Erosion Corrosion Control

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Just the other day, I was out at my boat dock. While there, I saw that some guide poles for my Jet Ski Lift and the section of the dock that was always in the water had corroded quickly, in just over two years. It amazed me how bad the corrosion was and how bad it looked. The end pieces looked as if I had dipped them in acid and the acid ate away at the poles. As it turned out for this application, at my boat house, I simply had the wrong stainless steel pipe. But this costly exercise got me thinking about all of the industrial applications I have worked on and how I "blew" the design at my own home.

What I am primarily concerned with, in this article, is erosion corrosion control. Now, what is erosion corrosion? Well, no matter how you might look at it, erosion corrosion involves the degradation of the material by some mechanical action, in conjunction with a chemical interaction between the material and the media it is in contact with.

There are many forms in which erosion can be expressed and below you will find one formula that does such. Keep in mind that there are many other ways to do this and some chaps have spent lifetimes coming up with their equations. However, the point I am trying to make will become clear as we go along.

The first principal in using third party data is that your ultimate work probably has errors in the solution, and depending on the application, these errors could, quite possibly, be significant. For example, in the equation above, the constants C and n greatly affect the results. These constants are dependent on specific experimental conditions and can vary greatly. Also, notice how significant velocity can be to the problem if it builds up to a high level. The rest of the parameters in the equation are relatively "hard numbers" in which one can have some level of confidence. Remember, it is the number of particles that are hitting the sample and not the number of particles in the flow field.

The best test is one that considers the exact application and where samples can be put in an actual operating environment. However, this option is not always possible when failure occurs in the "real world". This is due to the fact that, sometimes, the actual failure conditions cannot be duplicated or determined without great difficulty and cost.

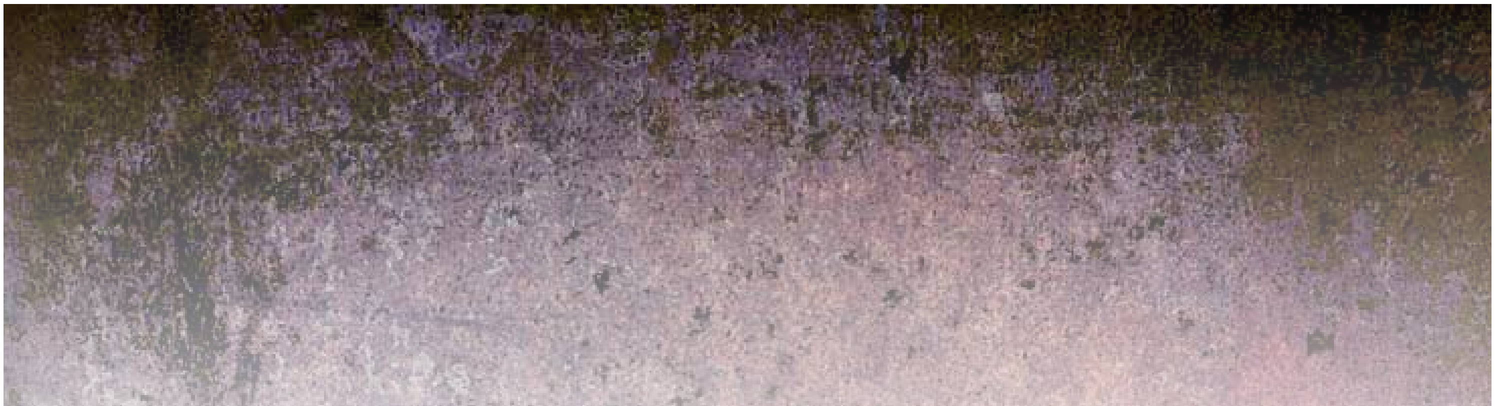
One way to determine C, $\dot{m}_p$, or v^n, is to perform what is called a reverse analysis. In such a situation, you have had a failure and there is a desire to determine what the corrosion erosion rate was. A CFD (computational fluid dynamics) model can be developed and sensitivity studies can be performed to extract reasonable values for the constants. There is typically enough data available in the problem such that one can set an "anchor" on one or more of the critical parameters that will enable one to extract, through the simulation, what the other values may be. Using this approach is typically and remarkably more accurate than using third party data and information.

$$L = \frac{C\, v^n \dot{m}_p t}{\rho A}$$

Nomenclature	
L	Linear loss of material
C	Pre-exponential erosion / corrosion constant
v	Impact velocity
n	Power-law erosion constant
$\dot{m}_p$	Mass flow rate of particles hitting sample
t	Time of exposure to erosion
ρ	Density of rubber or steel
A	Rubber packer or steel components impacting area

Figure 1

There are many successful case studies



that detail this approach, one of which involves erosion in a mixer. In the case, several things were known such as flow rate and particle composition that was contained within the carrier fluid. We found through the CFD studies that the failures were occurring at locations of high velocities. Since we knew that the component of erosion was a function of $v^{2.5}$, we knew what the target velocities had to be. We anticipated the impact would be the same, we just wanted to keep the velocity down. The project was successful and the erosion was no longer a problem because we reduced the velocity by streamlining the mixer (i.e. smoothing out the flow path to reduce turbulence and local velocity).

As with many of these complex systems, this analysis should be led by a professional engineer who is competent to do the work, using a multidiscipline approach.

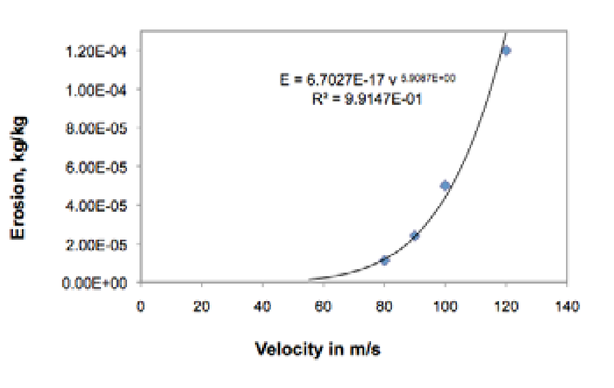


Figure 2. Example of how the increase in velocity greatly effects the erosion in rubber.

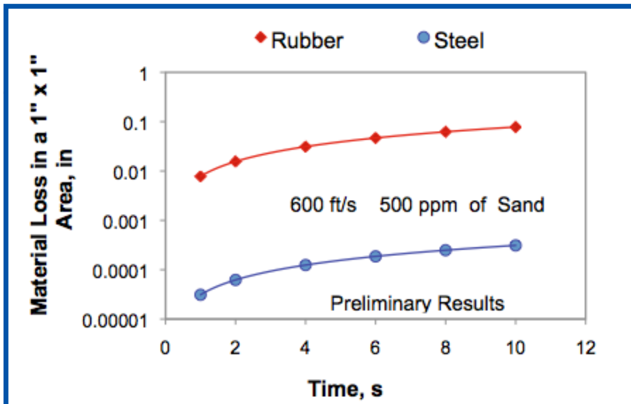


Figure 3. Comparison of Steel and Rubber under the same conditions.

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Cliff is President and co-founder of KnightHawk Engineering, Incorporated since 1991. He is a Professional Engineer with 31 years of experience. Besides his corporate responsibilities as President of KnightHawk, Cliff is also Chief Engineer and Supervising Professional for the Engineering Consulting Group. As Chief Engineer, Cliff serves as the lead technical professional for major multidiscipline investigations into industrial static and rotating equipment failures. Cliff holds five US Patents and is a registered Professional Engineer. Cliff has a BSME from Louisiana State University 1980.