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Fuzzy Controlled System for Bituminous Concrete Plant

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Abstract —Abstract The control level in bins and effective rate of discharge is very complex as there are many dynamic variables such as time of discharge cycle, speed of feeders, physical characteristics and chemical composition of the ore. This work addresses two variables to apply fuzzy logic, which are the level of material in the Bitminus concrete plant and the effective rate of discharge. The ideal discharge occurs when the desired yield is achieved and when the level of material in the varies within the range specified by the supplier. In this work we use the speed of rotation of feeder conveyor to control by the application of fuzzy logic. If the speed of feeder conveyor is low, the level increases in the silos and the effective rate decreases and whether the speed of feeder conveyor is high, the level decreases and the silos effeective rate increases. The fuzzy logic was applied in this work because it is very difficult to make the modeling using classical logic, when the variables are inaccurate as in the case discussed.

I. INTRODUCTION

The theme of this paper is the proposal to introduce programming Fuzzy Logic to control level in Bitminus concrete plant. The control is done by keeping the minimum and maxi- mum desired, but also the control of the flow rate through effective during the unloading process. Fuzzy systems are used to solve problems that are complex for human understanding, many human skills are learned from examples. So this is natural setting "didactic principle" in a computer program that learns how to provide the desired output for a given input function .
Somehow, computational intelligence techniques, ba- sically derived from the theory of Fuzzy Systems (fuzzy),
Artscial Neural Networks and Evolutionary Computing, computer programs are able to process numerical data and / or linguistic information, whose parameters can be adjusted from examples. Examples representing these systems must respond when sub jected to a particular entry. These techniques use numerical representation of knowledge, demonstrate adaptability to fault tolerance which is in contrast to the classical theory of artificial intelligence that uses symbolic representation of knowledge The level of control and the productivity are done by varying the speed of the conveyor feeders, for this, it was necessary that the mathematical modeling of the system to the fuzzy logic developed represent the reality of the operational process . It was observed in the field and with experts what the best level to be maintained in silos and better effective rate of discharge, with this information the system was modeled .

II Control of Industrial Processes

The control of industrial processes has been a tool every day that industries seek to optimize their processes. Often this control is done manually by experts, or mechanically by devices installed in the plant. The control systems are usually nonlinear, which complicates control technique with classic control, but the knowledge engineer develops mathematical models of linear approaching real models . In critical systems is essential to search for failures that can occur and their respective solutions at the time of oc- currence or in real time. Nevertheless it is the realization of redundancy for all the tasks that the system will perform . It features a real time system that can be classified according to the consequences from a failure to observe the specified time limits. This classification is directly related to the nature of the element to be controlled.

A. Control And State Problems

Optimal Control Theory and a mathematical tool that can be used to make decisions involving several prob- lems, among them are controlling the level of silos and productivity of discharge. For example, hen a particular discharge wagon event has a lower effective tax rate, we want to know what were the problems that occurred, to be solved in order to minimize or eliminate such problems in order to achieve the desired result .

The behavior of a dynamical system is described by a fundamental state variable, which are quantities that we wish to control. These variables represent the conditions under which lies the problem being modeled, at time t. We assume that there is a way to direct state variable acting on it with a suitable control function .

In optimal control problem for ordinary differential equations, we use u(t) to denote the control variable and z(t) to denote the control variable and denote the state variable at time (t). The state variable satisfies the differential equation, with dependence on the control variable:

dz

(t) = g (t, z (t) , u (t))

dt

Equation (1) above is called the Equation of State.sets and is therefore of limited use. The rule method is more general. In the rule method, a set A is represented as

A = {x ∈ U \x meets some conditions} There is yet a third method to define a set A-the mem-bership method, which introduces a zero-one membership function (also called characteristic function, discrimination function, or indicator function) for A, denoted by μA (x)

As the control function is changed, the solution of the deferential equation will also change. So we can see the re-

μA (x) = (4)0 if x ∈/ A

relationship as a state-control application u (t) → z = z (u).

Where z is a function of the independent variable t, we write simply to remind us of its dependence on u. The basic problem of optimal control is to find a control, continuous by parts, and state variable associated z(t) to maximize (or minimize) the ob jective functional data, which in our case is given by J . So the problem is:

The set A is mathematically equivalent to its member- ship function μA (x) in the sense that knowing μA (x) is the same as knowing A itself.

”FUZZY LOGIC” was developed in 1965 by Lot A. Zadeh, a professor of Computer Science at the University of California at Berkeley. Fuzzy logic is an extension of conventional (Boolean) that handles the concept of partial truth, truth values between ”completely true” and

max J (u) = max

f (t, z (t) , u (t)) dt, (2)

t0

”absolutely false”. Zadeh noticed that the complexity of the system comes from how the variables were represented and manipulated. The Theory of Fuzzy Concepts and Fuzzy Logic can be dt (t) = g (t, z (t) , u (t)) , z (t0) = z0 and z (t1) (free).

Such control, if it exists, will be called optimal control and will be denoted by u∗ and the corresponding state will be denoted by z∗ . Where the functions f and g are continuously differentiable functions in three variables. Thus, as the control is always ongoing in parts, the state will always be associated differentiable by parts .

III. Fuzzy Systems

Fuzzy mathematics provide the starting point and basic language for fuzzy systems and fuzzy control. Fuzzy mathematics by itself is a huge field, where fuzzy mathematical principles are developed by replacing the sets in classical mathematical theory with fuzzy sets . In this way, all the classical mathematical branches may be used to translate into mathematical terms the inaccurate information expressed by a set of linguistic rules.

If a human operator is able to articulate his strategy of action as a set of rules of the form IF ... THEN an algorithm that can be implemented on a computer may be constructed .The result is a system based on rules of inference, in which the Theory of Fuzzy Sets and Fuzzy Logic provides the mathematical tools to deal with such linguistic rules .

In classical theory of sets, the concept of relevance of an element to a set is well defined. Given a set A in a universe X , the elements of this universe simply belong or not belong to that set. This can be expressed by the characteristic function fA :

”fuzzified.” We have seen the birth of fuzzy measure theory, fuzzy topology, fuzzy algebra, fuzzy analysis, etc. Under

fA (x) = 0 ⇔ x ∈/ A standably, only a small portion of fuzzy mathematics has found applications in engineering. In the next five chapters, we will study those concepts and principles in fuzzy mathematics that are useful in fuzzy systems and fuzzy control .

Let U be the unaverse of discourse, or universal set,hwhich contains all the possible elements of concern in each particular context or application. Recall that a classical (crisp) set A, or simply a set A, in the universe of discourse U can be defined by listing all of its members (the last method) or by specifying the properties that must be satisfied by the members of the set (the rule method) [13]. The list method can be used only for finite Zadeh proposed a broader characterization, generalizing the characteristic function so that it could assume an infinite number of values in the range [0, 1]. A fuzzy set in the universe one X is de ned by a membership function μA (x) : x → [0, 1] and represented by a set of ordered pairs A = {μA x/x} x ∈ X

where μA (x) indicates how x is compatible with set A. A given element can belong to more than one fuzzy set, with different degrees of relevance.

The support assembly of a fuzzy set A is the set of elements in the universe for which XμA x > 0. A fuzzy set whose support is a single point x with μA x = 1 is called unitary set fuzzy or singleton. Thus, a fuzzy set can also be seen how the mapping assembly supported in the interval [0, 1] which implies express fuzzy set by its relevance function.

Fuzzy sets can be defined in continuous or discrete universes. If the universe, X , is ifinite and discrete, the fuzzy set A is typically represented:

- For a vector containing the degrees of relevance in the set of the corresponding elements of X;
- By the following notation (not to be confused with the algebraic sum):

If the universe X is continuous, it often employs the following notation (where the integral sign is to be inter- preted in the same way that the sum as in case of a discrete universe)

Linguistic Variables

A linguistic variable is a variable whose values are names of fuzzy sets. For example, the temperature of a given process can be a linguistic variable taking values low, medium, and high. These values are described by means of fuzzy sets, represented by relevance functions, as shown in Figure 1

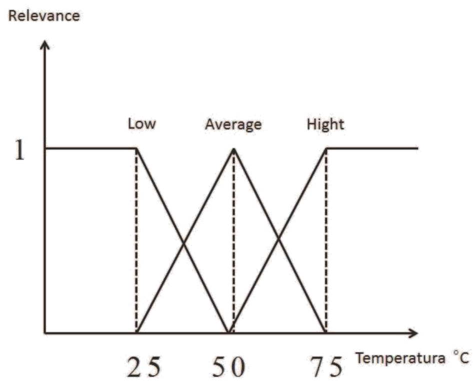

Fig. 1. Representation of Function Relevance

The main goal of the linguistic variables is to provide a systematic way to approximate a characterization used by humans rather than quantized variables, allows treatment of systems which are complex and poorly dened. Thus, using the complex description language type analyzed for conventional mathematical terms.

IV. METHODOLOGY

In this paper we used the methodology commonKAD to collect data and prepare the production rules, MATLAB software was used to test the experiments .The observation in the field, watching the operator, maintenance technicians and engineers was made 180 days, an average of 2 hours per day, was also observed physical behavior dumper wagon and made tests by varying the speed of feed conveyor and checking at bins.

The process of acquiring knowledge is not only the extraction and transcription of knowledge, but rather a modeling activity . This requires a methodology to implement the designed project.

Among existing method- ologies highlight the KOD, the PROTEGE, the COMMET and COMMONKADS, the latter is the most widely used.

CommonKADS provides a series of detailed models that can express the solution of the situation. The six models problems are:

- Organizational Model;
- Task Model;
- Model Expertise;
- Communication Model;
- Model Agent;Model Design

Together, the organization, task, and agent models ana- lyze the organizational environ-ment and the correspond- ing critical success factors for a knowledge system. The knowl-edge and communication models yield the concep- tual description of problem-solving func-tions and data that are to be handled and delivered by a knowledge system . The design model converts this into a tech- nical specification that is the basis for software system implementation. This depends on the goals of the pro ject as well as the experiences gained in running the pro ject . Thus, a judicious choice is to be made by the pro ject management. Accordingly, a CommonKADS knowledge pro ject produces three types of products or deliverables:

1) CommonKADS model documents;
2) pro ject management information;
3) knowledge system software.

A. Knowledge Engineering and Knowledge Systems

Mentioned knowledge engineering as one of the newly emerging disciplines sparked by the Information Age, similar to how the Industrial Revolution gave rise to mechanical and electrical engineering . The knowledge we now consider knowledge proves itself in action. What we now mean by knowledge is information eff ective in action, information fo-cused on results. Results are outside the person, in society and economy, or in the advancement of knowledge itself. To accomplish anything this knowl-edge has to be highly specialized. .. It could neither be learned nor taught. Nor did it imply any general principle whatever. It was experience rather than learning, training rather than schooling. But today we do not speak of these specialized knowledges as ”crafts.” We speak of ”disciplines.” This is as great a change in intellectual history as any ever recorded. A discipline converts a ”craft” into a methodology — such as engineering, the scientific method, the quantitative method or the physician’s diff er- ential diagnosis. Each of these methodologies converts ad hoc experience into system. Each converts anec-dote into information. Each converts skill into something that can be taught and learned.

Knowledge engineering has evolved from the late 1970s onward, from the art of build-ing expert systems, knowledge-based systems, and knowledge-intensive infor-mation sys-tems. We use these terms interchangeably, and call them knowledge systems for short. Knowledge systems are the single most important industrial and commercial off spring of the discipline called artificial intelligence. They are now in everyday use all around the world. They are used to aid in human problem-solving ranging from, just to name a few of the CommonKADS applications, detecting credit card fraud, speeding up ship design, aid-ing medical diagnosis, making scientific software more in- telligent, delivering front-office financial services, assessing and advising on product quality, and supporting electrical net-work service recovery.

V. Unload System Description

The Vale S/A is the second largest mining company in the world, most of the Americas, one of the world’s largest producers of iron ore and pellets and ranks second in the production of nickel. The Ponta da Madeira Port Terminal, located in Sao Lu´ıs at Maranh˜aoo state, located in the northeastern of Brazil, is part of the North VALE System which also includes the Cara jas, as Railroad. Its proximity to the North American and European positions it strategically in the export of iron ore and grain farm.
The car dumpers rotating equipment are positioning the pair of cars in a barrel and rotate up to 180, each spin is unloaded two cars. The carriages are conjugates, between one and another wagon has a fixed coupling, called a fixed bar and the ends of each pair of carriages are movable couplings allowing the rotation of the wagons during discharge without requiring the decoupling thereof, in accordance with Figure 2

Fig. 2.1 car dumber in congrete plant

The ore coming from Cara j´as comes to Sa˜o Lu´ıs via trains that are unloaded in car dumpers. The ore is unloaded by car dumpers transported to the machines piling and ore in stockyards. The storage material for a certain period is needed to correct or ameliorate some of its physical and chemical characteristics, as well as to meet a logistics operating.

One way to control the standardization process is through the study of time. According [17], the study of time is a measurement technique for recording work times and work rate for the elements of a specialized task, performed under specified conditions, and to analyze the data in order to obtain the time required to perform the work with the defined level of performance.

One of the main precursors in efficiency and productivity in the history of the production was Frederic W. Taylor, who with his studies even in 1903, already showed the standardization of time and motion. In intensive pro uction systems in the use of hand labor, the time study is an important tool in setting the production capacity, according to. In this work we adapt the study of time and motion, with a focus on improving the productivity of the automatic process of unloading the ore by car dumper.

According to Naka jima (1986), TPM (Total Productive Maintenance - Total Productive Maintenance) is a revolu- tion, since it suggests the complete integration of man x machine x company, where the maintenance work of the means of production becomes the concern and action of Defect products. A machine always available and in perfect condition provides higher operating income, reduced man-ufacturing costs and reduced inventory levels. Improving the performance of work is indisputable. The silos of car dumper compose an important role in the process of unloading the trains loaded with ore iron. The constructive dimensions of silos restrict ac capacity maximum equivalent to load 4 cars and there to recommendation of the manufacturer in order to maintain the level within a range to prote? tion feeders and ockers.

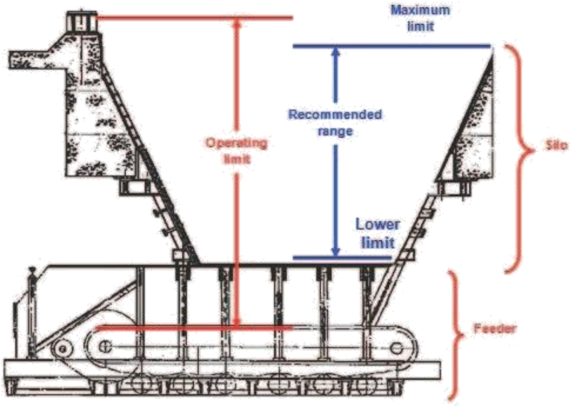

Fig. 3. LATERAL VIEW OF A SILO CAR DUMPER

As monitoring the levels of the silos are carried out manually by the operator through the supervisory system. The level of material in the silo and feeds the material outlet stream are process variables which vary throughout op- eration and require continuous monitoring, in accordance with Figure 4

Fig. 4. LEVEL AND FLOW CONTROL BY SUPERVISORY

A. Storage

The bins storage the car dumpers has the function of load during the discharge process to form a stock to maintain a constant load or with minor variations. The ability to storage the bins is 800 tons of iron ore. Figure5 illustrates a feeder conveyor car dumper.

Fig. 5. FEEDER CONVEYOR CAR DUMPER

VI. Degree of Belief X Probability Theory

At 80% of the time operated, the car dumper (VV-311K01) works below its rated capacity. A probability of 0.8 does not mean "80% true", but a degree of belief in the rule of 80% degree of truth x fuzzy logic.
The productivity of VV-311K 01 is low. The proposition is true for eff ective rate of 5,000 t/h? More or less, it is observed that there is no uncertainty, we are con the eff ective rate of VV-311K 01. The term "low" is vague, how to interpret it? The fuzzy set theory, fuzzy logic to semantics, allow you to specify how well an ob ject satisfies a vague description. The degree of membership of an object to a fuzzy set is represented by a number in [0, 1].
The conventional logic is yes or no, true or false, fuzzy logic now reflects what people think, tries to model our sense of words, decision making or common sense. Works with a wide variety of information and uncertain vacancies, which may rewritten by expressions such as most, more or less, perhaps, etc.

Before the emergence of fuzzy logic as this information had not be processed. The fuzzy logic includes as special cases not only binary logic systems, but also multi-valued. Set of mathematical principles for knowledge representation based on the degree of relevance of terms.

VII. System Modeling

The system was modeled to maintain an average yield desired by the user during the process of unloading the car dumpers according to the ore type, taking into account the physical and chemical . In this work we are considering two types of iron ores SFCJ and PFCJ with diff erent physical and chemical characteristics. As shown in Table I.

For each ore type has diff erent productivities, in this work we will cross the speed of conveyor feeders with the physical and chemical characteristics and observe the load was measured in the balance dynamic possessions of these data, we constructed the rules of the fuzzy system.

VIII. Fuzzy System Rules

The production rules of the knowledge base in the form of logical sentences of the type IF (condition is satisfied) THEN (action is executed or inferred) [23]. Rules con- structed to determine the desired productivity of SFCJ via a system using fuzzy logic Rules constructed to determine the desired productivity of SFCJ via a system using fuzzy logic, see below and Figure 6

1) If (speed is Extra) then (Productivity is Extra-Low;) If (speed is Very-Low) then (Productivity is Very- Low);
2) If (Speed-F-Conveyor is Low) then (-SFCJ Produc- tivity is Low);
3) If (Speed-F-Conveyor is more or less normal) then (Productivity-SFCJ is more or less normal);
4) If (Speed-F-Conveyor is Normal) then (Productivity SFCJ is Normal);
5) If (Speed-F-Conveyor is High) then (SFCJ is HighProductivity);
6) If (Speed-F-Conveyor is Very High) then (Productivity is SFCJ Extra-Low).

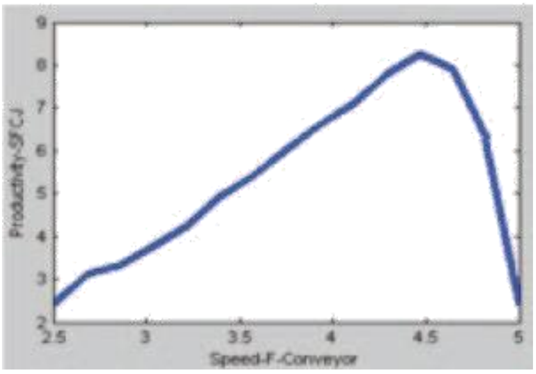

Fig. 6. Behavior of Productivity SFCJ

Rules constructed to determine the desired productivity of PFCJ via a system using fuzzy logic Rules constructed to determine the desired productivity of PFCJ via a system using fuzzy logic, see below and Figure 7

1) If (Speed-F-Conveyor is Ex-Low) then (Productivity is Ex-Low);
2) If (Speed-F-Conveyor is Very-Low) then (Productiv- ity is Very-Low);
3) If (Speed-F-Conveyor is Low) then (Productivity is Low);
4) If (Speed-F-Conveyor is M-L-Normal) then (Productivity is M-L-Normal);
5) If (Speed-F-Conveyor is Normal) then (Productivity is Normal);
6) If (Speed-F-Conveyor is High) then (Productivity is High);
7) If (Speed-F-Conveyor is Very-High) then (Productivity is High).

The results achieved in this work were carried out with simulations in Matlab, it was observed that in practice do not behave in a linear fashion, so we analyzed the results for the two types of ores and SFCJ PFCJ, we saw that for the behavior of PFCJ productivity was gradual until the feeder conveyor speeds of 4.5 meters per minutes, after which the rate exceeded 4.5 meters per minute, productivity began to decline to an unacceptable level, this was because when the index reached its maximum speed, ore was missing intermittently in the system, so that uploaded some instants in the system operated under vacuum. As for the PFCJ, we noted that productivity was also progressive, but more steeply to the feeders reach speeds of 4.5 meters minutes and after that exceeded the speed of 4.5 meters per minute productivity reached its maximum level and remaining linear.

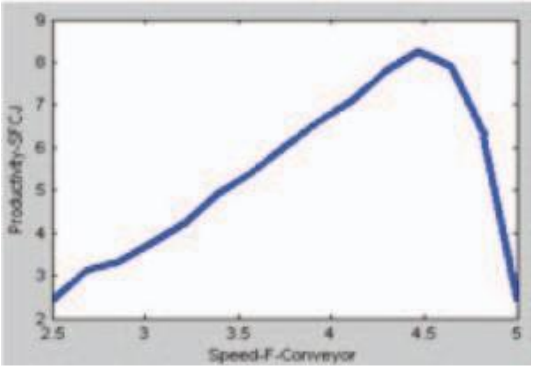

Fig. 7. BEHAVIOR OF PRODUCTIVITY PFCJ

Conclusion

According to the analysis results for SFCJ and PFCJ, leads to a very curious finding, because the density of the two types of ores are different, therefore the volume of PFCJ is much greater than the bulk of SFCJ with so when the speed of the conveyor feeders exceed 4.5 meters per minute SFCJ productivity decreases because the system runs on empty at intermittent intervals and the PFCJ remains at its highest level in a linear fashion, because the volume is greater for a SFCJ the same, however, the system does not work for PFCJ in empty with intermittent intervals. Therefore, it is concluded that fuzzy systems is a valid approach to the level of control in silos cars dumpers acknowledgment We Appreciate the company Vale S.A. by providing a car dumper and its employees specialists for testing and validation of this trablaho.

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