THE ROLE OF FUZZY LOGIC SYSTEMS FOR CONTROL OF THE PNEUMATIC VALVE OF BOTTLE WASHER IN BEVERAGE COMPANIES, SPECIFICALLY THE KRONES GROUP OF COMPANIES.

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ABSTRACT: Intelligent systems have greatly contributed in automating the process segments that includes the maintenance function in the manufacturing industries. The purpose of this research was to come up with an intelligent monitoring tool to reduce the number of breakdowns in Krones machinery (selected the bottle washer as a study sample). The objective of the research was motivated by an appreciation of considering Human Machine Interface (HMI) and automatic monitoring of the plant while in the office. The case of a local beverage manufacturer (anonymous) was used who has installed a bottle washer of this nature. The research entirely was centred on Krones machinery in order to model around similar operational conditions regarding their design orientation and function embedded within them. The Fuzzy Logic system was derived among other Artificial Intelligent systems to be best appropriate to solve the breakdown challenges automatically. Total breakdown of the bottle washer was realised at any time it would experience a minor failure. The bottle washer is complex so much that it is not easy to carry out a successful troubleshooting. For instance, the pneumatic valve could just stick and cause production to stop immediately. The researchers carried out a company audit, interviews and questionnaires in order to gather relevant data. Different data analysis techniques were used such as Ishikawa diagram. The results of which were used in intelligent condition-based-maintenance modelling to solve the problem using fuzzy logic system. MATLAB software was used as a means for data modelling and manipulation. The researchers recommend the use of this intelligent monitoring tool to all beverage manufacturers who have installed the krones machinery. This will increase productivity, reduce number of breakdowns, increase plant availability and lean maintenance will inevitably be applied to the bottle washer.

KEYWORDS: Condition Based Maintenance, Fuzzy Logic, Intelligent Monitoring, Krones Machinery

1.0 INTRODUCTION

The Krones Group, headquartered in Neutraubling of Germany plans, develops, and manufactures machines and complete lines branded as the Krones for the fields of process technology, bottling, canning and packaging and intra-logistics. Every day, millions of bottles, cans and specially-shaped containers are "processed" on lines from Krones; particularly in breweries, the soft-drinks sector and at still-wine, sparkling-wine and spirits producers, but also in the food and luxury goods sectors, as well as the chemical, pharmaceutical and cosmetic industries. Since being founded in 1951, the Krones Group has evolved far beyond its original role as a mere producer of machinery and bottling lines. The company has meanwhile become an "all-round partner" for its customers, creating harmonious, optimized synergies of mechanical engineering, line-related expertise, process technology, microbiology and information technology. Today, Krones is synonymous with "systems engineering". (krones.com, 2012)

Maintenance of equipment is a very vital activity among other process segments. Downtime is one of the most costly conditions a manufacturer can reluctantly experience. A proactive technical support program which can generate significant cost savings can be developed. Continuous-monitoring services can also generate cost savings by protecting existing investments.

The case study (anonymous) that the researchers used refers to a Company that installed the Krones machinery. A cleaning machine is used to ensure that any bottles being filled are free from contaminants. Bottles are washed both inside and outside and then dried by the bottle washer as shown in Fig 1.1 that follows. The parameters in this machine can be accomplished in monitoring by using an Artificial Intelligent system. Temperature variations that come from the boiler might cause some problems to the bottle washer, so control and monitoring devices like the POKA-YOKE system can be used to control how hot and how cold the water is before entering the machine. This is a proactive type of maintenance to prevent breakdowns and unnecessary shut downs doing crisis maintenance.

Fig 1.1: Krones group of companies' bottle washer (krones.com, 2012)

2.0 CONDITION BASED MAINTENANCE MOTIVATION

2.1 CBM as a subcomponent of RCM

CBM is enabled by the evolution of key technologies, including improvements in sensors, microprocessors, digital signal processing, simulation modelling, multisensory data fusion, and automated reasoning. CBM involves monitoring the health or status of a component or system and performing maintenance based on that observed health and some predicted Remaining Useful Life (RUL). It is a subcomponent of Reliability Centred Maintenance (RCM).

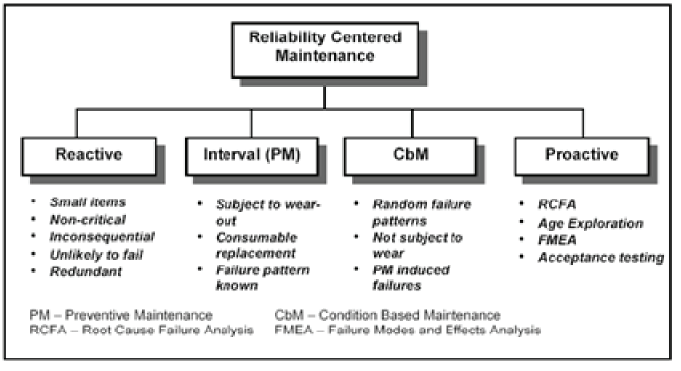

Fig 2.1: Components of an RCM diagram. (RCM php, 2012)

2.2 Failure Patterns

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Fig 2.2: Stan Nowland and Harold Heap Curves [3]

3.0 RESEARCH METHODLOGY

Measuring knowledge management is a critical basis for developing incentives for further stimulating knowledge sharing and networking on local and global levels. Without ability to quantify, measurement endeavours remains elusive. Further, it is critical to ensure that existing knowledge assets are constantly challenged in a purposeful way. Especially in the current Internet Age, where today's core competencies quickly turn into tomorrow's core rigidities, it is incumbent upon companies to ensure that the knowledge they nurture inside is still relevant to the market thus, the need to explicitly address the issue of developing metrics and incentives for knowledge management.

The following tools were then used to carry out the research by the researchers.

a. Company visits (anonymous company in Harare, Zimbabwe which bought krones bottle washer from Germany)
b. Ishikawa diagram (Root cause analysis) using EDRAW MAX SOFTWARE (Finding the reason why a certain problem persists)
c. MATLAB software (Input data, model and simulate fuzzy logic systems)

4.0 FINDINGS

4.1 Human Machine Interface

The user interface, in the industrial design field of human–machine interaction, is the space where interaction between humans and machines occurs as shown the framework of Fig. 4.1. The goal of interaction between a human and a machine at the user interface is effective operation and control of the machine, and feedback from the machine which aids the operator in making operational decisions. (Wikipedia.org., 2012)

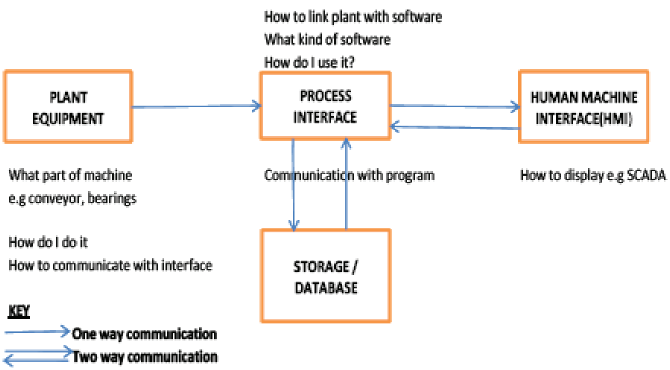

Fig 4.1: Human machine interface

4.2 Root Cause Analysis for the Bottle Washer

The pneumatic valve often sticks at start-up. Slack chain will cause uneven entry of teeth through the gears and overload occurs. This is shown in Fig 4.2 with identified problems using the Ishikawa diagram.

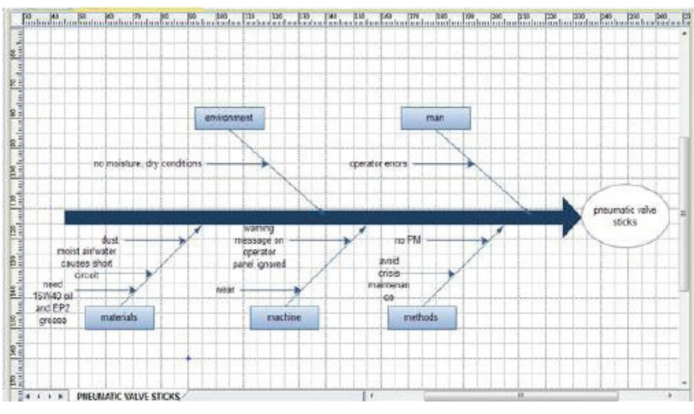

Fig 4.2: Ishikawa diagram for pneumatic valve sticking

The researcher identified that the foreign materials like moist and dust that enters the bottle washer need to be removed from the washer to prevent sticking of the valve.

4.3 Intelligent System Option Modeling

A.W Labib et al stated that, one of the major problems in maintenance practise is the lack of systematic, focused and adaptable approach in setting Preventive Maintenance (PM) instructions. Hence PM instructions tend to be static, and not adaptable to changes in the shop floor. Maintenance criticality and fault analysis is of concern. The fuzzy logic rule based [FLRB] seeks an efficient approach to specify the most appropriate maintenance action to follow based on different rules. Fuzzy logic is used to determine the most efficient actions to be undertaken to overcome these faults.

Maintenance as a function, compared to other areas in operations, is considered to be of a fuzzy nature. When dealing with ambiguous data, desktop fuzzy-logic applications deliver precise results. Fuzzy logic is a branch of artificial intelligence (AI). Technically, fuzzy control system is a control system based on fuzzy logic , a mathematical system that analyses analog ue input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false respectively). (sccs.swarthmore.edu, 2012)

Some other components besides Fuzzy Logic of AI are Genetic Algorithm, Artificial Neural Network, Expert Systems (Rule Based Reasoning and Case Based Reasoning). Table 4.1 shows how the researchers selected the Fuzzy logic system and why it was used in this research ranked against the expected operational attributes.

Table 4.1: Matrix to select AI systems when doing maintenance [6]

Intelligence tool	Response time	Scalability	Flexibility	Ease of use	Embedability	Processing overhead	Expert Dependence	Tolerance for dirty data	Implementation speed	Tolerance for complexity	Accuracy
Genetic algorithm	H	L	L	L	H	H	L	-	H	H	H
Neural networks	H	M	L	L	M	L	L	H	M	H	H
Fuzzy logic systems	H	L	M	H	M	H	H	H	H	M	M
Rule-based systems	X	L	M	H	H	M	H	L	H	M	H
Case based reasoning	L	H	L	M	M	H	L	H	M	H	H

Legend:
H = High; L =Low; M = Medium;
X = Deteriorates as the number of active rules grows

Fuzzy Logic control of the bottle washer was then modeled using available software namely MATLAB among other suitable software.

5.0 FUZZY LOGIC CONTROL OF BOTTLE WASHER USING MATLAB

The researchers investigated on the acceptable values of moisture in air that does not affect anything as follows.

a. 0-5% as the whole range
b. 0-1% low
c. 1-3% acceptable vapour in air
d. 3-5% high (wikianswers.com., 2012)

Dust has the following values that are acceptable and not acceptable.

a. 0-1% as the whole range
b. 0-0.02% perfect
c. 0.02-0.5% better
d. 0.5-1% bad (ehow.com., 2012)

The valve has to open and close and only opens at 100% otherwise it will be closed. The given parameters were used to determine whether to allow the entrance of particles or not.

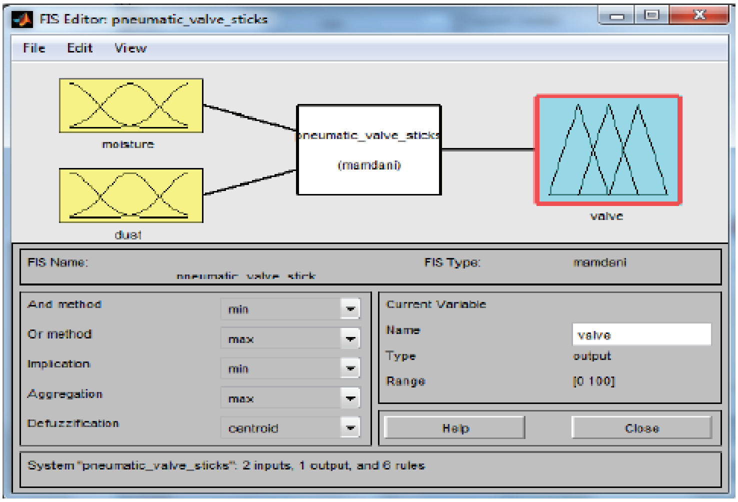

Fig 5.1: Fuzzy Inference System (FIS) Editor

Fig. 5.1 is the first stage in fuzzy logic followed by the membership functions that are also shown in
Figure 5.2-4.

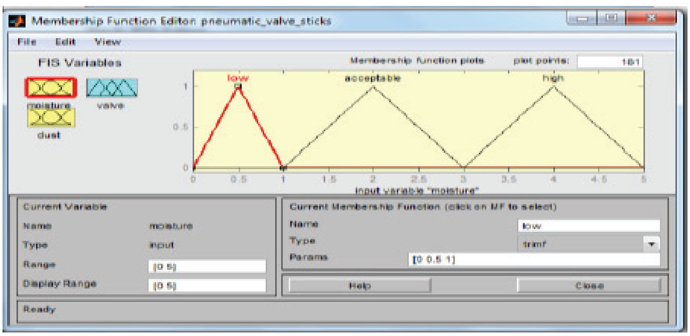

Fig 5.2: Membership function editor for the pneumatic valve in moisture control

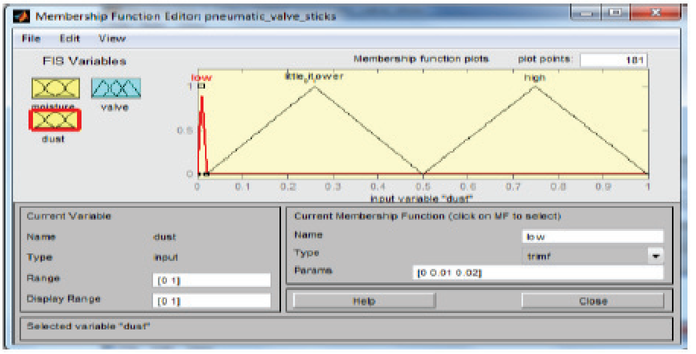

Fig 5.3: Membership function editor for the pneumatic valve in dust control

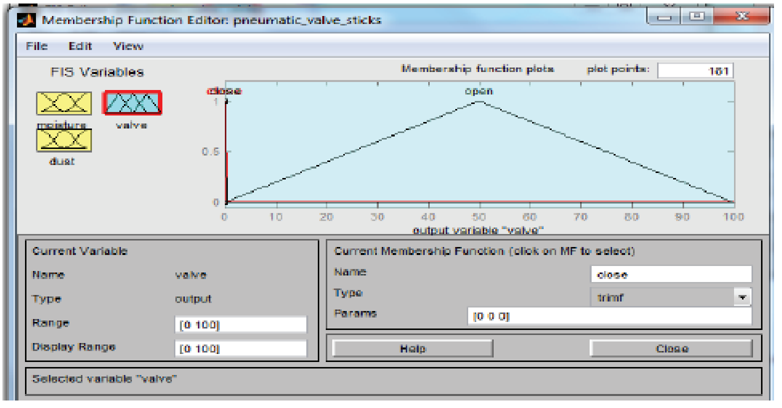

Fig 5.4: Membership function editor for the pneumatic valve in valve control

Fig.5.5-9 are the viewers of the critical components as follow.

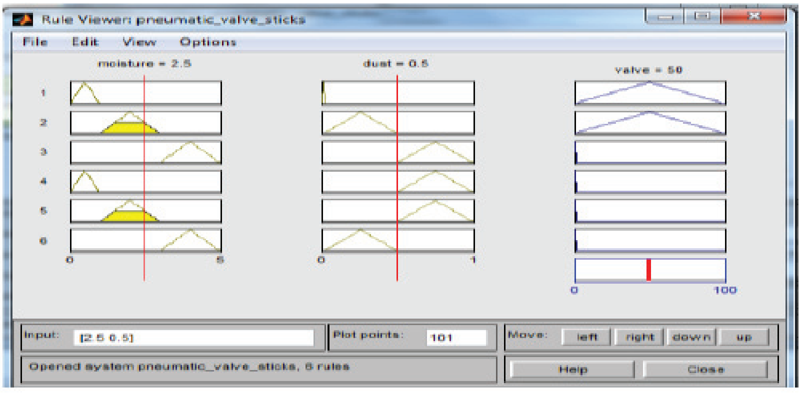

Fig 5.5: Rule viewer for the pneumatic valve in controlling moisture and dust.

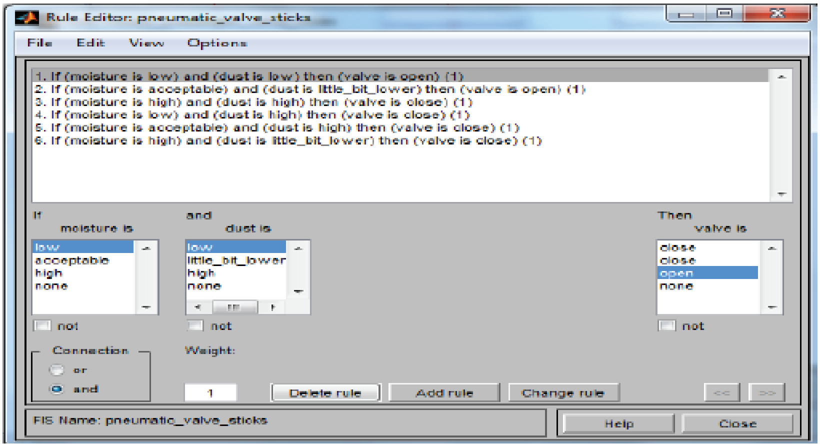

Fig 5.6: Rule editor for the pneumatic valve in controlling moisture and dust

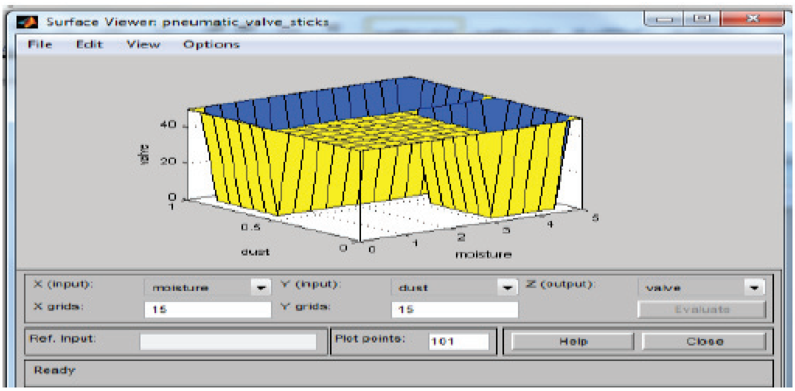

Fig 5.7: Surface viewer for the pneumatic valve

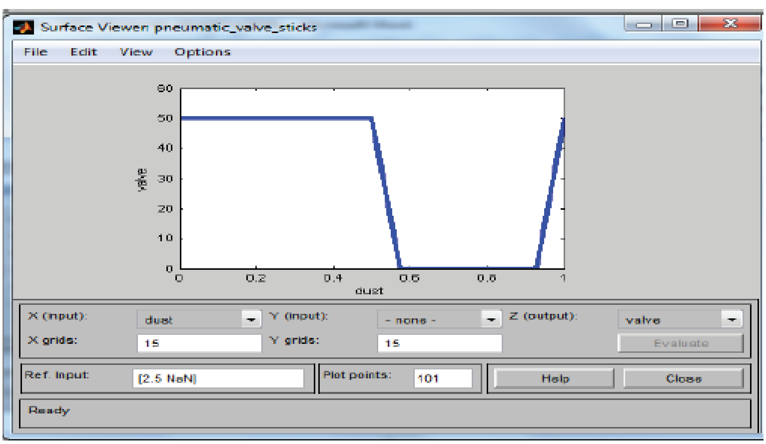

Fig 5.8: Surface viewer for valve and dust.

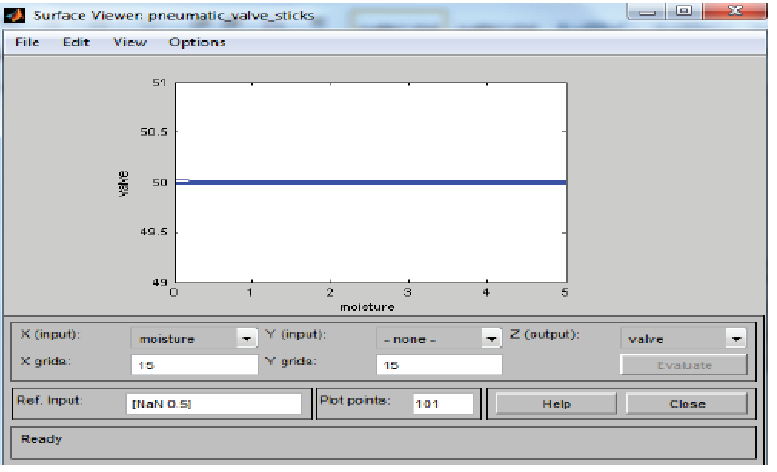

Fig 5.9: Surface viewer for valve against moisture

Using the two figures 5.7 and 5.8, analysis can be done and conclusion can be made.

6.0 INTEPRETATION OF RESULTS

Valve remains open at 50% from the value of dust 0 – 5.5%. Valve starts to decrease the value of opening percentage from 50% to zero in the range of dust from 5.5% - 5.75%. The valve remains closed up to 0.95%. The valve starts to open again from zero to 50%. This shows that at 5% level of moisture and below the pneumatic valve will not be affected at short term levels and it will remain safe.

Dust at above 0.95% will affect the pneumatic valve and must be blocked by the matlab software with fuzzy logic to prevent entrance into the bottle washer and hence proactive maintenance in an intelligent way. Dust can be controlled by the fuzzy logic control and hence the pneumatic valve is protected from sticking. The research objectives were met in that no accumulation of dust will still occur in the valve. The result is positive and was necessary to do. If the krones machinery are installed with this Fuzzy control system for CBM, a large improvement will be made in the productivity and reduction of unnecessary costs. Generally the MATLAB software is not expensive to buy. It costs US$149.45, especially the R2010b model. (softapplications.com., 2012). Installation and implementing might be generally expensive including paying the expert to do the job and leave everything functioning but it will pay back in approximately less than two years and this system will work for longer. Quattrocchi of Dow Agrosciences (2004) said “Pay me now, or pay me more later”, by this comes the concept of using proactive intelligent maintenance. If money is used in the beginning without hesitating, that means a lot is to be produced in the future. MATLAB software once installed will not have some problems and can work 24 hours non-stop for more than 10 years.

7.0 CONCLUSIONS

Dust must be maintained at a percentage below 0.5% to avoid sticking of the pneumatic valve. Moisture does not have any effect to the valve at below 5%. Intelligent maintenance will be done in this way. The intelligent systems will have to work hand in glove with the Supervisory Control and Data

Acquisition (SCADA) for monitoring the on-going of the plant while one is in the office. Presently the world has enormous advancement in science and technology. The area covered by the researchers is just a drop out of an ocean of knowledge. In the present scenario if we think of life without a computer then it is very difficult for any firm or organisation to survive in the market. Higher product quality, better reliability, better availability of plants, optimisation of cost and choosing right maintenance procedure is the chief concern nowadays. Generally, the production and maintenance task are going simultaneously, nearly 40 to 45% of production cost generally goes to the maintenance work. Hence, there is a lot of scope to minimise the maintenance cost. This Fuzzy Logic monitoring system that was modelled with MATLAB is an intelligent monitoring system framework that uses fuzzy logic for plant maintenance. Line utilisation will be improved and plant availability. Objectives and aims of the researcher were thus achieved in order to suggest a better way to avoid frequent breakdowns to the bottle washer. The researchers recommend the use of this model for all beverage companies, beverage companies should also be able to use the latest Siemens programmable logic controllers with Simatic SCADA for the intelligent monitoring to be done at advanced level without some interruptions and also to continuously upgrade the software as they use it. Expert and trained engineers must be used for the installation.

8.0 REFERENCES

www.krones.com[Accessed 20/02/2012]

www.sccs.swarthmore.edu/users/[Accessed 22/02/2012] http://www.wbdg.org/resources/rcm.php[03/03/2012]

http://en.wikipedia.org/wiki/User_interface [Accessed 18/7/2012]

http://www.strano.net/wd/fm_fz/fuzzy001.htm

www.springerlink.com [Accessed 7/06/2012]

wikianswers.com/Q/watervapourinair [Accessed 30/05/2012]

www.ehow.com>eHow>Home Maintenance & Repair[Accessed 03/06/2012]

http://softapplications.com/browse/search/?q=matlab&cpn=med_uchile_sf_14