DIAGNOSIS OF GEOMETRICAL DEFECTS AND REBUILT METHOD OF MACHINE-TOOLS ACCURACY

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Abstract. Today companies are, more than ever, faced to steady growing competition and must produce higher quality at lower costs [1].

However in industry machinery are used and suffer of accuracy, dysfunction, loss of performance, etc. These affect heavily the costs of production and hence increase sales prices.

In this work, it has been proposed to the maintenance services, a tool which helps to diagnose the geometrical defects of a machine tool and a scrapping method to recover its original geometry, hence leading to working accuracy and good performance.

Once the execution of all the necessary steps to rebuilt geometry, done. The reshaped machine will recover the optimum machining delays, operating costs, and its minimum waste production.

This study was realized between the mechanical engineering laboratory at Mentouri University and the Algerian machine-tools and equipments ALEMO, subsidiary company of the National Enterprise for Machine-tools production located in Oued Hamimime, Khroub, Constantine, Algeria.

Keywords: loss of performance, accuracy, geometrical defects, maintenance, geometrical rebuilt, diagnosis help tool

1. Introduction

Old generation machine-tools are sometimes better for some machining operations. For example; in milling operations it is preferable to use conventional milling machines with flat guide ways and gear box in order to take out ticker ships from hard material. Most users are perfectly aware of the advantage of old conventional machinery. That’s why there will always be a demand on this kind of machines.

Because of their strong structure, and once they reach the critical point in ware and loss accuracy, renewing of old machinery is always profitable.

The equation is very easy to solve, a renewed machine which acquire the same characteristics of a new machine will cost to be reconditioned one third of the price of new one.

Reconditioning of machine consists of dismantling all machines apart, check all parts and recondition or change with new ones.

In fact a complete reconditioning of an old machine can only be advised if the machine has reached a point of degradation and ware and usual maintenance service or repair can no longer do any good [2].

This type of machine tools are particularly interesting in tooling workshops where operations are specific in low batch and workers are used to these kinds of machines and know very well how to use it. This study aimed equipment of universal technology which was manufacture in 1971, and has a main position in process of manufacturing [3].

The obsolescence, ware and geometry defects generate cost which rise from one year to the other. To illustrate all the previously presented things, it has been proposed to take the case of production equipment “Lathe Pittler PDR250” belonging to the “Complexe Moteurs Tracteurs” production workshop, which was successfully renewed.

2. Life cycle of machine

Means of production are, same as all kind of tools or measuring instruments, subject to variation’s factors due to their use. Beside this, machines are sometimes solicited above their capacities and sometimes in severe conditions which are not recommended. Geometric defects up rise [2]. These defects influence performance and precision of machines.

The study parameters of the dependability (years 2006-2010) is calculated by the function R(t) = $e^{-\lambda t}$. It is evaluated by a probability calculation of a failure rate λ which is represented by a bathtub curve, Figure 1. It has been noticed that progressive increase of failure corresponds to age of machinery and a drop down in reliability [4]. This situation will lead to serious wear of machine organs and subsequently to important damage of structure and a high reliability failure rate. To correct this, machine will need a rebuilt of organs and a geometrical alignment.

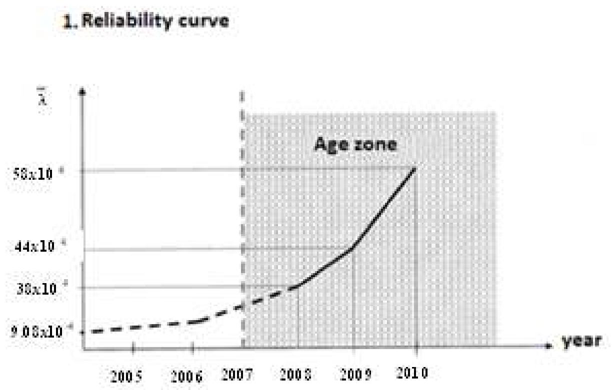


Figure 1. Reliability curve of LATHE PDR250

3. Maintenance Indicators

The maintenance table is a management tool based on measures and oriented towards action [5]. It is also a steering instrument, Figure 2. It gathers in a synthetic form all relevant indicators and it is shaped so as to show evolution of maintenance function. Each indicator in it must be compared to an 'objective' value.

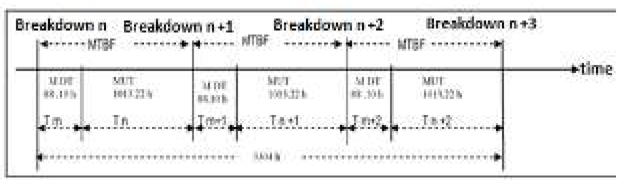


Figure 2. Frequency of machine breakdown (MDT: *Mean down time*; MUT: *Mean up time*; MTBF: *Mean time between failures*)

The fundamental indicator is the MTBF (Mean Time between Failures).

This is measurement of the mean period of time between two breakdowns which gives the level of non-disruption of system function [5].

Let's consider a machine-tool which has 03times/year (3P/yr) breakdown frequency.

For a breakdown frequency of three times a year, the MTBF Referential is:

$$MTBF_{Réf} = 1101.33 \text{ hours} \qquad (1)$$

Which correspond to a Referential of failure rate $\lambda_{Réf}$ (target of maintenance services (DMI)) is equal to MTBF $^{-1}$, thus:

$$\lambda_{Réf} = 1/1101.33 = 9.08 \times 10^{-4} \qquad (2)$$

3.1. Unavailability curve

Availability assessment gave the look next, figure 3.

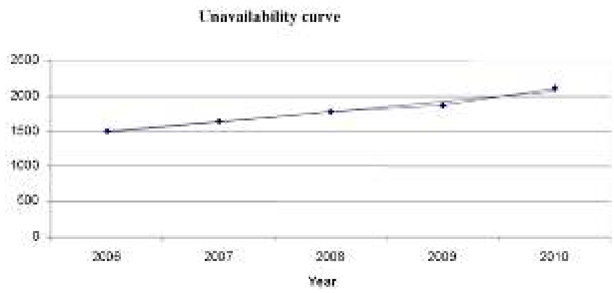


Figure 3. Unavailability curve

The reading of this curve shows an increase of unavailability which leads to an idle production time, figure 4.

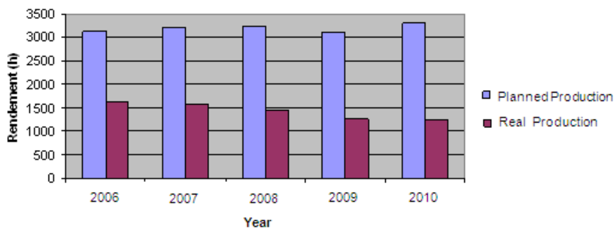


Figure 4. Production curve

3.2. Idle rate curve

The Reading of this drawing, figure 5, shows an increase in idle time due to cumulated breakdown time registered. It is unproductive lost time, which has negative economical consequences (see Table 1 and Table 2).

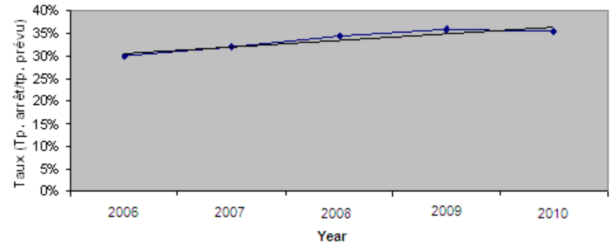


Figure 5. Expansion rate

Table 1. Major Production Costs (in Euro)

Year	Labor cost	Overtime Work cost	Re-machining Cost	Cost of junk	Setting Cost	Sub-contracting Cost
2006	9.10	2330	1365	728	1638	2994
2007	9.10	2530	1820	818	1911	3094
2008	9.10	2730	2093	910	2184	3194
2009	10.24	3072	2355	1228	2703	3400
2010	10.24	3572	2560	1741	3072	3600

Table 2. Major Maintenance Costs (in Euro)

Machine Idle Loss	Labor cost	Spare parts Cost	Total	Planned production cost	Over costs rate %
8563	992	41	18 652	28 537	65.36%
9382	514	256	20 326	29 393	69.15%
10146	771	384	22 413	29 538	75.88%
11479	149	62	24 450	31 969	76.48%

3.3. Cost curve

The analysis of this curve, Figure 6, shows a rapid increase in over costs, a major loss due to waste production and parts re-machining.

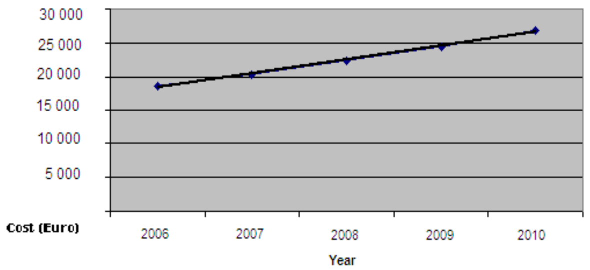


Figure 6. Increase of the costs

3.4. Global analysis Results

All results of analysis lead to the following:

- Age of equipment ⇨ Old
- Level of technology ⇨ Traditional
- Capacity ⇨ Short
- Rate of production ⇨ Low
- Added value ⇨ High
- Sub contracting work ⇨ Important
- Maintainability ⇨ Difficult, Expensive
- Condition of repair ⇨ Special
- Break down rate ⇨ Important
- Breakdown Frequency ⇨ Frequent
- Time of repair ⇨ Important
- Type of equipment ⇨ Specific
- Type of failure ⇨ Wear & Oldness
- Junk ⇨ Important
- Means of production ⇨ Specific & Expensive

In this study we tried to show, that based on the use of the 'Diagnosis help tool' which we developed [6] and the method of geometrical rebuilt of machines, the performance of the lathe PITTLER PDR250 N°1627 was recovered. The lathe was rebuilt and its geometry alignment done, hence its performance went back to normal.

However if rebuilt and alignment work has not been done on the machine. Situation would have lead to rapid increase in losses due to waste production, constant re-machining for parts recovery, and finally to a complete stop of machine work (see Table 3 and Table 4).

Table 3. Production Times

Year	Running time (h)	Settings		Control		Re-machining time (h)	Junk time loss (h)
		No. of time	Time (h)	No. of time	Total break down time (h)		
2006	194	36	180	100%	110	150	80
2007	196	38	210	100%	120	200	90
2008	186	40	240	100%	144	230	100
2009	189	44	264	100%	180	230	120
2010	280	50	300	100%	200	250	170

Table 4. Maintenance times

No. of break downs	Idle time	Idle rate %	MTBF	Failure rate λ (10^{-4})	Total idle time	Running time rate %	Performance (%)
			1101.33	9.08			
			1101.33	9.08			
11	941	30.01	285.09	35.1	1505	69.99	52.01
21	1031	31.92	153.80	65.0	1647	68.08	49.01
39	1115	34.35	83.23	120.1	1785	65.65	45.01
24	1121	35.91	130.08	76.9	1874	64.09	40.39
16	1165	35.26	206.05	48.5	2115	64.74	37.77

Remark: A general rebuilt of parts and a geometrical alignment is necessary.

4. Geometrical control

The general principals of geometrical control applied to machine tools are originally based on the need to establish suitable conditions which can be used by builders of machines and also users.

The need to fix reliable data and techniques to base on tests of machine tools has been developed with growing business and transfer of machines between countries.

To answer this need, the International Standard Organization (ISO) has published a code of testing procedures to check quality and accuracy of machinery.

However the general information does not apply to all categories if machine-tools. And in any case do never accept that quality and precision of testing devices be less than twice the one of the value to be checked [6].

4.1. Presentation of diagnosis help tool

4.4.1. Name of tool: The 'Diagnosis Help Tool' has been named «Calicontrôle» for a simple reason is to show the importance of calibration and control in machines-tools.

4.4.2. Definition and Target: Calicontrôle is a tool which allows localization of surfaces related to loss of geometrical performance which was shown during geometrical testing of machine. The proposed method that links geometrical test results to corresponding causes and failures and propose localized solutions.

The implementation of this method is shown on an Industrial example using the test results of roundness, flatness, alignment and straightness.

The target of Calicontrôle is to localize surfaces presenting serious failure and proposes solutions as where and how to fix these abnormalities.

In the content of Calicontrôle, pictures of different steps of testing on real machines are shown and also simulations of testing operations done using software CATIA V5 [7, 8], Figure7.

Figure 7:Tool interface

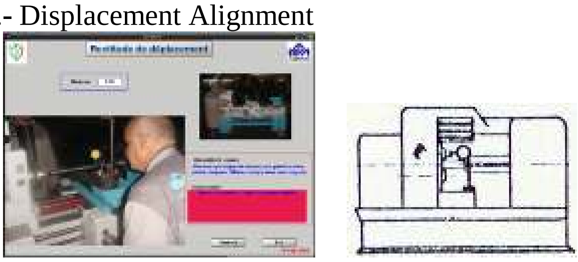
For security purpose a name and password has been set.

Once name and password have been introduced and validated, a series of different machine-tools will show, and then one can choose type of machines to be tested (lathe, milling machine, etc.).

4.2. Application on machine Lathe Pittler PDR250

First a geometrical control of equipment must be done [9]. This test has been simulated using the 'Diagnosis Help Tool' for geometrical defects analysis of machine tools called «Calicontrôle» [10]; as it is going to be shown, all results of test protocol will be out of a standard which means a geometrical rebuilt is necessary. The different steps of control are as follow:

1.- Displacement Alignment



2. - Alignment

3. - Shaft alignment

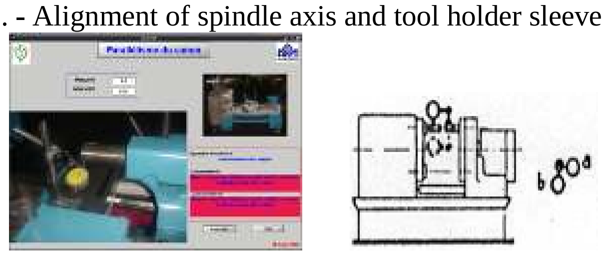
4. - Shaft alignment of tightening sleeve casing

5. - Displacement due to shaft misalignment

6. - Shaft alignment

7. - Parallelism of longitudinal displacement of carriage

8. - Alignment of spindle axis and tool holder sleeve



9. - Parallelism of tool holder sleeve and displacement

10. - Summary of diagnosis and actions to be taken, Figure 8.

Figure 8: Summary of diagnosis and actions to be taken

In this table, results of diagnosis and actions to be done on machine are given. The geometrical corrections to be done on this equipment (lathe PITTLER PDR250) will be as follow:

- Grindings of both carriages;
- Design and manufacture of Inserts, set of four parts;
- Adaptation by scraping of base with support;
- Adaptation by scraping of conical inserts, set of two parts;
- Adaptation by scraping of second base with its support;
- Adaptation by scraping of conical inserts set of two parts;
- Adaptation by scraping of pads, set of two parts;
- Fine Scraping finish.

5. Conclusion

Our contribution in this work is basically the development of a tool "Diagnosis help tool". This will be very usefull for any user.

Even if user is not familiar or doesn't know about geometrical control standards of machine-tools, and one will be able to find the geometrical of machines defects.

The geometrical defects can be set by scraping.

Scraping is a process used to withdraw micrometric size chips exactly where it is needed and not from all surface as do grinding.

The scraping has been used when renewing machine-tools and realized it is prerequisite that workers must learn how to use scrapers and scraping techniques. And it wasn't easy for anyone to learn it.

So before going into scraping techniques one must get familiar with scraper and the art of using it.

With the use of 'Diagnosis help tool' one can practically find out any geometrical failure in machine-tools.

To realize the work, a practical case which gather all geometrical checkups, corrections using scraping, application of the 'Diagnosis help tool' on a sample of machine-tools which was rebuilt for the order of CMT and also show the financial aspect linked to the machine failure, has been used

Finally and knowing the importance of scraping we hope that training schools will register the learning of its techniques in regular maintenance and rebuilt of machine courses.

This way it will help safeguard scraping jobs from disappearing from the industrial field.

Actually only few scraping masters remain on post but unfortunately not for long if no renewal is planned.

The hope is that this work has contributed to the enrichment of this aspect.

References

1. Shiba, S. (1995) *La conception à l'écoute du marché*. INSEP, Ministère de l'industrie, Paris
2. Chanal, H. (2006) *Etude de l'emploi des machines outils à structure parallèle en usinage*. Thèse de doctorat de l'Université Blaise Pascal, Clermont Ferrand, France
3. * (2006) *Convention de correction géométrique entre ALEMO et CMT*, Constantine, Algérie
4. Zwengelstein, G. (1996) *Maintenance Basée sur la Fiabilité, Guide pratique d'application de la RCM*. Edition Hermès, ISBN 2-86601-545-2, Paris
5. Zwingmann, X. (2005) *Modèle d'évaluation de la fiabilité et de la maintenabilité au stade de la conception*. Thèse de doctorat de l'Université de Laval, Québec, Canada
6. *** (1986) *ISO 230-1:Code de réception des machines outils, Partie I: Précision géométrique des machines*. Première édition
7. *** (2008) *Catia V5 R15*. Dassault Système, Velizy, France
8. **** (2005) *Environnement MATLAB 7.1*. Mathworks Incorporation, U.S.A.
9. Aib, S., Chaib, R. (2009) *Influence of Scraping Operations on Machine Geometrical Correction and Quality*. Proceedings of 1st International Joint Conference on Materials Science, Nanotechnology and Biotechnology "Future Challenge", January 4-6, Cairo, Egypt
10. Aib, S. (2009) *Contribution à la récupération des performances perdues et la précision des machines outils*. Thèse de magister de l'Université Mentouri, Constantine, Algérie

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