

A METHOD AND INSTRUMENT FOR AUTOMATIC
MEASUREMENT OF ANODE SLUMPING

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Abstract

A system has been designed to measure slumping in anodes manufactured for the aluminum industry. The non-contact system can resolve measurements to within .007 inches. Its components include a sonar device, electromechanical scanner, pulse width detector and single board computer. Pulses, whose width determines exact distance, are received from the sonar device as it scans the anode surface. The input is filtered to remove extraneous values and compared to stored specifications. If an anode is out of spec, an alarm is energized. Data from each anode is buffered and can be transferred to another computer for entry into a historical database. This information will be used to institute controls and provide graphic representation.

The commercial application of the method and instrument was used for the inspection of carbon anodes produced in Alumax plant of South Carolina. The results of this testing are presented.

Introduction

The addition of the proper amount of pitch to the coke aggregate is of premium importance for the production of good performing anode. There is unfortunately no satisfactory procedure available which would reflect all variables influencing the optimum pitching level and safeguard the constant consistency of the green paste. The plasticity of the compacted green paste depends on the following variables:

1. The viscosity of pitch, i.e. its softening point and temperature. (We have to keep in mind that the viscosity and flow properties of pitch within the confined space in the aggregate differs from the viscosity of pitch measured in bulk sample, e.g. the consistency of pitch within the aggregate is more sensitive to the concentration of primary and secondary QI.)
2. The ratio between pitch and aggregate.
3. The grain size distribution of the aggregate, especially the concentration of the fines.
4. The porosity of coke.
5. The method and degree of green anode compaction.

The operators of the aluminum carbon plants are mostly using an empirical trial and error method for the determination of proper addition of pitch.

For horizontal stud Soderberg paste Alcan published a formula which estimated the required pitch level from the bulk density of the coke, QI and softening point of pitch (1).

The operators of carbon plants fabricating prebaked anodes estimate the correct pitch level very often just by visual appearance or according to the amount of packing coke sticking to the surface of baked anodes or by the degree of slumping of anodes after leaving the press or vibrator.

A method, published by Alcoa (2), measures the degree of slumping by using a contacting wheel on a spring-loaded shaft which is connected to a displacement transducer. The disadvantage of this method is that the measuring device makes physical contact with the anode and can thereby become contaminated rendering inaccurate measurements. Furthermore, the roughness of the surface of the green anode inhibits an accurate tract of the anode surface by a contact measuring device. Moreover the anode has to be carefully positioned for accuracy and discrimination is not optimum when measurements are taken horizontally.

The Carbon Precursors Research Group at the Koppers Science & Technology Center has been looking for some time into ways to measure and control the pitch level in green paste for prebaked as well as Soderberg anodes. The most advanced version which is already yielding results in commercial environments is the subject of this communication.

Principle and Instrument for Anode Slump Measurement

The electrical and instrument part was designed and tested by Computer Services and the mechanical part by Engineering Services in Koppers Science and Technology Center. The instrument was installed and tested under commercial conditions in the carbon plant of Alumax of South Carolina.

Initially an electromechanical scanner and a sonar transceiver were used to monitor slumping of anodes. The sonar system was capable of displaying

measurements and generating a transistor-transistor logic (TTL) output pulse. Because the display was not sensitive enough to provide the required resolution, a computerized measuring system was developed that could read the TTL pulse, calculate anode slumping and provide an indication of "out of spec" conditions.

The measurement system consists of an electro-mechanical scanner, ultrasonic micrometer, pulse counting circuit and a single board microcomputer (figs. 1 and 3). The sensor of the ultrasonic micrometer is a transmitter/receiver (transceiver) that sends a 50 KHZ burst every .2 seconds, and receives the signal after it is reflected by the anode. As shown in fig. 2, the transceiver moves along the dotted lines to vertically scan the anode from top to bottom in approximately 17 seconds. During this time an average of 85 sample measurements are made. The time period between the start of transmission and reception of the reflected signal determines the positive pulse width of a 5 HZ TTL output signal. Since the distance between the sensor and the anode is fixed during testing, differences in output pulse width can be attributed to slumping. The TTL output pulse width of each sample is measured by a high precision counting circuit synchronized with the microcomputer internal (fig. 1) clock. The counter output registers are read into the microcomputer, filtered to remove extraneous values and stored in memory. After scanning is complete, the maximum slump of the anode is calculated and compared to a stored constant. If the anode is "out of spec" an alarm signal is energized.

The filtered data for each anode are saved in a buffer on the microcomputer. (Presently enough for 8 anodes). Upon receipt of a handshaking signal from the host IBM computer, the data are converted to serial ASCII (American Standard Code for Information Interchange) and uploaded for further analysis and archiving. A program, written in basic, displays the maximum slump value for each anode, a five anode average and a cumulative average. The program also displays a graph of the vertical profile of each anode when tested. All slump data are time stamped and stored on the disk for use in an historical database that will be used to optimize the mixing process.

The current implementation is a form of open loop control. It can be determined when anode slumping is excessive so that the pitch metering pump is adjusted manually according to the result. By combining the historical slump data and pitch percentages there are hopes that a control strategy would be developed that would directly control the pitch metering pump speed so that a constant optimum slumping of green anodes is maintained.

Results of Measurements in Plant Operation

At Mt. Holly, Alumax uses a UKE-500 Baker-Perkins continuous mixer to produce anode paste. The mixer operates at 35 short tons per hour using automated gates to control mixer power. Since only one mixer is used, liquid pitch is used.

The paste from the mixer is conveyed to either of two in-line anode vibrators to be formed into anodes. The vibrators were purchased from Humboldt-Wedag.

Four different aggregate scales feed coarse, intermediates, and fines fractions into the continuous system. The coarse material is composed of butts fraction and petroleum coke fraction. Scale outputs are adjusted to keep within a targeted aggregate distribution that is periodically checked.

The coke is pre-heated within a predetermined range. Prior to mixing green scrap paste can be preheated or fed direct to the mixer. The liquid pitch is metered into the mixer using a rotary vane metering pump purchased from Viking.

Anode quality is a function of raw materials and operating parameters. Operating parameters include process temperatures, aggregate distribution, and pitch control. Process temperatures include pitch temperature, aggregate temperature, mix temperature, and forming temperature. Each plant must choose the right heat balance depending on raw material characteristics and existing process equipment. Once this heat balance is selected, consistency must be maintained to prevent process temperatures from affecting pitch additions.

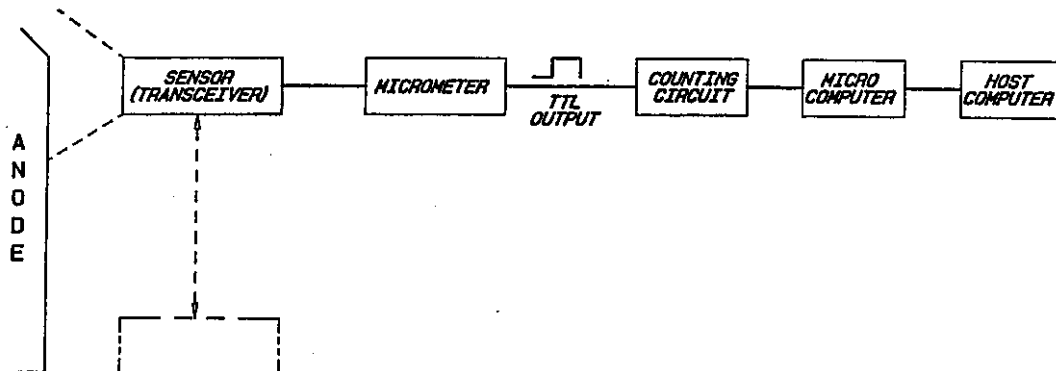


Figure 1. Schematic of Slump Monitoring System

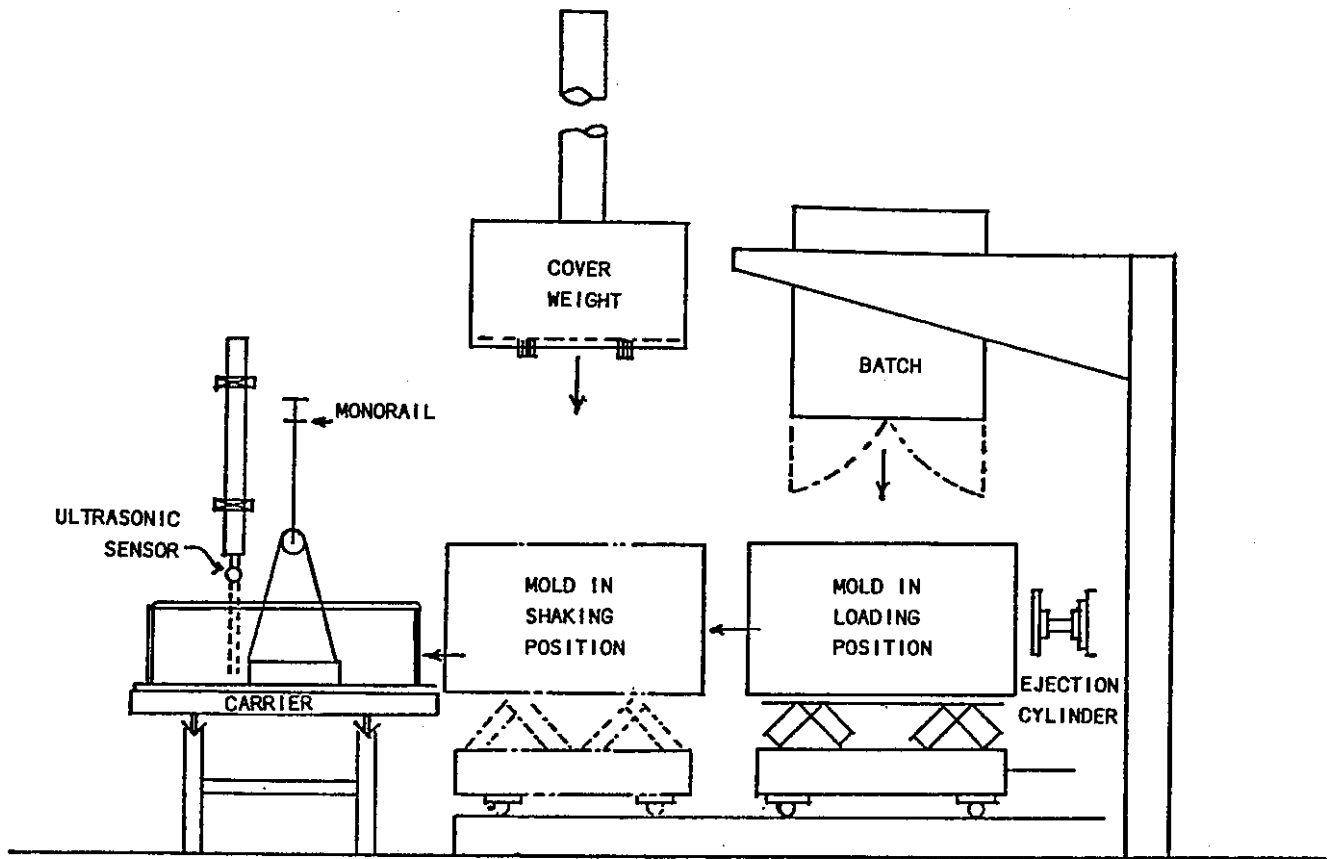


Figure 2. The Measurement of Anode Slumping by Ultrasonic Sensor.

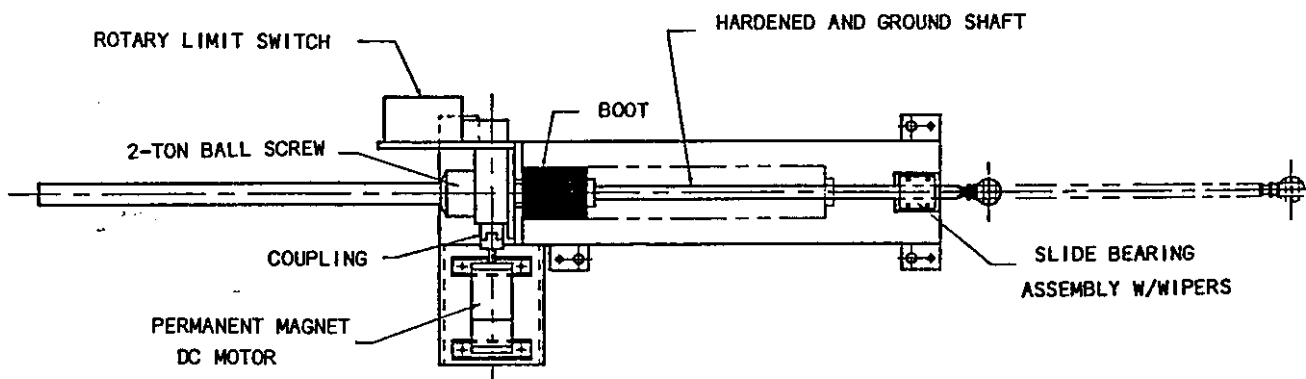


Figure 3. Detail of Electromechanical Scanner

While scale accuracies are important for material balance, aggregate control must take priority. Periodically, aggregate distribution must be checked and scales adjusted to maintain the aggregate to produce anodes with optimum densities. Again, consistency is important as shifts in aggregate surface area impact pitch demand.

Each aggregate has an optimum pitch demand to maximize baked apparent densities and anode performance in reduction cells. Too little or too much pitch in anodes leads to increased carbon consumption and inefficiencies in reduction cell operations.

Even with good aggregate control and constant adjustments, aggregate surface area is subject to constant variations. Therefore, Alumax of South Carolina has chosen to control pitch content by the degree of anode slump to insure aggregate pitch demand is met. For this to be effective, process temperature must be closely controlled.

In the past, the method for determining anode slump consisted of physical measurements. Based on the physical measurements, the operator would adjust pitch to remain within a certain range of anode slump. This range was determined by trial and error based on pot operation, condition and physical butt measurements. For Alumax of South Carolina, that range was determined to be 0.125 inches, plus or minus 0.0625 inches (1/8 inch \pm 1/16).

While this system proves to be effective, it requires an operator to do the physical measurement. This leads to two problems. First, the measurement can be inaccurate. Secondly, only a limited number of measurements can be done when only one operator is dedicated to this task.

The slump monitor developed by Koppers and explained above is non-contacting. Its measurements tend to be more accurate versus physical measurements. The slump monitor can record as many anodes as desired while maintaining an historical data base.

Once it was determined this method would detect slump in the desired range, software was developed based on Alumax of South Carolina input. The following photograph, Figure 4, shows the screen of the IBM Personal Computer used with this software.

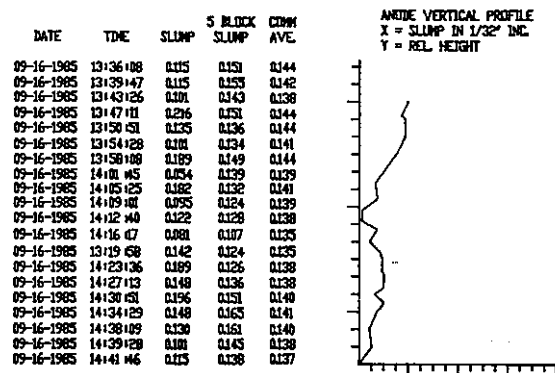


Figure 4. Slump monitor computer output.

First, the physical measurements and slump monitor were used simultaneously. From this, it was determined that several readings must be taken before proper pitch adjustment is made. The screen shown above shows a cumulative average of 5 anodes. This system is slowly replacing the physical measurements as operators gain confidence in the slump monitor.

Although some hardware and software problems still exist, they are minor. The length of the scan will need some refining also as occasionally the slump monitor shoots into the crown of the anode. This problem's solution, with continued software development, should be accomplished by spring 1986.

At that time software and hardware will be added to close the loop with the pitch metering pump. Then the slump monitor will be continuously adjusting pitch to meet aggregate pitch demand.

Conclusion

The described instrument and method seems to be a useful tool for efficient control of the carbon plant operation. The experience collected so far will be used not only for further refinement of the control at Alumax Mt. Holly Plant but also for the development of similar instruments and methods in carbon plants using other procedures of compacting the green paste into anode blocks.

References

1. L. Castonguay, S. K. Nadkarni, "Light Metals 1984", p.901.
2. R. W. Peterson, E. J. Seger, "Light Metals 1980", p.443.