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1. Abstract

The purpose of this paper is to discuss the differences in wear life of polyurethane when used for conveyor belt cleaning. The paper discusses the statistical distribution of wear life data for several blade designs commonly used in mining and heavy industry. The results show there is a significant difference in the mean and standard deviations for the five applications studied.

2. Background

The purpose of this paper is to discuss the differences in wear life of polyurethane when used for conveyor belt cleaning.

There are three basic classes of materials used as wear tips by manufacturers of conveyor belt cleaners, hard metals, ceramics, and elastomers. This paper is limited to discussion of belt cleaner blades made of polyurethane elastomers used in the primary or precleaning position in a conveyor belt cleaning system as Shown in Figure 2.1.

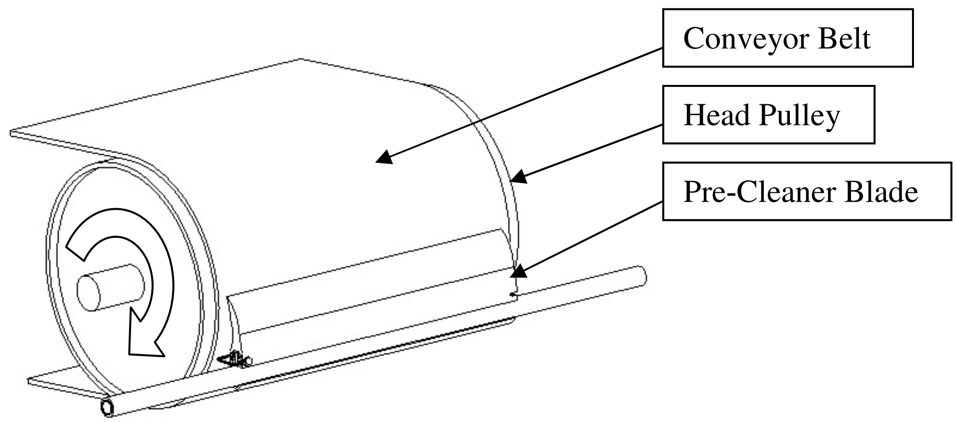

Figure 2.1. Typical Pre-Cleaner Location and Orientation on Head Pulley and Belt

There are dozens of variables that affect the wear life of belt cleaner blades that make it difficult to predict the wear life. Standardized laboratory tests for reliably predicting the wear life of belt cleaner blades have not yet been developed so manufacturers of belt cleaners do extensive field trials to determine the suitability of wear materials for various applications.

Because the blade wear materials are made from advanced engineering materials their cost is significant. Users of belt cleaners are concerned about the wear life of the blades because the life directly affects their maintenance costs. Many industrial operations shut down on a limited basis and consumable components must have a predictable life for proper preventive maintenance planning. The labor to replace the blades can be excessive if the blades do not have a reasonable life. For this reason users often require guarantees of blade life in terms of weeks or months and manufacturers often offer estimates in terms of a specific time period. In many cases there are dramatic differences between the estimated life and the actual life of the wear components even on similar applications. The variability of the wear life leads users to question the quality of the wear materials or the reliability of the manufacturer's equipment.

3. Procedure

The results presented in this paper are from eighty-nine field tests in five different industries over a two year time period. The industries were coal mining and power generation, paper products, Aggregates, and Non Metal mining. The polyurethane used for all tests was a polyester based MOCA cured to a nominal 87 shore A. The three blade sizes based on the same basic design technology that were used are shown below in Figure 3.1.

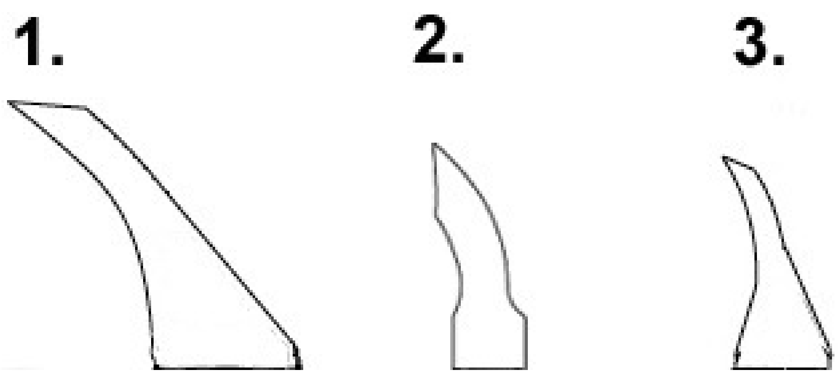

Figure 3.1. Standard Blade Profiles Used in Field Tests

There was no attempt to control or measure any variable other than to measure the perceived wear life of the blades. Test data was accumulated by gathering reports from maintenance technicians who regularly service the user's equipment. The dates that the blade was installed and removed as worn out were recorded along with basic information such as blade profile, material conveyed, belt width, and belt speed.

A large statistical population was required for the analysis. The experiment encompassed three different blade profiles, and a standard was needed to be used to compare the wear rate. This was accomplished by was calculating the wear per volume rather than a per blade profile basis. The total volume of polyurethane worn was measured for each sample. Each blade profile had a different wear area, and wear volume based on the width of the belt. The wear area of each profile are summarized below in Table 2.1.

	Blade Profile 1	Blade Profile 2	Blade Profile 3
Wear Area (cm^2)	172	72.9	55.1

Table 3.1. Associated Wear Areas for Blade Profiles in Experiment

The life of that particular blade was divided by the area worn. This normalized the data and removed a variable, resulting in a common measurement for wear of cm^3/hr.

A total of 89 observations were made and 61 observations were used in the analysis.

4. Results

Figures 4.1 through 4.5 show the results by application in the form of statistical distributions.

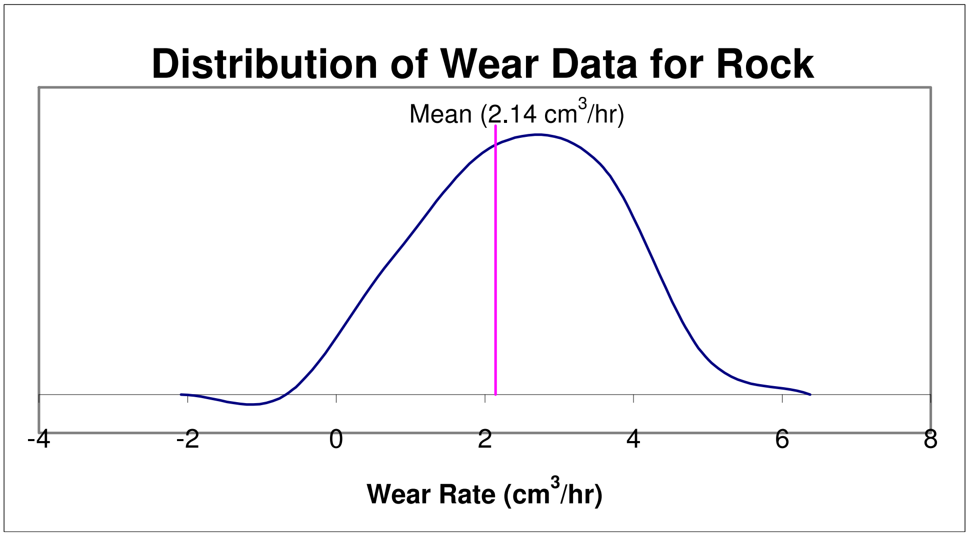

Figure 4.1. Distribution of Wear Data for Blades Cleaning Rock and Aggregate.

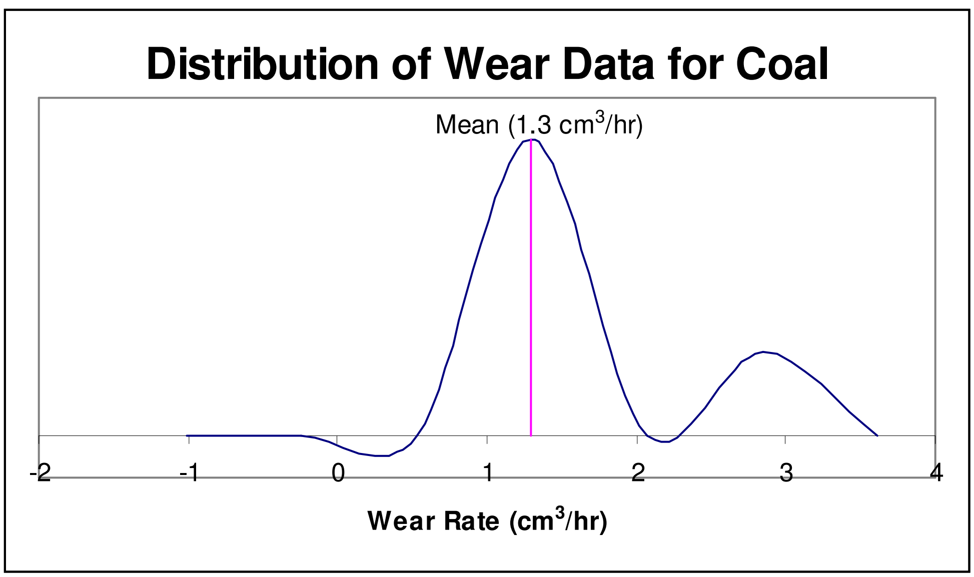

Figure 4.2. Distribution of Volumetric Wear Data for Blades Cleaning Coal.

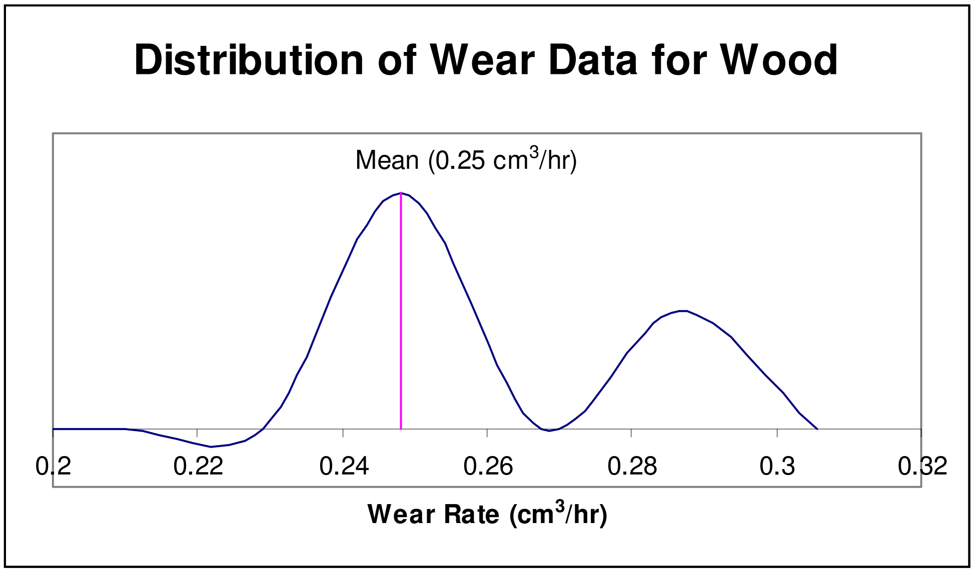

Figure 4.3. Distribution of Volumetric Wear Data for Blades Cleaning Wood and Pulp Products.

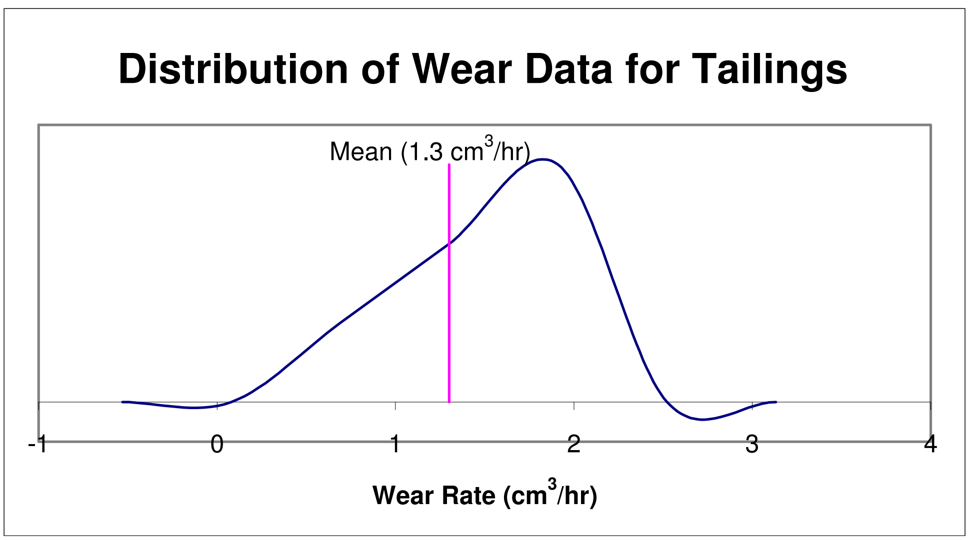

Figure 4.4. Distribution of Volumetric Wear Data for Blades Cleaning Iron Ore Tailings.

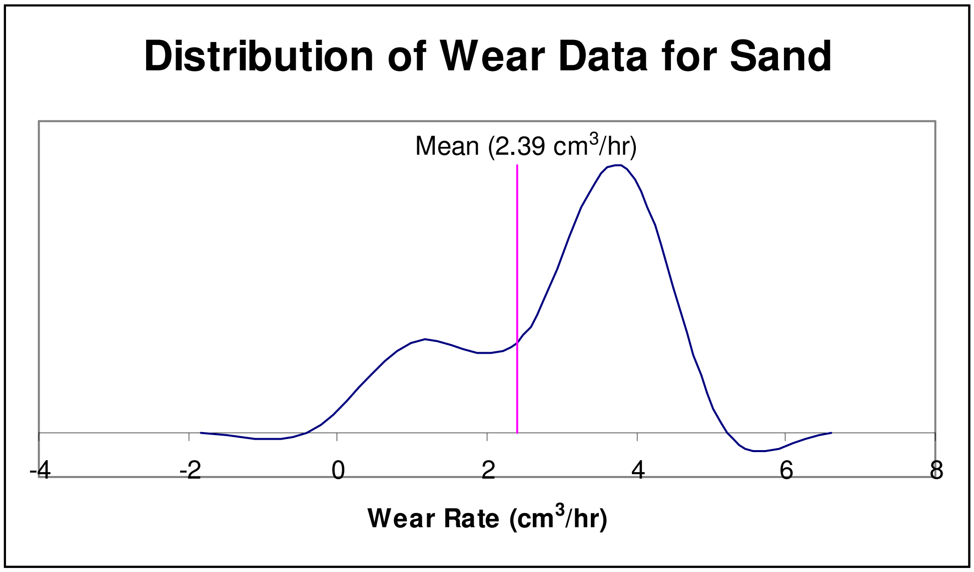

Figure 4.5. Distribution of Volumetric Wear Data for Blades Cleaning Sand.

When all the test data was combined, a normal distribution curve was generated. Figure 4.6 shows this distribution.

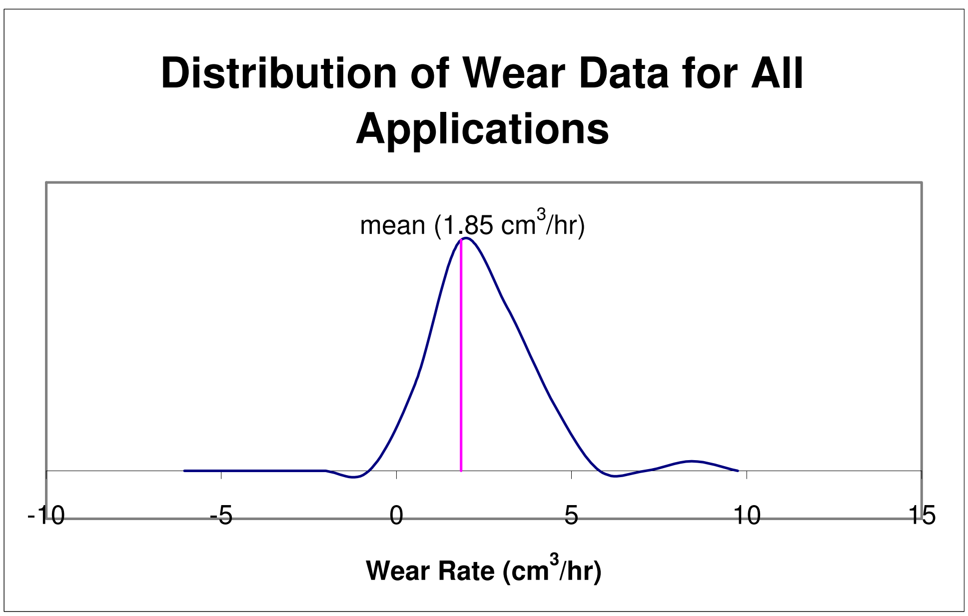

Figure 4.6. Distribution of Volumetric Wear Data for Blades in All Applications.

5. Discussion

The collected data was normally distributed about a mean. The results show that there are significant differences in the mean and standard deviation wear life by application. After the material conveyed, the most dominant variable was the volume of wearing material in the blade. Other variables, such as belt speed or width had some effect but were not as significant as wear volume. When all of the distributions for the applications are plotted together, differences in wear life can be seen. This is shown in figure 4.1.

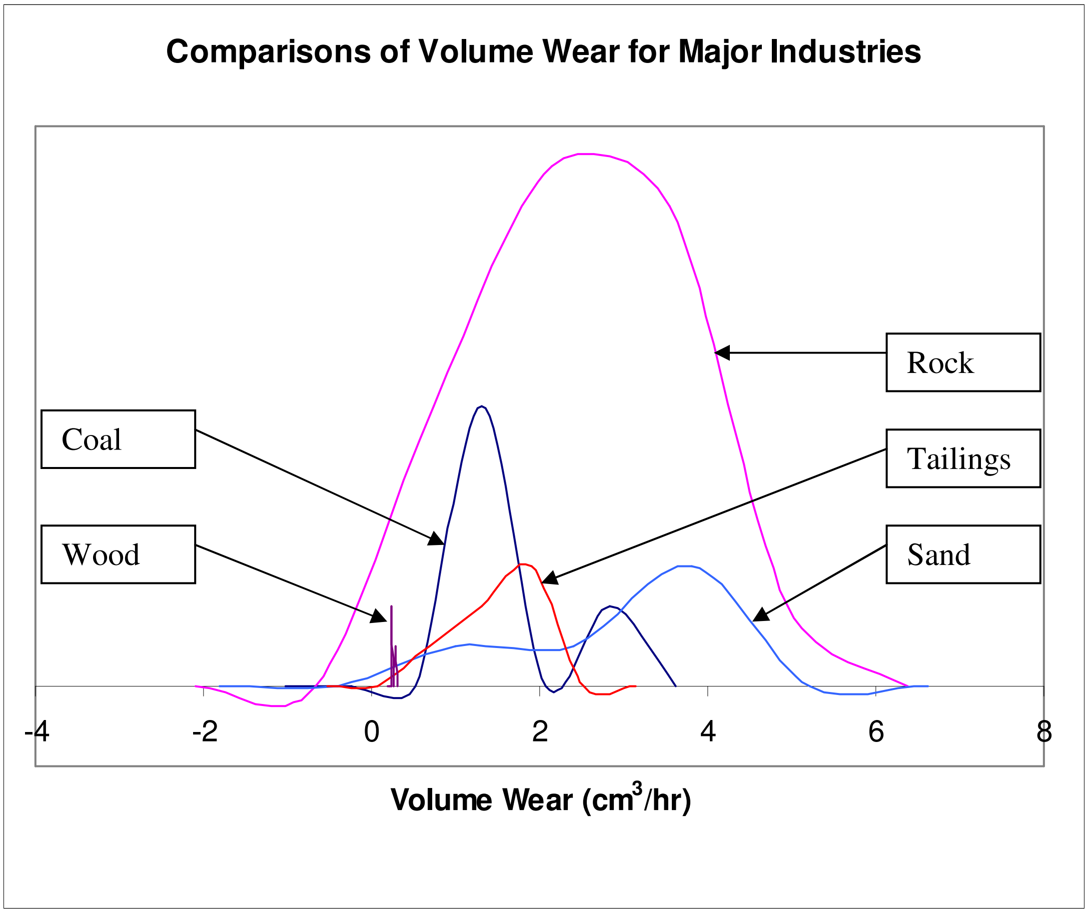

Figure 5.1. Distribution Curves of Volumetric Wear for Applications Included in Experiment

There are some anomalies that appear in the data. For example in the wood products curve there are two distinct peaks. This is due to having only two wood processing facilities in the test program and shows the differences that can be experienced from plant to plant in the same industry. In the coal and power generation curve there is also a double peak. The first peak represents single direction conveyors, while the second peak is related to the wear life on reversing belts.

The mean and standard deviations of each application do not fall within the standard deviation of the population data. This is best shown in figure 5.2 where all application means are plotted with bars to show one standard deviation. This information is also shown below in Table 5.1

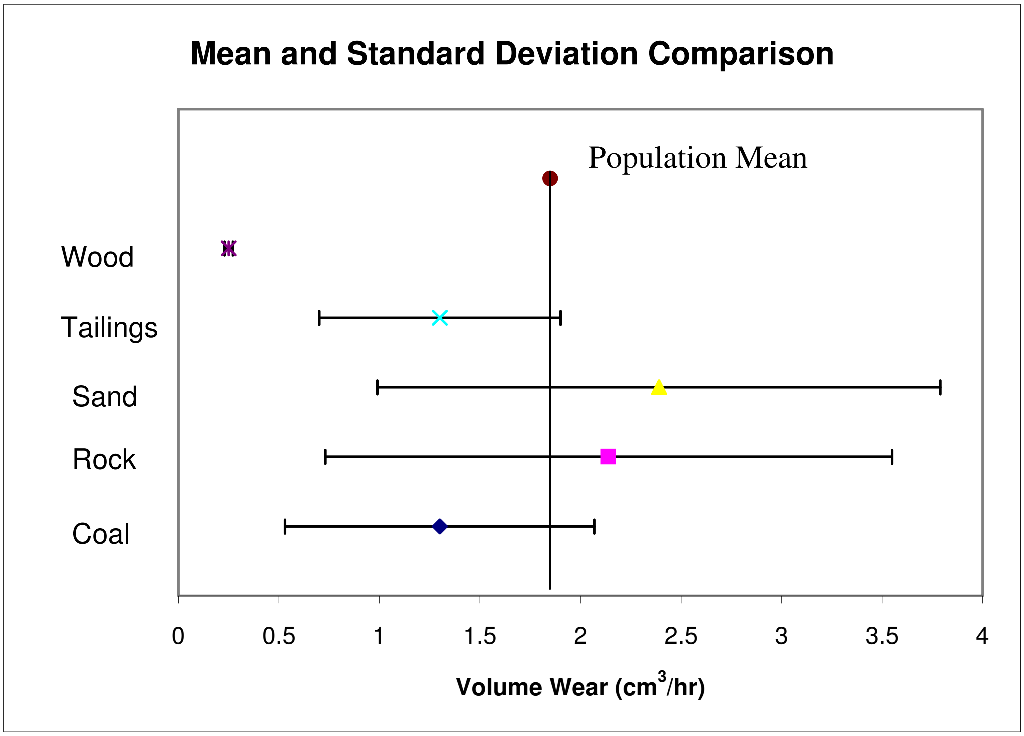

Figure 5.2. Comparison of Mean and Standard Deviations for All Applications Included in Experiment.

Application	Wear Life Mean (in^3/hr)	Wear Life Standard Deviation (in^3/hr)
Coal	1.3	0.77
Rock	2.14	1.41
Sand	2.39	1.4
Tailings	1.3	0.6
Wood	0.25	0.02
All	1.85	1.32

Table 5.1. Summary of Means and Standard Deviations of Each Application Included in Experiment

The data within one standard deviation of the mean wear life of rock and sand does not fall within one standard deviation of the mean of the entire population. The entire data set for the applications involving wood products falls outside the standard deviation of the combined population. As the area between the standard deviation bars represents 68% of the data for that set, the figure shows that a general population can not be used to predict wear life.

The average volumetric wear for each application was plotted to show relative differences. The comparison is shown in Figure 4.2.

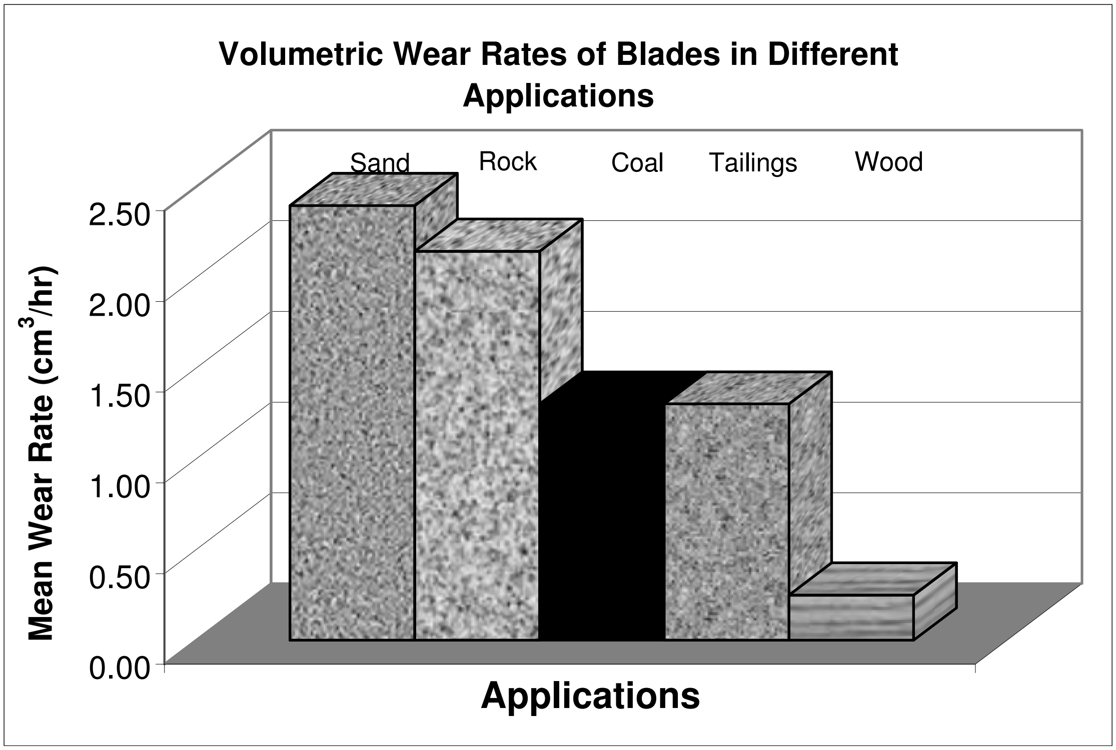

Figure 5.3. Comparison of Wear Rate in Divided By Major Applications.

This chart correlates well with the practical experience of the maintenance technicians and product engineers and customers general overall perception of wear rates. For example it is logical that sand is very abrasive and would wear polyurethane blades at a faster rate than wood products.

6. Recommendations

From this study it appears that some general conclusions can be drawn that there is a representative mean wear life and standard deviation for a given application. At ±one standard deviation the wear life of 68% of the applications in that application could be predicted. From the users point of view the higher the mean and the lower the standard deviation the more reliable the product is and the easier it is to predict maintenance intervals.

Example
A maintenance interval range could be calculated based on the statistical distribution mean and standard deviation. For this example, let the material be rock, the belt width be 1200 mm. and the blade be profile 3 from Figure 3.1. The belt cleaner blade width is normally narrower than the belt width so use 1100 mm blade width.

Multiply the wear area from table 3.1 by the belt cleaner blade width and divide by a wear rate from table 5.1. This will give a wear life projection in hours based upon a normal distribution curve .

$$WearTime = \frac{(Wear\ \ Area)cm^2 \cdot (Cleaner\ Width)cm}{(Wear\ \ rate)\dfrac{cm^3}{hr}}$$

In this example, the mean is 7022 hours and the standard deviation is 4130 hours. This shows that, 68% of the time, the blade will wear out in a range between 2892 hours and 11152 hours and the mean life will be 7022 hours. At first this seems like an unacceptable range but in fact it does represent the results experienced by users although not in a format they are accustomed to seeing. It is not unusual for users to complain that on one conveyor the blades wear out much faster even though the bulk material, conveyor size and belt speed are the same. Wear life variances of 2 to 4 times are not unusual even in the same facility. These large variances are reflected in the large standard deviations and would seem to indicate the large number variables in bulk material handling do have significant effects on the wear life of belt cleaner blades. In this example the manufacturer, if asked for a guarantee of blade life, would be wise to guarantee 2892 hours. The user on the other hand may find this unacceptable since the perception based on past experience may be closer to the mean life of 7022 hours.

It should be possible for a particular facility to modify the mean and reduce the standard deviation by controlling or eliminating variables. This process is called Blade Life Optimization. By setting up a controlled experiment the user, in cooperation with the manufacturer, can determine the most cost-effective combination of the controllable variables for their individual facility. The variables that are most easily modified are blade pressure and the quality of the polyurethane. Increases in mean blade life by a factor of two or three times are not unusual for a well-designed and documented Blade Life Optimization program. Conversely in any facility there is always at least one problematic conveyor that for undeterminable reasons defies any attempt at corrective action. Unfortunately it is often this problematic conveyor that is used as the examples of unacceptable wear life by the user when it is the entire population of applications that should be examined.

7. Conclusion

The wear life of polyurethane precleaner blades is better represented by a statistical distribution than a single period of time. The characteristics of the statistical distribution will be different for different general classifications of applications. This demonstrates different mean wear lives for different applications. Due to the statistical nature of wear, blade life still varies greatly about each mean. This makes predicting wear with just a mean impractical. By keeping accurate wear life records the distribution can be determined and a process of optimization can be implemented. It is suggested that the manufacturers begin to specify an expected mean and standard deviation for blade wear life guarantees and that users begin to adopt this method in their record keeping and specifications.

8. About the Authors

R. Todd Swinderman is CEO of Martin Engineering. Mr. Swinderman is a registered professional engineer who obtained his Mechanical Engineering degree from the University of Illinois in 1971. Mr. Swinderman has over 30 patents and has written numerous technical articles relating to bulk material handling.

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