SEMINAR

What's Hot in Glass Processing

October 4th 2017

High Performance Tools to Reduce the Total Cost of Ownership

October 4th 2017

OUTLINE

1. TCO vs. Cost in Complex Systems
2. Tooling and the End User Cost Structure
3. Variables Affecting Tool Performance
4. Optimization of Processes
5. Case Study and Patented Tools
6. Conclusion

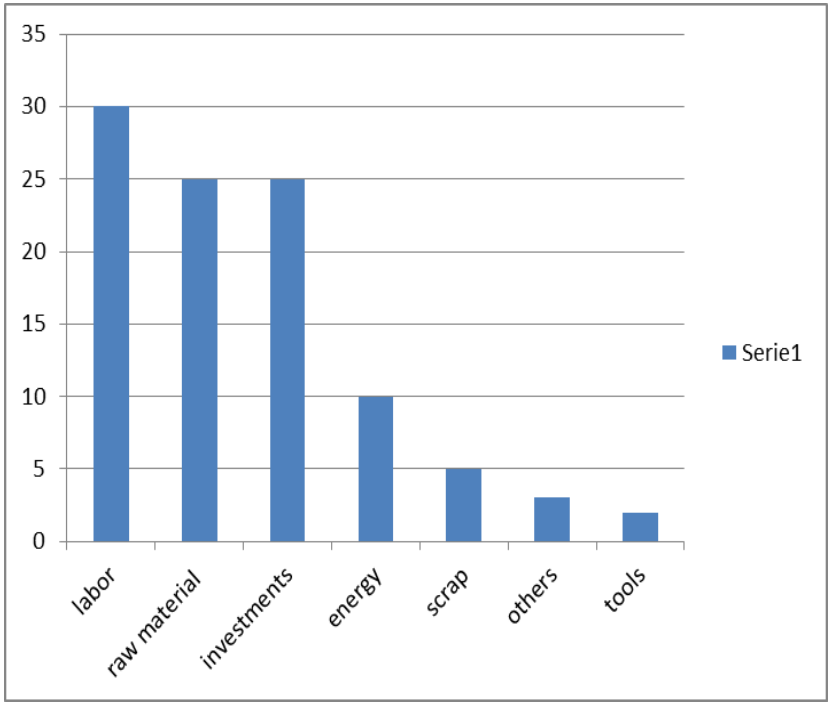
DIAMOND TOOLS: TCO CONCEPT

TCO: Total Cost of Ownership

Fact:
The price of a tool is not the most important thing in an industrial environment:

1) Tooling cost normally account for 1 – 3 % of the company costs but may affect them by 10 – 30 % (scrap, downtime, maintenance, etc.)

2) It is now common to consider the Total Cost of Ownership instead of the initial tool price



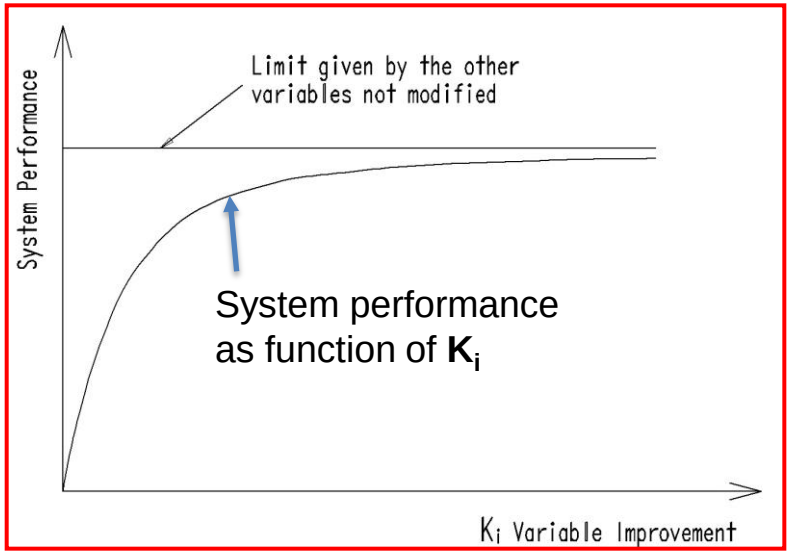
DIAMOND TOOLS: TCO CONCEPT IN COMPLEX SYSTEMS

SPRING MODEL

$K_T = f (K_1, K_2, \ldots K_n)$

K_i = (Machine, Tool, Coolant, Cone, …)

$$K_T = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \ldots + \frac{1}{K_n}}$$



DIAMOND TOOLS: TCO CONCEPT IN COMPLEX SYSTEMS

SPRING MODEL

If K1 is very low, then no matter how strong K2,…, Kn the result is governed by K1

So, for example, if :

-the coolant is bad
-the spindle is not balanced
-the cone is indented or not properly maintained

The performance of the system cannot be strongly affected by improving the tools

DIAMOND TOOLS: TCO CONCEPT IN COMPLEX SYSTEMS

SPRING MODEL

One often overlooked variable in the system is the dressing process

In fact, dressing will:

1) Affect the life of the tool
2) Change the exposure of the diamond (too much, too little,…)
3) Affect the grinding process (time and quality)

Customer and supplier needs to define appropiate dressing stick and parameters tailored on the tool

DIAMOND TOOLS: TCO CONCEPT IN COMPLEX SYSTEMS

TCO reduction actions that can be taken:

1) Process Evaluation and Measurement of Parameters
2) Team work to define and determine a Plan of Action
3) Use of Continuous Improvement Techniques; PDCA, (Plan, Do, Check, Act), DOE (Design of Experiments), and other Continuous Improvement Tools

VARIABLES AFFECTING TOOLS PERFORMANCES

:

1) Diamond Type
2) Diamond Grit Size
3) Diamond Concentration
4) Bond
5) Temperature
6) Pressure
7) Time

External Parameters which influence the performance of a diamond tool:

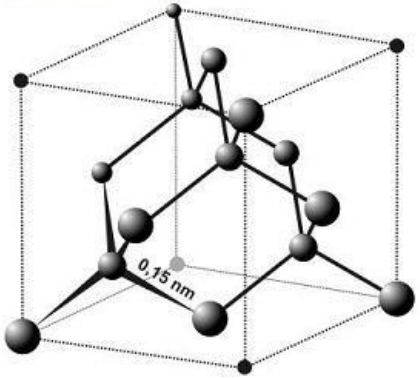
1) Machine Conditions (Vibration)
2) Coolant (present conditions)
3) Suction Pods or work holding appliances
4) Working Parameters: feed rate, stock removal, RPM, score quality, glass

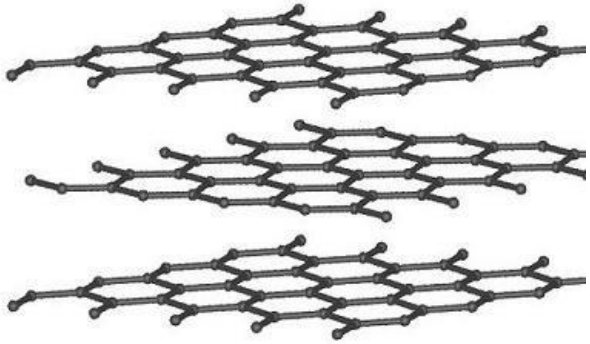
Performance= f(x1, x2, … ,xn)

DIAMOND TOOLS: BASIC KNOWLEDGE

Diamond: Carbon's metastable form

Graphite: Carbon's stable form

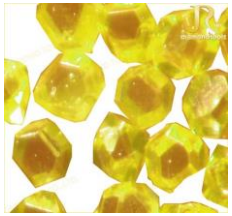




DIAMOND TOOLS: BASIC KNOWLEDGE

INDUSTRIAL DIAMOND CAN BE DIVIDED INTO:

-SYNTHETIC



-NATURAL DIAMOND

- In the past, most heavy duty processes were done with natural diamond (higher toughness index)
- Now, more than 99% of the products are synthetic as they became more reliable, consistent, tailored for many different applications and less expensive

DIAMOND TOOLS: BASIC KNOWLEDGE

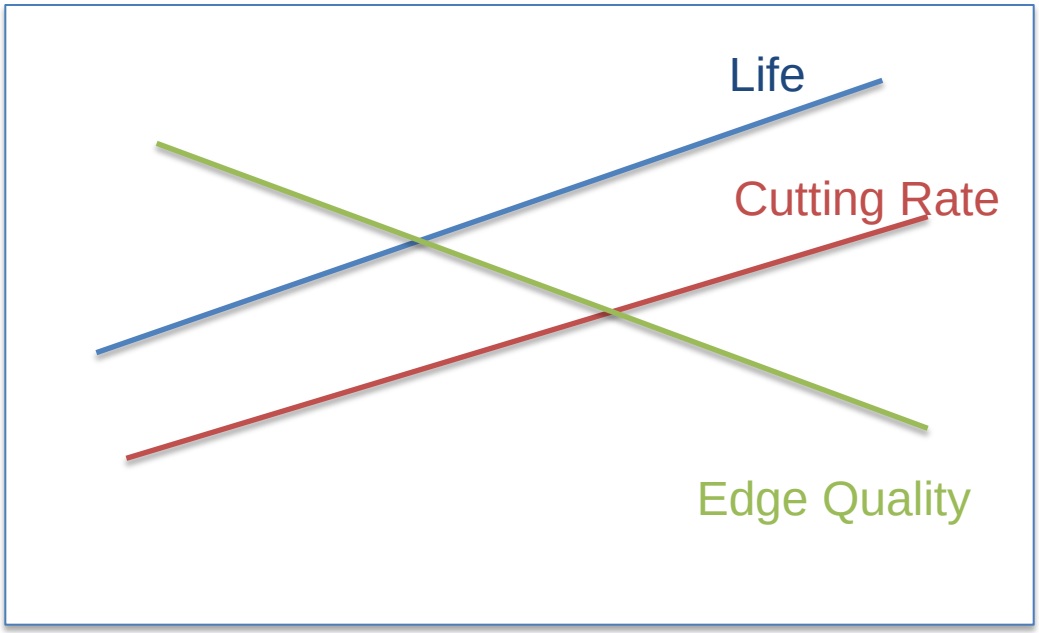
Enhancing Diamond Retention:

Many diamond coating have been devised to improve the bond diamond retention

- a) Ni and Ni Spiky (Nickel)
- b) Cu (Copper)
- c) Ti and TiC (Titanium & Titanium Carbide)
- d) combined coatings (mixture of the above)

EVERY COATING IS DEDICATED TO A DIFFERNT APPLICATIONS

DIAMOND INFLUENCE ON GRINDING



Fine — Diamond Size US Mesh — Coarse

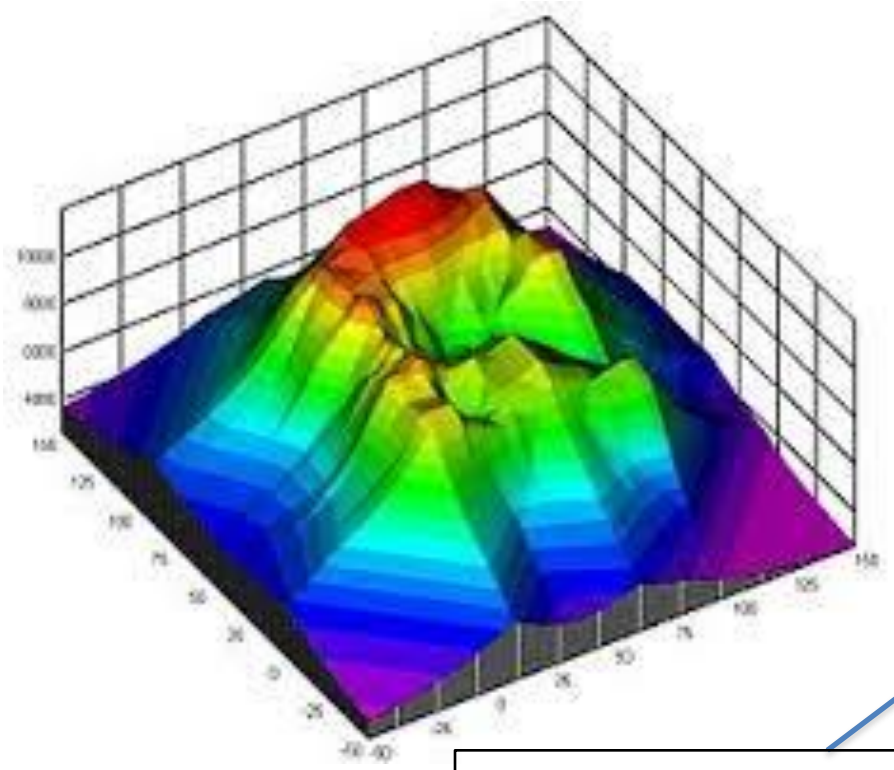
DIAMOND TOOLS: OPTIMIZATION PROCESS

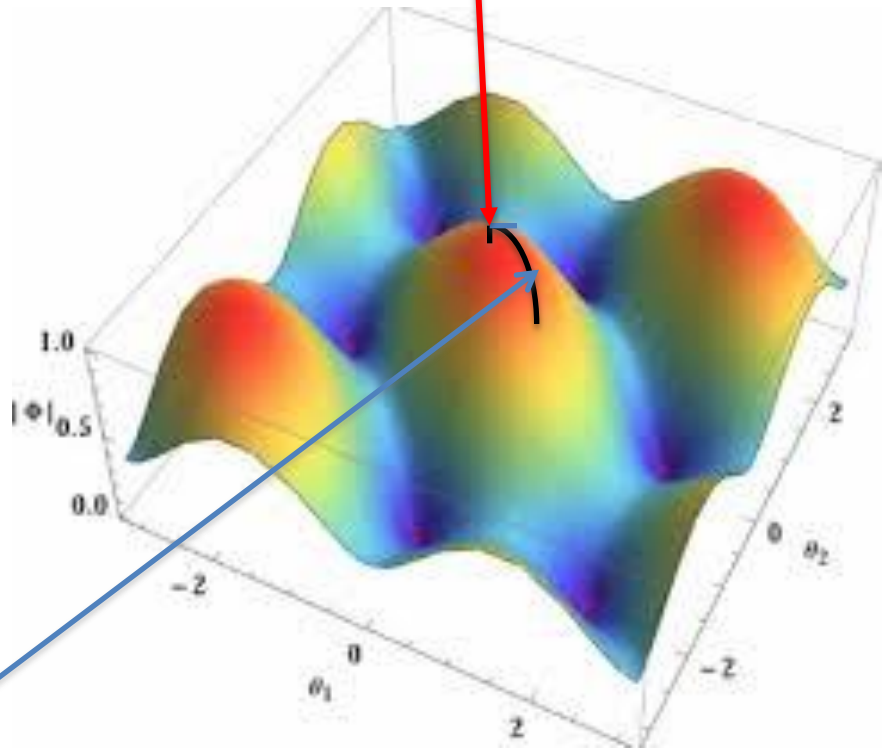
- Multi Variable Process
- Steepest Descent
- Shooting
- Empirical
- Combined

DIAMOND TOOLS: OPTIMIZATION PROCESS

Performance= f(x1, x2, … ,xn)

Local Optima





Optimization Process: Gradient or Steepest Descent

DIAMOND TOOLS: OPTIMIZATION PROCESS

Performance= f(x1, x2, … ,xn)

Consideration of Local Optima:

1) No information about other possible better solutions
2) Vague idea about solution sensitivity (how much the performance is affected by a slight change in the parameters)
3) Difficult to achieve without extensive experimental trials

As a consequence, a correlation between measurable variables such as Bond Hardness, Bond Tensile Strength, Bond Resilience, etc. and the performance is more than desirable (to drive the developments).

DIAMOND TOOLS: OPTIMIZATION PROCESS

Performance= f(x1, x2, … ,xn)

FACTS:

With a multi variable function it is impossible to determine the «Global Optimum Point»

The only possible alternative is to work on a «Local Optima» via different methods:

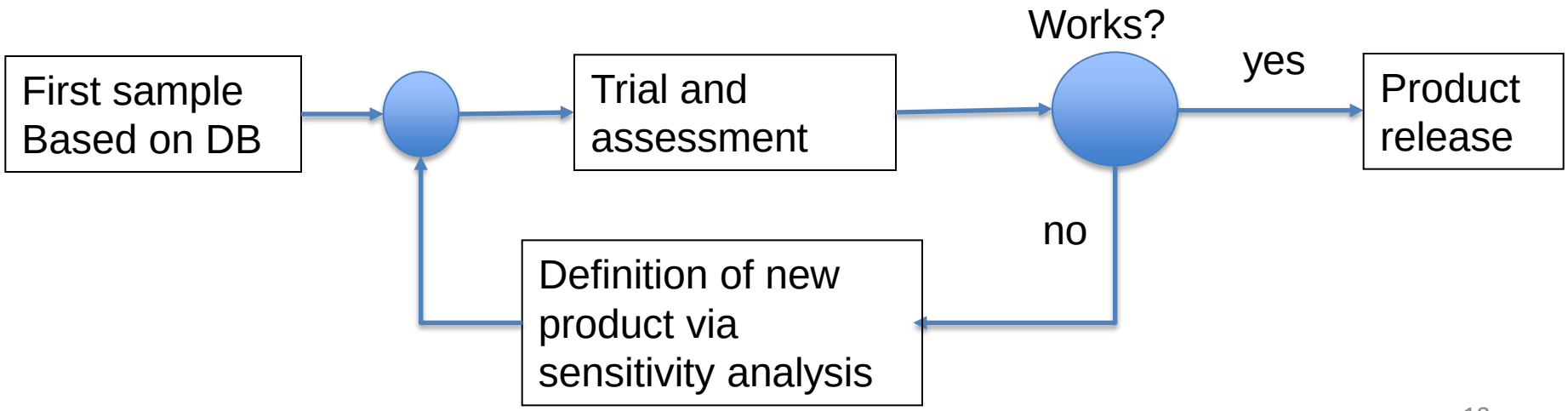
1) Empirical method - meaning based on evidence by testing a hypothesis (most common among diamond tool manufacturers)
2) Gradient or Steepest Descent Method
3) DOE Design of Experiment - (related to the second and suitable for a production environment)
4) Combined Shooting Method (sponsored by ADI)

DIAMOND TOOLS: OPTIMIZATION PROCESS

Performance= f(x1, x2, … ,xn)

Combined Shooting Method:

1) First trial to assess the performance (Original tool based on data base)
2) Modification of the wheel according to sensitivity analysis (from data base)
3) Trial and further iterations



DIAMOND TOOLS: OPTIMIZATION PROCESS

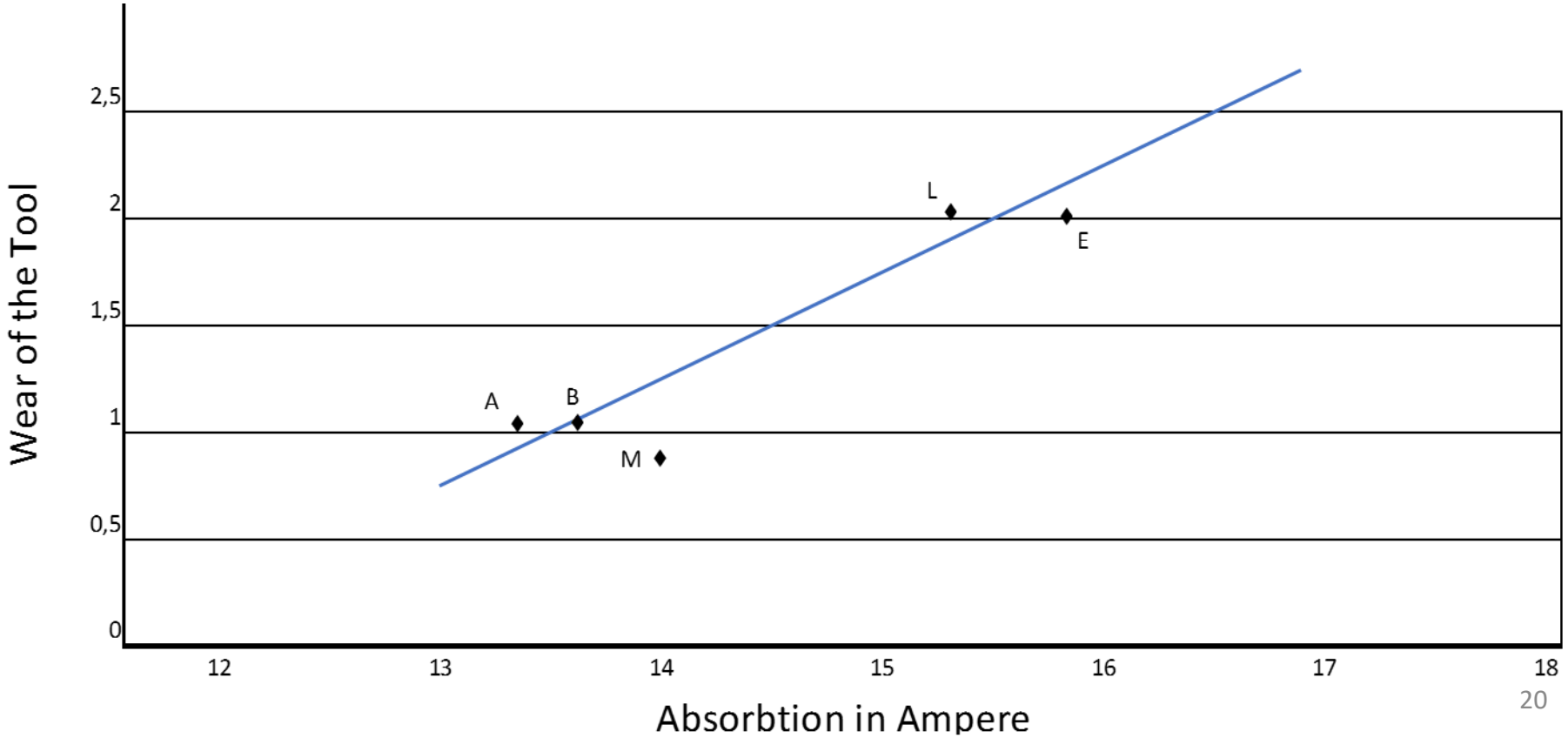
Unfortunately, extensive studies have demonstrated that there is no direct correlation between tool's performance (life and cutting capacity) and technical measurable variables such as:

1) Bond Tensile Strength
2) Bond Hardness (micro and macro)
3) Bond Resilience

This is due to the particular sinterized (non homogeneus) matrix and the many variables involved

DIAMOND TOOLS: OPTIMIZATION PROCESS

Good Indicator: extensive studies have demonstrated that there is slight correlation between Machine Current Absorbtion (Amps) and tool's wear (**the lesser the Amps the longer the life**):



DIAMOND TOOLS: OPTIMIZATION PROCESS

A positive correlation has been noticed between:

1) Hardness and Tensile Strength
2) Hardness and Yield Strength

DIAMOND TOOLS: OPTIMIZATION PROCESS

Conclusion:

It is impossible that two manufacturers produce the same perfomance wheel: there is always a difference which could be related to:

1) Life (the most looked at)
2) Cutting capacity
3) Start up
4) Scrap
5) Sensitivity to changes
6) Surface Finishing

TOOLS PATENTED AND RELEVANT DATA

CASE STUDY

TRADITIONAL WORKING SYSTEM
VS
NEW SYSTEM PATENTED BY ADI

DIAMOND TOOLS: TCO CONCEPT

CASE STUDY

TRADITIONAL WORKING SYSTEM

DIAMOND TOOLS: TCO CONCEPT

CASE STUDY

PATENTED SYSTEM BY ADI
UTILIZING W.E.T. WHEEL
TECHNOLOGY

DIAMOND TOOLS: TCO CONCEPT

CASE STUDY

TRADITIONAL PROCESS

Production (3 diamond + polish): ~4,000lin/CNC/shift
Labour: € 0.034/lin
Diamond Tooling: € 0.0014/lin
Conditioning Stones: <€0.001/lin
TOTAL (affected parameters): €0.036/lin

lin= linear inches

DIAMOND TOOLS: TCO CONCEPT

CASE STUDY

ADI W.E.T. SYSTEM

Production (1 diamond + polish): ~10,000lin/CNC/shift
Labour: € 0.014/lin
Diamond Tooling: € 0.0055/lin
Conditioning Stones: € 0.0055/lin
TOTAL (affected parameters): € 0.0244/lin

DIAMOND TOOLS: TCO CONCEPT

CASE STUDY

POTENTIAL SAVING BASED ON AVERAGE CONSUMPTION € 113.000 ~

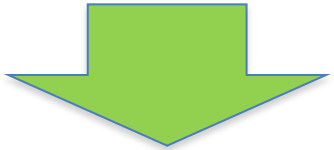
OTHER BENEFITS

- SIMPLER SETUP (ONLY 1 DIAMOND TOOL
- LESS INVENTORY
- LESS EQUIPMENT FOR THE SAME PRODUCTION
- LESS ASSOCIATED STAFF (SUPERVISOR, MAINTENANCE, ADMINISTRATION

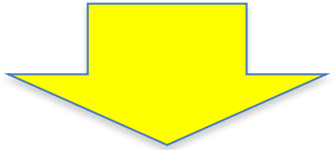
CONCLUSION

IT IS IMPORTANT TO MEASURE THE PROCESS.

GIVE FEEDBACK TO DIAMOND TOOLS MANUFACTURER



IMPROVEMENT



TCO REDUCTION

ADI
INDUSTRIAL DIAMOND APPLICATION

CONCLUSION

There cannot be TCO reduction without the tool manufacturer and end user working together

ADI
INDUSTRIAL DIAMOND APPLICATION

THANK YOU !