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Proposal For The Wear Analysis Of Metallic Material Cutting Tools

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ABSTRACT:
A research is presented to perform a wear analysis of industrial cutting tools, dedicated to the conversion of flat metal-mechanical materials in industrial parts, detailing the production costs, time, functions, training and bibliographic material necessary to implement it as a model to be followed in this type of companies. The wear analysis will be carried out by means of artificial intelligence techniques which will allow to know the useful life time of the blades used in hydraulic shears and benders. The aim is to reduce the costs and the final production time of the parts, as well as to improve the quality by making adequate cuts and bends. The results will allow to know when preventive or predictive maintenance should be done, avoiding the subjective value that an operator can give, which can cause disturbances in the production line when errors are detected in the finished parts. A review of the literature is carried out to determine the factors that affect tool wear, and suggestions are made as to how the cutting and bending process can be improved.

Keywords: tool wear, production, shears, hydraulic shear, hydraulic bender.

1. INTRODUCCION

In industrial processes where metal materials must be cut, it is important to know the useful life time of the cutting tools, because it causes deformations and imperfections in the final product and the costs increase for the company. It is not only the increase in production costs, which may involve more at first, but also the quality of the product delivered to the customer, because the parts or products are part of a chain that includes a final product, which can deteriorate the entire production chain of the company.

When a piece presents deformities, it cannot be delivered and once it has been cut or bent, its price drops notably, because the material practically has to be discarded and used as scrap material, even if it can only be used for sale as scrap. This implies an enormous economic loss, in addition to the production time and employees who perform this function.

The tool supervision system is carried out manually by the operators, who little by little let the different defects pass, without giving adequate notice for their change. This is due to a lack of control in the amount of cuts and bends that the machines must perform, because there is no specific amount for the proper change.

The research focuses on the wear of the shear blade, which, when deteriorating, can reduce the tool life. Factors influencing life can be the geometry of the blade, the materials to be cut, and the coating (Bray, 2019; Trejo et al., 2007), all of which focus on the blade. When designing a blade, it must be taken into account which materials are to be cut, the direction and the finish of the part, that is why a diagnosis of the materials being cut and the blade material must be performed; to determine the influence on wear. As for the blade material, it should always be harder to extend the life of the tool; it may also be the case that a coating must be used on the blade when harder materials that can generate more heat must be cut (Bolufer, 2014; Glatz et al., 2017; Navarro-Devia et al., 2017). Another important factor is the maintenance to the machine or cutting tool which can overload the blade, if not done at the right time. One of the best maintenance techniques known as Failure Mode and Effect Analysis (FMEA), which seeks to perform preventive and predictive maintenance, can be applied using visual techniques without the frequent human error (Sosa et al., 2018).

Regarding the bending machine, it is important that the angles of the bends are accurate so that it can fit into the specific configurations desired by the customer for the manufacture of the final products, a shod bends, in addition to the economic loss can alter the final piece (Arzola et al., 2007; K et al., 2018). For this purpose, processes similar to the cutting tool will be carried out but focused on the bending that allows extending the useful time.

The techniques employed to improve quality and timely blade change are based on machine vision techniques in the spatial domain. These techniques have been employed for tool wear in turning operations and roughness quality of parts. The co-occurrence matrix is one of the most widely used (Alegre et al., 2008; S. A. Suárez Castrillón et al., 2009), which allows determining wear times through a supervised classification by discriminating patterns in the image through the co-occurrence of shades of gray present in it by differentiating the texture (Morala-Argüello et al., 2009). Laws descriptors also offer a form of discrimination to determine wear, which is why they are used by applying filters where the image is convolved (Alegre et al., 2012; A. M. Suárez Castrillón et al., 2011). Nowadays, parts generated by chip removal are obtained by machining operations, in which important parameters are present (cutting tool life, insert performance, cutting speed, cutting fluid, tool feed and surface roughness) to obtain optimal finishes in the chip removal processes. These parameters are of great importance for manufacturing processes in today's metalworking industries.

Therefore, industries seek to minimize processes, which involve continuous improvements in production times and costs, hence the importance of studies that cover these processes. Some machining operations are studied by different authors. As shown below.

In preliminary studies (Alves et al., 2011) evaluate surface roughness through an image, by means of a Haralick descriptor system that feeds a neural network that facilitates the recognition of surface roughness.

Similarly, Flórez et al. (2011) present a softcomputing technique that generates a predictive pre-process model of surface roughness, based on experimentation with different characteristics of the high-speed milling process.

It should be said that Francisco et al. (2013) establish the relationships between cutting conditions (cutting speed Vc and feed rate Va) and roughness, developing second order mathematical models while Moises and coworkers (Hinojosa Rivera & Reyes Melo, 2001) discuss the importance of roughness measurements and the most common techniques to record topographic profiles.

With respect to the above (López Guerrero et al., 2003) proposes a method based on the decomposition of roughness in terms of frequency analysis, in order to identify tool marks on a machined surface.

A review of the literature is carried out to determine the factors that affect tool wear, and suggestions are made as to how the cutting and bending process can be improved. The analysis is performed by extracting the information present in the images, with which it is necessary to normalize the data for greater robustness of the tests. At the end, the project is documented with the necessary information data through the publication of scientific articles or information documents for the company, thus creating a proposal that can serve as a model to be implemented.

2. METHODOLOGY

Different phases will be developed, ranging from the test of operations on the machinery, to achieve a proper configuration of the cutting and bending processes, then the image of the tools and their wear according to different configurations is captured, then it focuses on the phase of capturing the image with different lighting angles, allowing to create a vector of features extracted from the images for processing. Subsequently a supervised classification test is performed, with the help and experience of the company HEP, which have the appropriate knowledge for the useful life of the tool. Recognition techniques and feature extraction in the frequency domain will be applied, in order to find the most appropriate for a good discrimination. Then the data analysis phase is performed, where the wear values are determined to know when to change or maintain the tool or machine. Once the results are available, a review of possible repositories for publication is carried out, as well as the creation of documents to reflect and consolidate all the results, which is the most significant phase for HEP and the researchers. The phase of publication of results will allow finalizing the execution of the project by mediating the published documents. The analysis will have a quantitative approach where the information provided by the different devices must be standardized, the objectives are:

- Determine the service life durability of blades on hydraulic shearing and bending machines.
- Perform digital wear recognition of cutting tools.

- Determine the cutting irregularities in the material to determine the appropriate tool change time.

3. RESULTADOS

The activities to be implemented are:

I. Operational tests
II. Digital image capture
III. Information extraction
IV. Classification test
V. Data analysis
VI. Document development and repository analysis
VII. Publication of results

The description of activities is detailed in Table 1, with an estimated time of one and a half years, which may overlap according to production problems.

Table 1. Description of activities

	MESES																	
A	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
I	X	X																
II		X	X	X	X													
III					X	X	X											
IV							X	X	X	X	X	X	X	X				
V							X	X	X	X	X	X	X	X	X	X	X	X
VI									X	X	X	X	X	X	X	X	X	X

Table 2 shows the products that lead to the improvement of the national scientific capacity, which may include projects, graduate work, research networks and cooperation between research networks; in this case, the training of human resources in the company is presented, as well as the verification of criteria based on the standard. Table 3 allows the transfer of knowledge to society or the company in a specific way, including joint actions such as the creation of manuals, guides, videos, presentations at events; in this case, the most important thing is the creation of a booklet indicating the standards to be followed. The impacts at the end of the project may be social, economic, productivity and competitiveness, which should begin to be realized after 2 years of the project (Table 4).

Table 2. Conducive to the strengthening of national scientific capacity

Expected result/output	**Indicator**	**Beneficiary**
Training of human resources in the management of the HEP enterprise system.	Certificate	HEP
Verification of the criteria of the standard	Wear tests	Scientific community

Table 3. Social appropriation of knowledge

Expected result/output	Indicador	Beneficiario
Presentations at events	Certificate	Scientific community
Primer for HEP	Certificate	Company and Scientific Community

Table 4. Expected impacts after project completion

Impacts	Deadline	Indicator	Assumptions
Social	2 years	Physical document	Perspective of the attrition criterion
	2 years	Physical document	Universities involved, author and scientific community
Economic	2 years	Machining times	Reduction of the cost of the machining process. metal-mechanic sector
		Decrease in the cost of the machining process	Reduction of the cost of the machining process. metal-mechanic sector
Productivity	2 years	Machining Times	Increasing productivity in the metal-mechanic sector
Competiveness	2 years	New analysis developments	Increasing productivity in the metal-mechanic sector

The budget is the criterion that takes more strength at the time of making the proposal and approval, where the value of the personnel by the university and the external company must be included, the items must be specific for subsequent disbursement and support of expenses (Table 5). The description of the personnel according to their function and weekly time is important for the payment of the hours and academic discharges or permission to perform different functions in their work focused on research (Table 6), likewise the expected impacts must be determined according to the call (Table 7).

Table 5. Global budget of the proposal (in Colombian pesos)

	Items	Sources		Total ($)
		University ($)	External ($)	
1	Staff	**6000000**	**25000000**	**85000000**
2	Equipment to be purchased			
3	Equipment for own use			
4	Software			
5	Travel	**1500000**	**1500000**	**3000000**
6	Field trips			
7	Materials and supplies		**30000000**	**30000000**

8	Technical and technological services			
9	Bibliographic material			
10	Patenting expenses			
11	Dissemination and promotion material	**2000000**	**2000000**	**4000000**
12	Equipment maintenance		**500000**	**500000**
13	Seminar and course logistics			
14	Infrastructure adjustments			
15	Administration			
	TOTAL ($)	**63500000**	**59000000**	**122500000**

Table 6. Staff description

# Researcher	Role	Project Responsibilities	Dedicated in months	Dedication Hour/week (work)
1	Principal Investigator	General Project Management	18	8
2	Co-Investigator	Project development	18	2
3	Co-investigator	Information analysis consulting Matlab	18	2
4	Co-investigator	Consulting in information analysis Cutting tools	18	2

Table 7. Expected impacts

Expected impact	Time frame (years) after project completion: short (1-4), medium (5-9), long (10 or more)	Verifiable indicator	Assumptions
Reduced product delivery time	Short	HEP Statistics	Proper use of systems
Reduced production costs	Short	HEP Statistics	Proper use of systems

Table 8 shows the description of the individual budget according to the time of dedication and specific function, and Table 9 shows the materials to be used, the justification and the institution or company that will be in charge of contributing to the budget.

Table 8. Budget description

# Researcher	Academic background	Function	Dedication Hours/week	Resources Counterpart	Total

				Cash	Species	
1	Systems Engineer	Capture of digital image samples	4		2000000	2000000
2	Mechanical Engineer	Machine operator	4		2000000	2000000
3	Systems Engineer	Data analysis	4		2000000	2000000
TOTAL						6000000

Table 9. Materials and supplies

Materials and supplies	**Justification**	**(cash)**	**Resources Counterpart**		**Total**
			Cash	**Species**	
Blade grinding for bending machine	It must be rectified so that it continues to bend the materials well, accurately, without leaving a gap.		14000000		
Grinding of cutter blades	It must be rectified so that it continues to cut the materials well, accurately, without leaving a gap and without leaving shavings.		16000000		
TOTAL					3600000

4. CONCLUSIONES

The research presents a referential framework of budget, time and functions of the researchers, and support material for companies engaged in the cutting of metallic materials, so that they can anticipate possible failures of the cutting tool, and avoid the possible stoppage in production, with the loss that can cause directly and indirectly, finally it aims to be a guide to follow in companies in the region of Norte de Santander.

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