Cutting tool behavior when machining new concrete

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Abstract

Composite materials are materials with high mechanical performance; they are developing today in practically all fields. Obtaining parts in composite materials is difficult either by machining or by molding. In this article we propose the manufacture of molds for parts in composite materials. These molds are made from a new material called HPC (High Performance Concrete) and HPFC (High Performance Fiber Concrete). Obtaining this material requires thermal treatment to improve performance except that it's machining leads to wear of the cutting tool.

For this we propose in this work the machining of this new concrete before the thermal treatment in order to avoid the wear of the cutting tools.

Keywords: machining of new HPC and HPFC concrete, tool wear, mold making.

1. Introduction

Material removing machining remains the most important manufacturing process in the engineering industry. However, the influence of cutting tool wear on the quality of the surface condition and the lifetime of the cutting tool remains the primary issue facing machining professionals. [1]

Indeed, the phenomenon of wear is progressive and develops during cutting, which affects the quality of the machining. The degradation of the tool condition affects the quality of the machined surfaces, the imposed geometric tolerances, the durability of the tool over time, and generates high forces, which have the effect of increasing cutting power and energy consumed [2] [3]

There are two main parameters that influence the wear of the cutting tool; the first is formed by the material being machined and the cutting conditions (cutting speed, feed, depth of cut and lubrication). The second is formed by the physical and mechanical parameters of the cutting tool (geometry and composition of the material of the tool, hardness, stress and thermal property). [4] [5]

The wear of the cutting tool is due to the stresses placed on it during machining. In fact, cutting metals is a plastic deformation operation which must result in failure. The mechanical and thermal stresses sustained by the cutting tool are therefore very high.

It follows that a tool wears which can be of thermo mechanical or chemical origin. This wear is caused by the concentration of stresses in various places of the tool which depends on the machining parameters.

Excessive wear of the cutting edge causes its destruction.

The degree of wear determines the lifetime of the tool, it depends on: volume of chips, number of parts machined, length machined, and maximum cutting speed between two edge replacements. The lifetime of a tool represents the total time required to reach a specific lifetime criterion.

The various forms of wear on a cutting tool are shown schematically below.

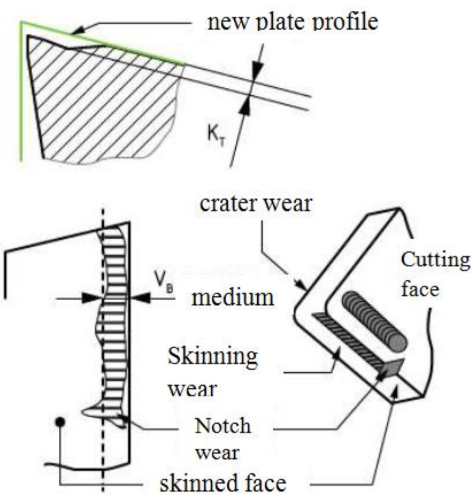


FIGURE1.

THE VARIOUS FORMS OF WEAR ON A CUTTING TOOL [6]

Through this overview we have made several machining tests on our new HPC and HPFC Concrete, in both cases treated and its thermal treatment, with and without lubrication, to control the wear of the cutting tool, various operations of machining are done on whatever machine tool (lathe and milling machine).

2. Experimental mode

2.1. Materials used

The materials used for the manufacture of Concrete (BHP and BFHP) are: [7]

- CEM 42.5MPa cement (see table 1)
- Sand dune from the eastern erg of the Taghit region (Bechar)
- Dune sand crushed to 80μm
- SIKA S95 DM slice smoke
- SIKA plast 5045 super plasticizer
- Fiber (metallic, synthetic, glass, carbon)

TABLE1.

PHYSICAL PROPERTY OF CEMENT AND CRUSHED SAND [7]

	Apparent density	Specific density	Fineness
CEM Π/B42.5	1030	3242	
Crushed Sand Dune	1150	2650	3000

Table2.

Mineral composition of cement (%)..

Cement type	C3S	C2S	C3A	C4AF
CEM Π/B42.5	55.41	13.65	2.25	14.83

TABLE3.

CHEMICAL ANALYSIS OF CEMENT AND CRUSHED DUNE SAND FROM TAGHIT [7]

Elements	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO3	Na2O	K2O	autres	P.F.
Crushed sand Dune	97.15	0.79	0.21	0.11	0.05	0.14	0.18	0.02	<0.02	0.58
cement	17.49	4.51	3.02	62.78	2.5	2.3	0.05	0.64	0.02	8.10

TABLE4.

CONCRETE FORMULATION (HPC AND HPFC) [7]

Materials (kg/m^3)	HPC	HPFC
Cement CEM 42.5MPa	691	691
Dune sand from oriental erg	759	759
Silica fumes SIKA S95 DM	172	172
Dune sand crushed to 80µm	276	276
Super plasticizer SIKA plast 5045	37	37
Fibre	-	138
Drinking water	200	287

2.2. Mechanical tests on HPC and HPFC Concrete specimens (4x4x16)

The tests will show what type of concrete will be used for machining the mold of composite materials.

- Compression test

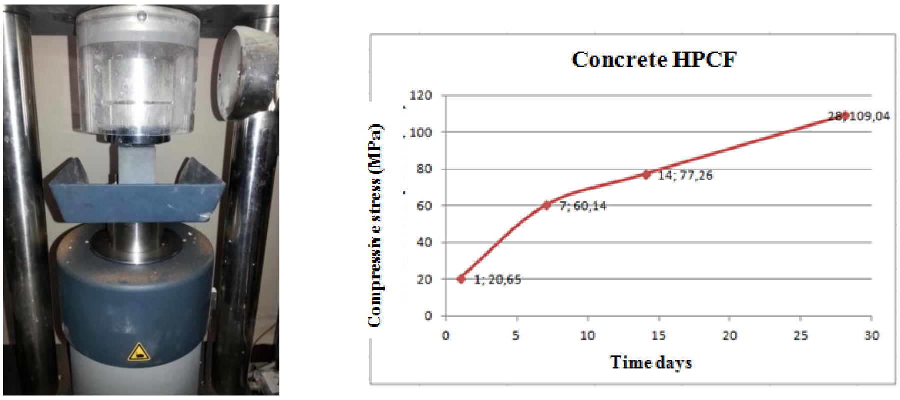


Figure 1. HPFC compression test

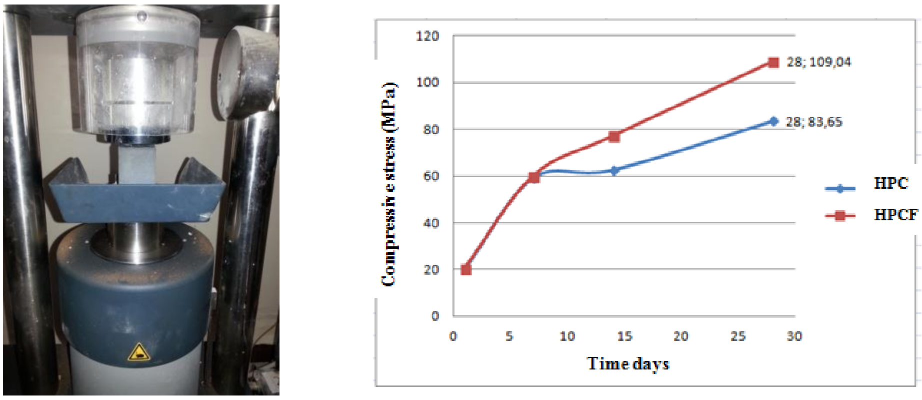


Figure2. HPFC and HPC compression tests

Table1. Compressive stress value

Specimen	Materials	Stress maxi (MPa)	Time (days)
E1	HPFC	109.04	28
E2	HPC	83.65	28

- Three-point bending tests

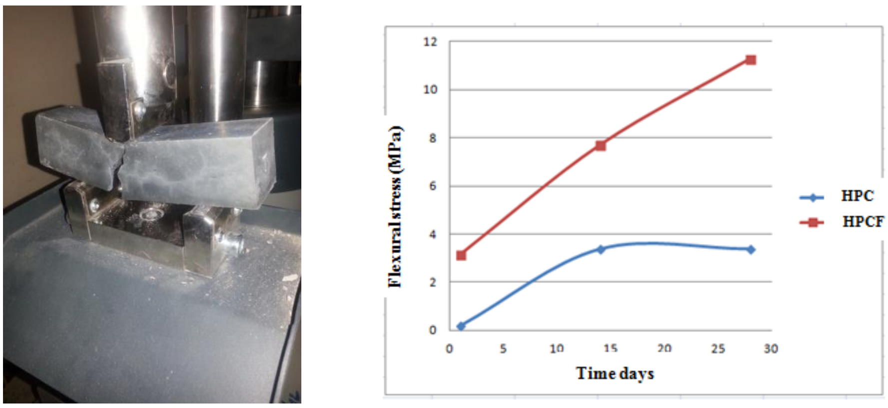


Figure 3 HPFC and HPC three-point bending tests

Table1. Three-point bending stress value

Specimens	Materials	Stress maxi (MPa)	Time (day)
E1	HPFC	11.28	28
E2	HPC	05.36	28

Result 1:

The mechanical tests of tensile and compression bending of HPC and HPFC have shown that HPFC concrete has a high stress compared to HPC concrete during the first day until the twenty-seventh day according to figures 1, 2, 3 and two tables1 and 2 show that the compressive and bending stress of fiber-reinforced concrete is higher compared to the stress of non-fiber concrete. Therefore, HPFC fiber-reinforced concrete is chosen as the manufacturing materials for the molds of composite materials by machining or molding, better than HPC concrete.

2.3. Preparation of two ingots

After casting two HPFC ingots, one is treated in an oven at 160 ° C for three days as shown in figure 4; the other is directly machined without thermal treatment.

Figure4. HPFC ingot Treated at 160 ° C for three days.

After three days, we open the oven doors in order to cool the ingot slowly to room temperature.

After complete cooling, the ingot is machined on a parallel lathe.

Figure5. Untreated HPFC ingot

2.4. Machining test without lubrication

- Machining of the ingot on a lathe machine tool:

Several machining tests are performed without and with lubrication to see the possibility of machining both treated and untreated ingots.

The machining mode chosen in turning is the carriage.

We chose a reference plate PCLN R 20-20 K12 oriented and fixed on a plate holder whose geometric characteristics are shown in figure 5.

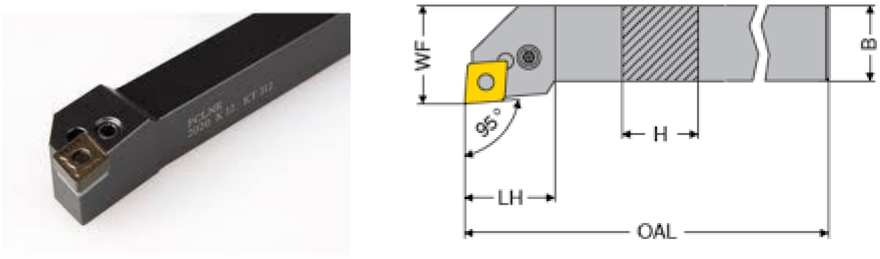


Figure 5: PCLN turning tool

The following table shows the variation of the rotation speed as a function of the depth of cut in mm.

Table5. Variation of the rotation speed as a function of the depth of cut

Test	Number of revolutions rpm	1st cut mm	2nd cut mm	3rd cut mm	4th cut mm
Test1	220	0.5	0.75	1	1.5
Test2	120	0.5	0.75	1	1.5
Test3	92	0.5	0.75	1	1.5
Test4	48	0.5	0.75	1	1.5

These tests are used for both ingots (treated and untreated), with and without lubrication. The optimization of the rotational speed and feed was made in a previously published work. [8]

For each test we set the speed of rotation, we vary the depth of cut, we see that even we reduce the speed of the spindle there is always the problem of machining difficulty for the treated ingot figure7, unlike for the untreated ingot, from the first test, the machining is carried out without problems figure6.

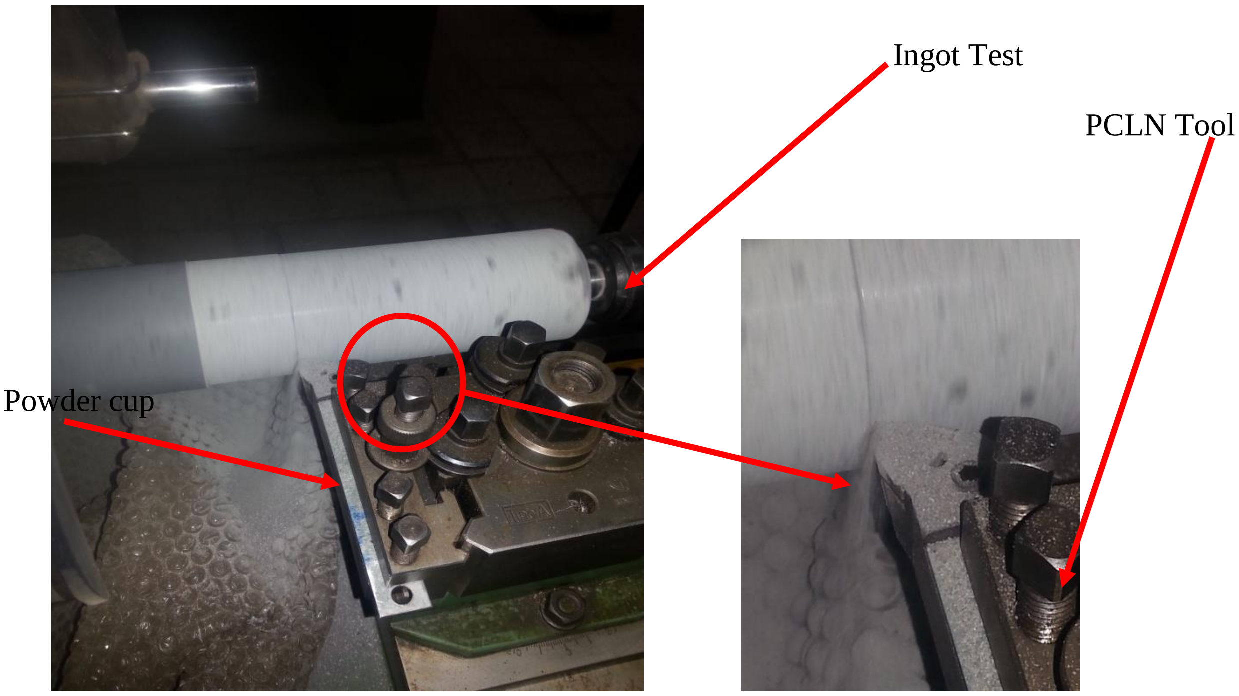


Figure6. Turning of untreated ingot

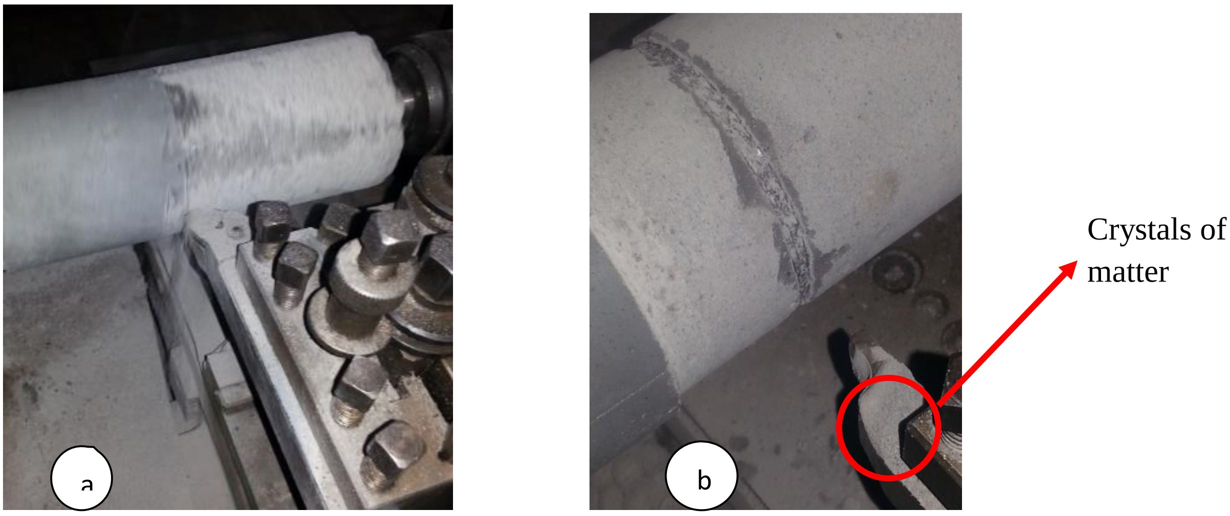


Figure7. Carriage machining of the treated ingot (a), grooving of the treated ingot (b)

Result 2

The machining before treatment figure6, does not cause problem, and the chips are in powder form and the wear of the cutting tool does not figure, tan disc machining after treatment figure7, cause problems during machining as an example the grooving operation with the grooving tool tears off the crystals from the ingot material figure 7 b, the machining after treatment has worn out the insert turning tool as shown in figure 8.

- Surfacing on universal milling machine:

The surfacing and drilling operation on a universal milling machine of a new concrete HPFC part using different types of milling tools and a concrete drill Figure 9, these machining operations are done on the new concrete treated or not to find the effective tool and see if the processing is done before or after machining, to make the mold of composite materials.

a) Dry surfacing with SANDVIK tool   b) Surfacing with carbide tool

a) surfacing with high speed steel tool   d) Drilling with concrete drill

Figure8. Surfacing of new HPFC concrete using different types of milling tools (a, b and c) and (d) concrete drill without lubrication.

2.5. Machining test with lubrication

➢ Surfacing of new concrete

The surfacing operation done on new concrete using lubrication and varying the cutting speed also wore the milling tool figure 13

Figure9. Surfacing of new concrete with lubrication

Result 3

Likewise by using surfacing operations of the new heat-treated HPFC concrete on a universal milling machine with different types of milling tool figure8 and 9 (high speed steel (c), metal carbide (b), insert inserts (a)) and drilling with a concrete drill tool (d)), with and without the lubrication, we play on the speed of rotation, the feed rate and the depth of cut, the machining causes problems and leads to the wear of these tools observed in figures 10.

3. Wear of cutting tools

3.1. Manifestation of wear

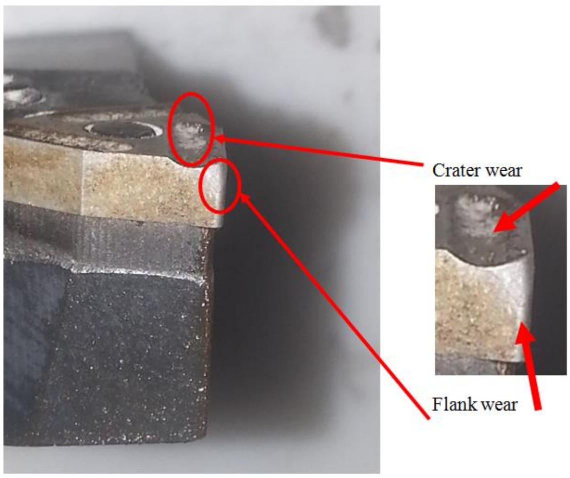
Two manifestations of wear take place during the cutting process: wear on the cutting face, flank wear and crater wear.

• Crater wear

The flow of the chip on the cutting face of the tool causes severe friction and the formation of a crater on the surface of the tool. This manifestation of wear is called crater wear; it is often linked to abrasion phenomena or physicochemical mechanisms due to the high temperatures which prevail during the machining process.

• Flank wear

Flank wear appears on the face where the tool contacts the surface of the new machined concrete. Flank wear typically develops due to abrasion of the cutting tool edge against the machined concrete surface.



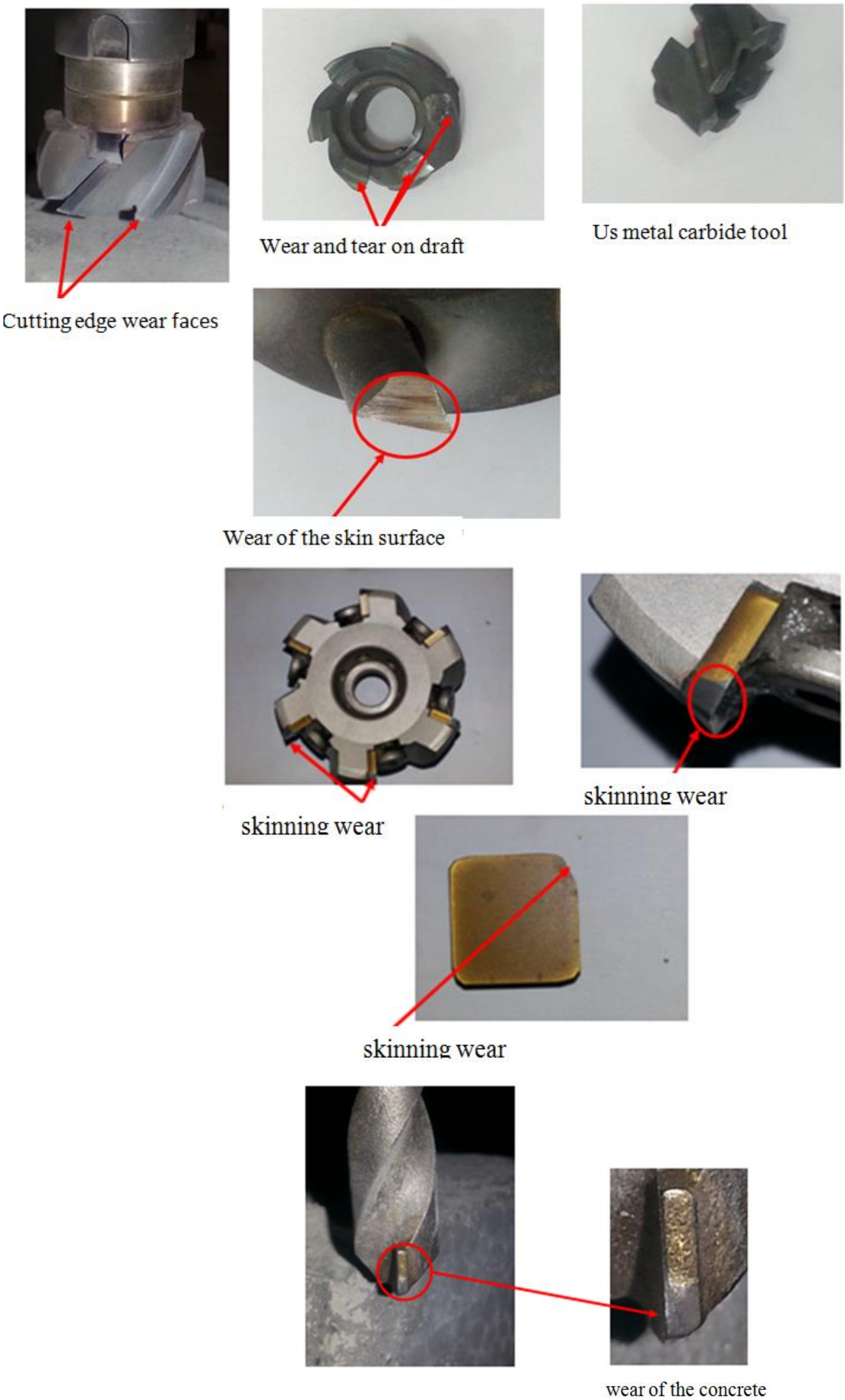


Figure10. Wear of different types of turning, milling and drilling tools

4. Roughness measurement

The roughness measurement is made on the two machined cases of the new treated and untreated concrete with a roughness meter, it is noted that the surface of the new treated concrete is nasty figure11,

While the other is acceptable figure12

Figure11. Roughness measurement on new treated concrete

Figure12. Roughness measurement on new untreated concrete

5. Results and discussion

The different tests of machining operations on different machine tools lathe and milling machine with different types of tools have shown that the machining with and without lubrication of the new HPFC concrete has caused problems after thermal treatment and causes wear of the cutting tool, also the surface finish obtained on the new untreated concrete is acceptable compared to the treated one.

To get around these problems, this type of material must be machined before it is heat treated, which preserves the cutting tool.

6. Conclusion

The longitudinal turning and grooving tests on a lathe machine tool on the HPFC ingot are carried out in both cases without treatment and with treatment; the first caused machining problems, which appear in the wear of the active part of the cutting tool, the second without heat treatment showed the possibility of machining without any problem and surfacing operations with different types of milling tools (high speed steel, metal carbide and SANDVIK inserts), and a drilling operation with a concrete drill tool on a prismatic piece of new HPFC concrete with and without lubrication in both cases without treatment and with treatment, the first caused machining problems while the second did not caused problems, then the machining operations are done before processing, and the heat treatment process will take place in the oven at a temperature of 150 ° C for three days after machining.

The following figure shows the example of the finished product by machining and molding before thermal treatment.

(a) New machined HPFC concrete model

(b) Model of the new HPFC cast concrete

Figure13. HPFC concrete mold machined and molded before thermal treatment.

7. Bibliography reference

[1] W. RMILI, R. SERRA, C. GONTIER & A. OUAHABI, Surveillance de l'usure des outils de coupe en usinage, Conference Paper · August 2005, See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/257298440

[2] Jae-seob K., Application of wavelet transforme technique to detect tool failure in turning operations. Int Adv Manuf Technol 28, 1078-1083. 2006

[3] Mohamed Khemissi Babouri, Nouredine Ouelaa, Abderrazek Djebala, Evolution et estimation de l’usure des outils de coupe en usinage Journées d’étude nationales de Mécanique Centre universitaire, Khenchela, 2010

[4] Martin P. Influence de l’usure d’un outil de tour sur les vibrations entretenues en coupe. PhD thesis, Université de Nancy I, France, 1973.

[5] BER A., GOLDBLAT M., The influence of temperature gradient on cutting tool’s life. Annals of the CIRP, 1989, Vol 381, n°1, pp.69-73

[6] A. TAFRAOUI , Gilles Escadeillas , Thierry Vidal ; Durability of the Ultra High Performances Concrete Containing met kaolin; Article history: Received 5 April 2014 Received in revised form 3 February 2016 Accepted 23 February 2016.

[7] Kamel Bousnina , Usure des outils, Université de Lille, science et technologie 01/01/2017.

[8] A. CHAOUFI, A. TAFRAOUI, M. ZAOUI, S. TAFRAOUI & M. DAHMANI, Research of the parameters of cut for the machining of the new concretes, international journal of mechanical and Production Engineering Research and Development (IJMPERD), Dec 2017