to find. An exception was 304SS, which maintained a smooth surface cross section up to 10,000 magnifications.

VIII. Discussion

Effect of alloy composition. The effect of alloy composition on the relative erosion behavior of the alloys tested was not clearly discernible in the tests performed. For the ferritic alloys, an increasing amount of chromium up to the 12% Cr of the 410SS appeared to reduce the amount of erosion that occurred. However, the highest chromium content alloys, the austenitic 300 series stainless steels which contained 18 to 25% Cr, had a spread of erosion rates that ranged through those of the ferritic steels. The lowest erosion rate 300 series steel, 316SS, generally eroded at nearly the same rate as the 410SS. The highest erosion rate austenitic steel, 304SS, eroded in the same range as the highest ferritic steel, the A53 mild steel piping alloy.

The hardness and strength of the steels also did not relate to their erosion rates. The lowest hardness steel tested, the 2-1/4Cr1Mo steel with a hardness of RB72, generally had erosion rates on the low side of all alloys tested. The cold-rolled A53 steel at a hardness of RB94 generally eroded at the same rate as the 304SS, which had a hardness of RB80. The lowest erosion rate steels, 410SS and 316SS, had hardnesses of RB97 and RB85, respectively. Therefore, it can be concluded that within the hardness range of the steels tested, RB72 to RB97, hardness was not a significant factor in establishing the erosion behavior of the material.
While the ductility of the alloys tested can be used to relate the erosion behavior of different alloys in gas-solid particle erosion\textsuperscript{1} with the more ductile alloys having lower erosion rates, no such correlation was possible in the liquid-solid particle erosion behavior reported herein. The relatively low elongation of the A53 steel (25%), and the much higher elongation of the 304SS (55%), made no difference in their erosion rates, which were nearly the same in all of the room-temperature tests performed in coal-kerosene slurries.

The large amount of difference in cumulative erosion among the various steels tested also could not be explained by relation to any material composition or properties. Differences of as much as 100% between steel alloys tested under the same test conditions were reproducible but not explainable at this time.

Effect of particle size and solids loading. The effect of particle size and solids loading on the erosion rate of A53 steel and 304SS, the two highest erosion rate alloys tested, showed that more particles and larger particles generally resulted in more erosion (Figs. 6-8). However, the larger size particle grind (-30 mesh) eroded the steels more than the finer grind only at higher velocities. At 10 fps, both coal grinds caused nearly the same amount of erosion. Also, while the finer sized particles showed a consistent difference in erosivity as a function of solids loading at all velocities (Fig. 6), the larger coal particles showed a difference only at the higher velocities (Fig. 7).

The combination of velocity and particle size effects on erosion relates to the kinetic energy of the particles and the degree of effective insulation of the metal surface from the particles trying to impact it provided by the liquid. Apparently there is some critical level of particle kinetic energy at which the insulating capability of the liquid changes markedly, permitting a more direct relationship between the kinetic energy of the particles and erosion of the metals to occur.

The number of particles in the flow, the solids loadings, effects the amount of erosion differently above and below this insulating critical level. In the -200 mesh coal slurry, the kinetic energy level is below the critical level, and the more particles there are in the flow the more erosion occurs. In the -30 mesh coal, the kinetic energy of the particles is only below the critical level around 10 fps. At this velocity, the insulating ability of the liquid equalizes the quantity of particle effect and particle size effect. As the velocity increases for the -30 mesh particles, the critical level is exceeded and a difference between the two solid loadings again occurs. Also, the increased kinetic energy of the larger particles results in higher erosion levels (see Fig. 8, which compares the erosion caused by the -30 mesh and -200 mesh particle grinds). The velocity exponent for large particles is also greater.

Effect of lubricity. The ability of the carrier liquid to somehow insulate the impacting particles from the target metal surface was investigated by using a liquid whose lubricity or insulating effect could be separated from its viscosity, which can also affect the ability of the particles to impact their kinetic energy to the target metal.\textsuperscript{2} The two curves (Figs. 10 and 11), which show the results of the experiment very effectively, showed the role of lubricity of the liquid in modifying the erosivity of the slurry. The change to a greater level of lubricity, as the
result of adding the small amount of acid, significantly decreased the erosivity of the slurry to less than one-third of its level in the untreated solvent.

Determining that there is a significant effect of lubricity on the erosivity of non-aqueous slurries opens the way for an analytical treatment of the erosion behavior of ductile metals in these slurries. Now the lubrication literature can be used in conjunction with the fluid mechanics of two-phase flow and the latest models for the erosion mechanism of metals to develop a model that can describe the transfer of kinetic energy from a particle through the carrier liquid to the metal surface being eroded.

**Effect of temperature.** The effect of temperature on the erosion behavior of steels in the temperature range that occurs in the slurry formation stages of coal liquefaction systems, 177°C (350°F), follows a pattern first seen in gas-solid particle erosion. Four of the six alloys plotted in Fig. 12 had lower erosion rates at slightly elevated temperatures than they had at room temperature. This effect could be due to interactions between the solvent and the coal particles that effectively increased the viscosity of the slurry, or to small but important modifications in behavior of the alloys in resisting erosion. It is not possible at this time to know exactly what caused the decrease in amount of erosion. In the case of the gas-solid particle erosion, it is fairly certain that increased ductility of the alloys tested at elevated temperatures was responsible for decreased erosion.

The large spread in amount of erosion occurring on a number of steel alloys at 94°C (200°F) and 177°C (350°F) of similar mechanical properties, shown in Figs. 13-17, cannot be readily explained. The relative erosion resistance of the various alloys, and the changing of the order of that resistance as a function of the slurry velocity, is also not explainable after a somewhat cursory look at their hardness, strength, toughness, microstructure, and ductility. More work needs to be done to determine what combination of characteristics leads to higher or lower erosion resistance. The consistent higher erosion of A53 carbon steel, which is particularly pronounced in Figs. 14 and 15, persists at low elevated temperatures as does the considerably lower erosion of its finer-grained counterpart, A106 steel.

It is interesting to note that most of the curves are essentially straight lines, indicating that erosion rates of alloys are constant over the erosion exposure period from one hour to five hours. Also, little or no comminution of the solid particles in the slurry occurs. These facts indicated that slurry erosion at low elevated temperatures in non-corrosive solvents, and possibly even in corrosive solvents, reaches a steady state condition early in the exposure time period. However, the slopes of the curves are different, so the spread in erosion resistance cannot be readily observed when the test exposure period is too short. While five-hour exposures do not appear to be necessary, exposures of greater than one hour are required to determine the relative erosion behavior of the different alloys. Figure 16 is an excellent example of this observation.

**Metallography.** Efforts to determine the mechanism of erosion that occurs in non-aqueous slurries using metallographic observations are considerably more difficult in liquid-solid particle erosion than in gas-solid particle erosion of ductile metals (Figs. 18 and 19).
It is speculated that the reason for the much smaller amount of deformation in the slurry tests relates to transfer of the kinetic energy of the impacting particles to the metal surface and the heat transfer differences in the two media. The liquid carrier of the eroding particles in the slurry significantly decreases both the kinetic energy of the particles that is transferred to the metal, and the adiabatic shear heating of the immediate surface region, compared to the levels in gas-solid particle erosion. The liquid acts as both a lubricant and a coolant at the erosion surface.

IX. Conclusion

1. The slurry pot tester is a low-cost effective tool for studying the erosion behavior of materials in liquid-solid particle slurries.
2. Different steel alloys display erosion behaviors that vary significantly as a function of testing conditions, and cannot be readily related to their composition, morphology, or mechanical properties.
3. In general, higher solids loadings in a slurry and larger particles result in higher erosion rates.
4. The use of a liquid carrier fluid for a stream of particles, compared to a gaseous carrier fluid, reduces the kinetic energy of the particles that is transferred to the target metal surface, and hence the erosivity.
5. A liquid carrier fluid acts as both a lubricant and a coolant to reduce the erosivity of impacting solid particles in slurry erosion.
6. Essentially the same mechanism of platelet erosion occurs in both gas-solid particle erosion and liquid-solid particle erosion.

Acknowledgment

This work was supported by the Assistant Secretary for Fossil Energy, Office of Coal Research, Materials and Components Division of the U.S. Department of Energy under Contract Number W-7405-ENG-48 through the Fossil Energy Materials Programs, Oak Ridge National Laboratory, Oak Ridge, TN.

References

TABLE I. Steel Compositions.

<table>
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<th>Alloy designation</th>
<th>Cr</th>
<th>Ni</th>
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<th>Mn</th>
<th>Si</th>
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<th>Fe</th>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>1.2</td>
<td>-</td>
<td>0.30</td>
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<td>A106</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.25</td>
<td>-</td>
<td>0.5</td>
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<td>5Cr-1/2Mo</td>
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<td>-</td>
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<td>0.15</td>
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<td>9Cr-1Mo</td>
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<td>-</td>
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<td>0.5</td>
<td>0.15</td>
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<td>12</td>
<td>-</td>
<td>-</td>
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<td>321</td>
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<td>10</td>
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<td>(5xC)</td>
<td>2</td>
<td>1</td>
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<td>BAL</td>
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* - P. and S

TABLE II. Coal particle size distribution (in wt%).

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<tr>
<th>Particle size</th>
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<th>-30 mesh</th>
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<tr>
<td>&gt;600 µm</td>
<td>0.24</td>
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<tr>
<td>495-600 µm</td>
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<td>90-150 µm</td>
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<td>38-90 µm</td>
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<tr>
<td>&lt;38 µm</td>
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TABLE III. Erosion Velocity Exponents

<table>
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<tr>
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<th>A53 Steel</th>
<th>304SS</th>
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<tr>
<td>20 wt coal-kerosene</td>
<td>-200 mesh</td>
<td>1.91</td>
</tr>
<tr>
<td></td>
<td>-30 mesh</td>
<td>2.97</td>
</tr>
<tr>
<td>50 wt coal-kerosene</td>
<td>-200 mesh</td>
<td>1.68</td>
</tr>
<tr>
<td></td>
<td>-30 mesh</td>
<td>3.07</td>
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Fig. 1 Exterior view of slurry pot tester.
Fig. 2 Cross-section design of slurry pot tester.
Fig. 3 Reproducibility of erosion measurements in slurry pot test.
**Fig. 4** Cumulative erosion of several steel alloys at 40 fps.

- O A53  Ra 94
- □ 9Cr - 1Mo  Ra 93
- ■ 410  Ra 97
- ● 2 1/4 Cr - 1Mo  Ra 72
- △ SS 304  Ra 80

SLURRY POT FILLED

<table>
<thead>
<tr>
<th>EROSION (ΔG/cm²) x 10^3</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
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<tr>
<td>1.5</td>
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40 FPS  25°C  30 wt% COAL IN KEROSENE

TIME OF EXPOSURE (MINUTES)
Fig. 5 Cumulative erosion of several austenitic stainless steels and A53 mild steel at 40 fps.
Fig. 6 Effect of velocity on two solids loadings coal-kerosene slurries using -200 mesh coal.
Fig. 7. Effect of velocity on two solids loadings coal-kerosene slurries using -30 mesh coal.
Fig. 8 Comparison of coal grinds on erosion of steels in 20 wt% coal-kerosene slurry.
A53 MILD STEEL
30 WT % COAL - 200 MESH
40 fps
25°C

Fig. 9 Erosion of A53 steel at 25°C (75°) in coal-kerosene and coal-hexadecane slurries.
A53 MILD STEEL, 304 STAINLESS STEEL
30 WT % COAL-200 MESH
40 fps
25°C

Hexadecane

0
30
60
90
120

Time of exposure (minutes)

0
10
20

Erosion (Δgm/cm²) x 10⁻⁴

□ A53
○ 304

Hexadecane, 1/2% hexadecanoic acid

Fig. 10 Erosion of A53 steel at 25°C (75°F) in hexadecane and hexadecane + 1/2% hexadecanoic acid.
Fig. 11 Erosion of A53 steel at 94°C (200°F) in hexadecane and hexadecane + 1/2% hexadecanoic acid.
Fig. 12 Erosion of steel alloys vs test temperature.
30 Wt % coal, -200 mesh, in kerosene
20 fps
200°F

Fig. 13 Cumulative erosion of steel alloys at 94°C (200°F), 20 fps.
Fig. 14 Cumulative erosion of steel alloys at 94°C (200°F), 40 fps.
Fig. 15 Cumulative erosion of steel alloys at 177°C (350°F), 20 fps.

30 wt % coal, -200 mesh, in kerosene
350°F
20 fps
Fig. 16 Cumulative erosion of steel alloys at 177 C (350°F), 40 fps.
Fig. 17 Comparison of erosion of steel alloys at 177°C (350°F) at two velocities.
Fig. 18 Eroded surface of 316SS in coal-kerosene slurry
Fig. 19  Eroded surface of 1020 steel in SiC-air erosive stream.
Fig. 20 Cross sections of eroded steel alloys at 40° position.
Fig. 21 Cross section of 9Cr-1Mo steel showing presence of platelets.
Fig. 22 Cross section of A53 steel showing presence of platelets.
This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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