TTT Tapping-Torque-Testsystem

The „TTT Tapping-Torque-Testsystem“ as a Multiple Evaluation System for Efficiency Ratings of Lubricants, Tapping Tools and Coatings

A Window into Tribology

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The TTT System for Comparing Efficiency Rating

Physical Conditions

Substituting all kinds of machining and forming the **TTT** System as a multiple system for development and evaluation of lubricants and threading tools employs torque-and process-controlled threading.

Requirements

Just as the lubricant industry depends on the characteristics of the tool, the tool manufacturers depend on the nature and the properties of the lubricant.

Evidence of performance, quality and effectiveness, being used as evaluation parameters, are indispensable.

The measure of all things are the customer's complex production demands. This includes the influence of material as well as cutting speed and many other mutual elements.

Solution

With torque- and temperature-determination the TTT Tapping-Torque-Testsystem, designed as a multiple evaluation system, visualises a real proof of defining process parameters during forming and machining. By this means predications according to IQ, PQ and CQ* about the performance ability of lubricants, tool-geometries and coatings are possible.

Analysis

In combination with an evaluation software specific features of lubricants and tool structures can be recognised and evaluated. This applies in particular to the complex interactions between formulations and their additives with various work materials and tool coatings in dependence of cutting speed and the temperatures occurred in process. With the integration of an Analyser single measurements as well as series of measurements can straight forwardly be analysed, evaluated and compared with any reference desired (steps in development / market products).

Performance

From the basic measurement values of torque determination and temperature difference Δ**T** can clearly be allocated to the factually occurring tribological effects. Appropriate modifications according to the exclusion principle submit exertion of influence.

*IQ Installation Quality / PQ Process Quality / OQ Operation Quality

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Temperature-Sensor-Measurement

Approach

At the time of the greatest heat build-up the exact temperature at the tip of the tool can be measured only with an enormous effort.

Temperature Value ∆T

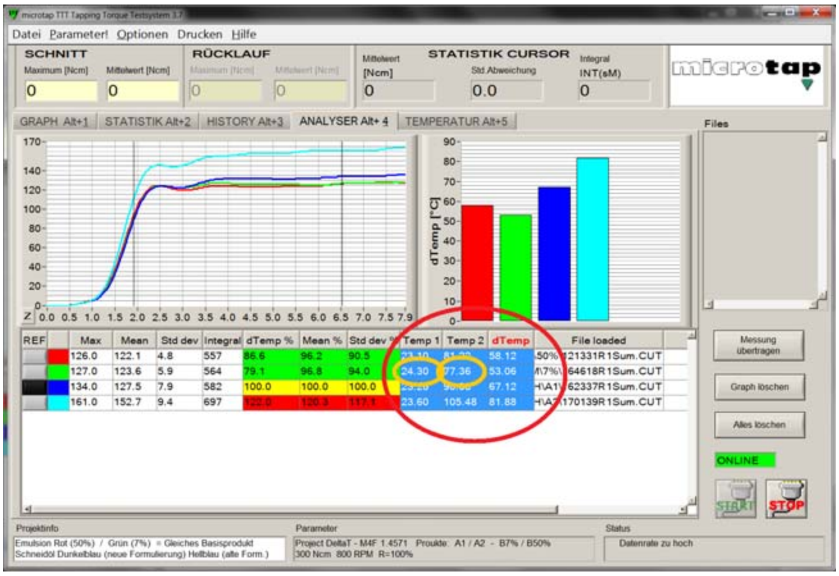
As a possible solution the temperature value Delta T (∆**T**) is computed

Procedure

Employing infrared thermometry by use of the **T**emperature-**S**ensor-**E**quipment **TSE** the temperature is determined at the tip of the tool right before measurement…

…and compared with the determined temperature value right after measurement.

The difference results in the temperature value ∆**T**.



Temperature mean values and ∆**T** supplemented to torque values of series of measurements.

Torque- and Temperature-Values
TTT Standards and TTT Methods

Demand & Coverage of Process-Temperature

With the integration of the **T**emperature-**S**ensor-**E**quipment **TSE** the temperature value **ΔT** is added as an additional evaluation factor, to the various values of torque.

Practice Oriented Efficiency Rating

The **TTT T**apping-**T**orque-**T**estsystem determines the following values of the torque progression for visualisation of tribological invents*:

1. **Torque** (Mz in Ncm) as a value for the factually generated work performance
2. **Mean Value** (Mz Mean) as a value for the generated work performance in average (arithmetic mean)
3. **Standard Deviation** (Std. Dev.) as a value for the mean deviation of torque around the Mean Value (distribution, synchronisation & homogeneity)
4. **Gaussian-Distribution** / Frequency Distribution as a graphic depiction of the torque values occurred and their distribution as a histogram (Statistics)
5. **Integral** (INT) as a value for the total work load (stress) on the measurement tool

The Temperature-Sensor-Equipment TSE determines the starting- and the end-temperature for the calculation of Δ**T**.

6. **Delta T (ΔT)** as a value for the interpretation of tribological mechanisms*

TTT Methods & Standards

In adaption of different TTT Methods (creation of series of measurements) and specified TTT Standards (material** & parameters), controlled, comparable and repeatable results are realised. The therefore developed TTT Methods and fixed TTT Standards consequently applied – according to task –, submit to compare the determined results internally and in different laboratory groups. Each test-bar (of one and the same material) submits 140 faultless measurement results with one installation only.

*At determination of the friction coefficient the physical load parameters in a wear process are defined in four quantities:
- Normal Force FN (Torque)
- Velocity V (Cutting Speed)
- Temperature T (Delta T)
- Time of Load tB (Depth of Thread / Time)

GFT, Tribologie from 2002, sheet 7, page 8)

**For additonal information please see "TTT-Measurement-Equipment

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TTT Methods and Evaluation

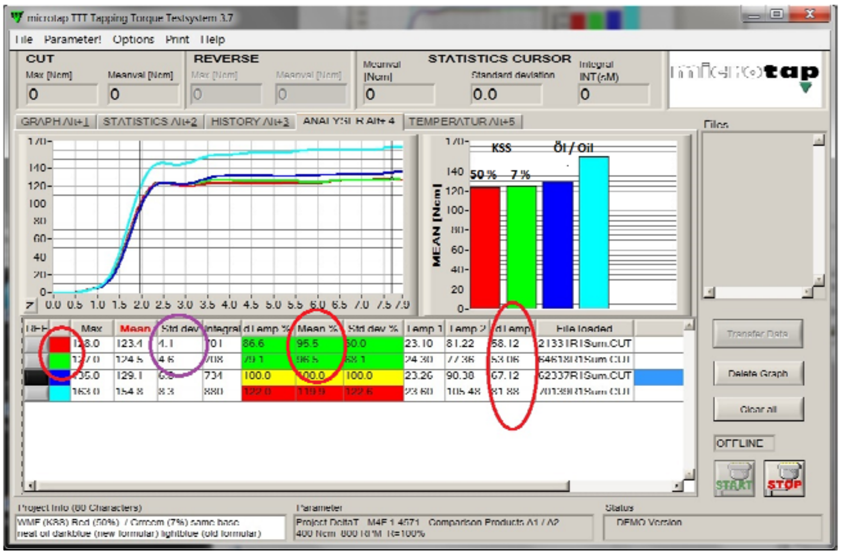
With the application of various TTT Methods (following the so called “Exclusion Principal”), the lubricating mechanisms-of-action of individual formulation-ingredients can be recognised and allocated to specific properties of tool geometries and coatings.

TTT Methods

Via various TTT Methods specific properties of formulations and neat oils and their interactions with various kinds of tool coatings on the one side, and thread profiles and tool geometries dependent on process speed on the other, become transparent end evaluable. With appropriate modifications they are systematically amenable to influence.

With the computation of the temperature value Δ**T** we gain adequate information about the cooling capacity of the parts of water and their correlation with other process parameters, e.g. process speed and also the slippage of tool coatings.

When simultaneously observing torque values, e.g. the Mean Value of the Standard Deviation relating to the parts of water of a MWF, and Δ**T,** tribological effects become visible.



Analyser Evaluation

The TTT System visualises test results according to the guide lines mentioned above and the determined values thereof. The MS Windows compatible Evaluation Software (MS-2000 / MS-XP / MS-Win7 32/64) submits a practice oriented performance evaluation via integrated analysis for the assessment of all torque and temperature values occurred.

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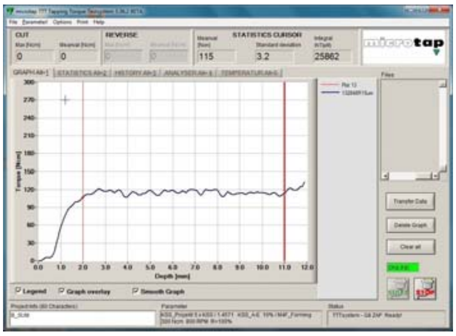
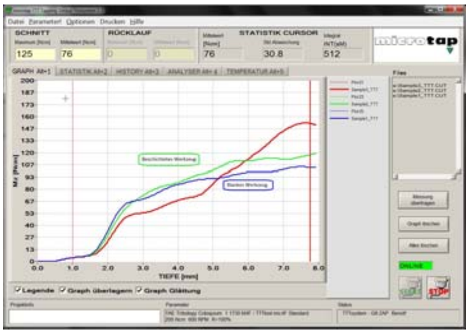
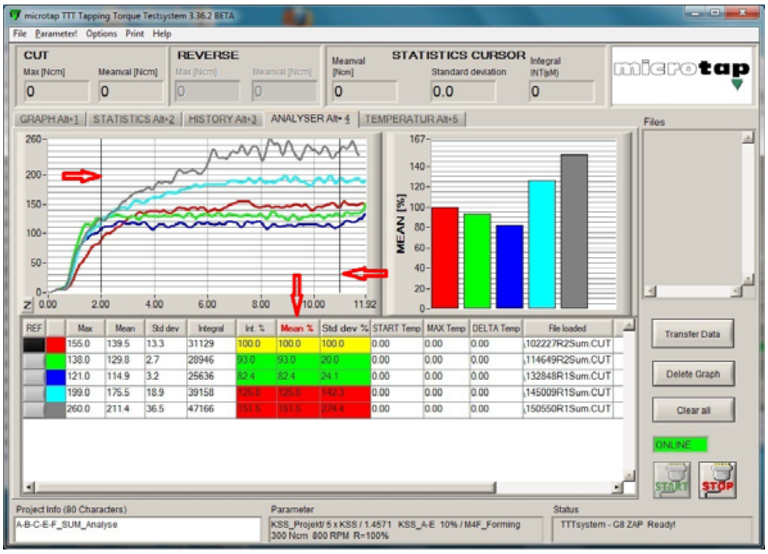
Torque Evaluation-Parameters at a Glance





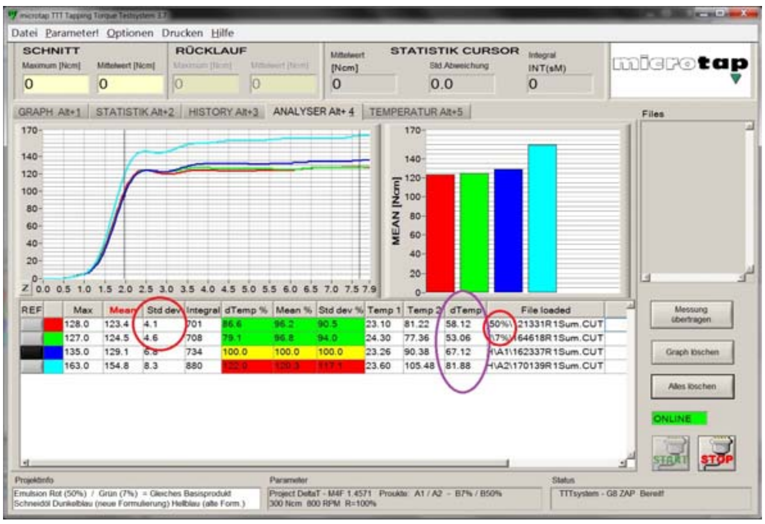
Torque

.. as a value for the work performance (Torque Mz in Ncm)



Mean Value

.. as a value for work performance in average (Mz Mean)



Standard Deviation

.. as a value for the mean deviation of the torque around the Mean Value

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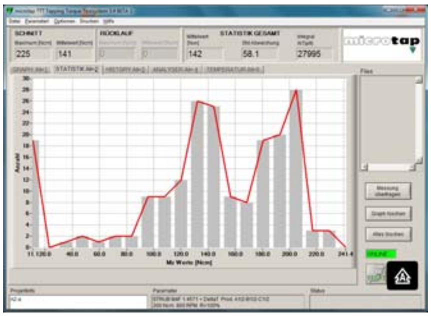
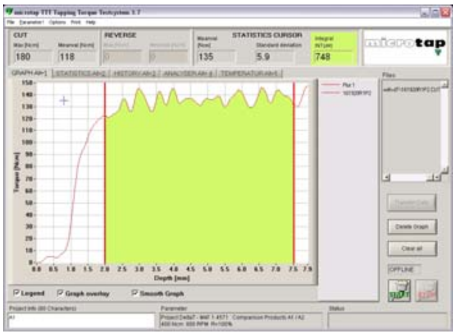
Gaussian Curvature / Statistics and the Integral



Gaussian Frequency Distribution

.. graphic depiction of the distribution of torques as a histogram (Statistics)



Integral

.. as a value for the total stress (friction) on the measurement tool

With the “Surface Integral” (Trapezoidal Rule) – as an additional feature to the measured values of torque to depth (Mz max. Ncm), Mean Value (Mz Mean) and Standard Deviation (Std. Dev.) –, it is also possible to display and to evaluate the total stress on the tool as an integral-value (➔ friction / stress / wear).

Area Calculation in Detail

The “Trapezoidal Rule“ describes the mathematical procedure of numerically approximating the integral of a function f (x) in the interval [a, b] (numerical squaring). That means to substitute the area below the curvature with the maximum number of trapezes of all possible sizes.

The sum of all trapeze-areas $(\sum A)$ $A = \frac{a+b}{2} \times h$ gives a value,

which we enlist as a ratio for friction.

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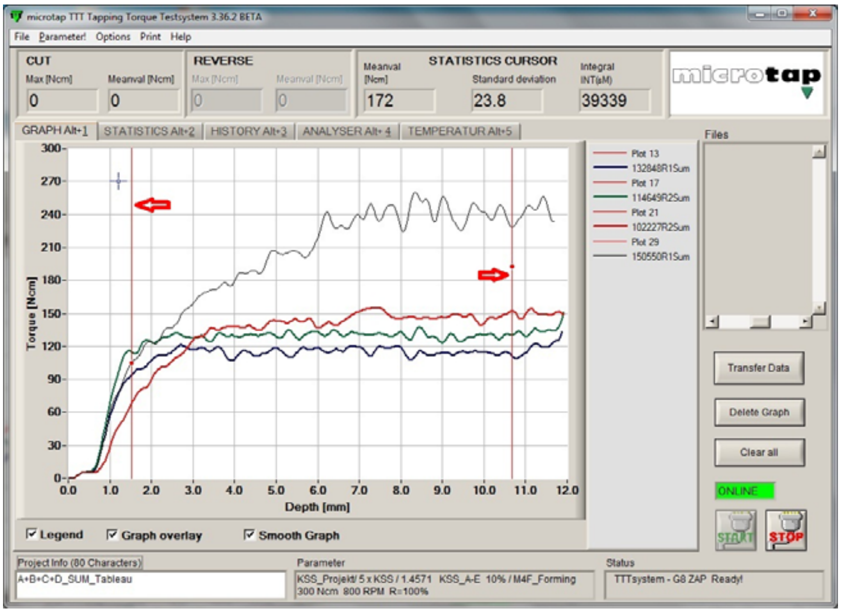
Evaluation Functions at a Glance

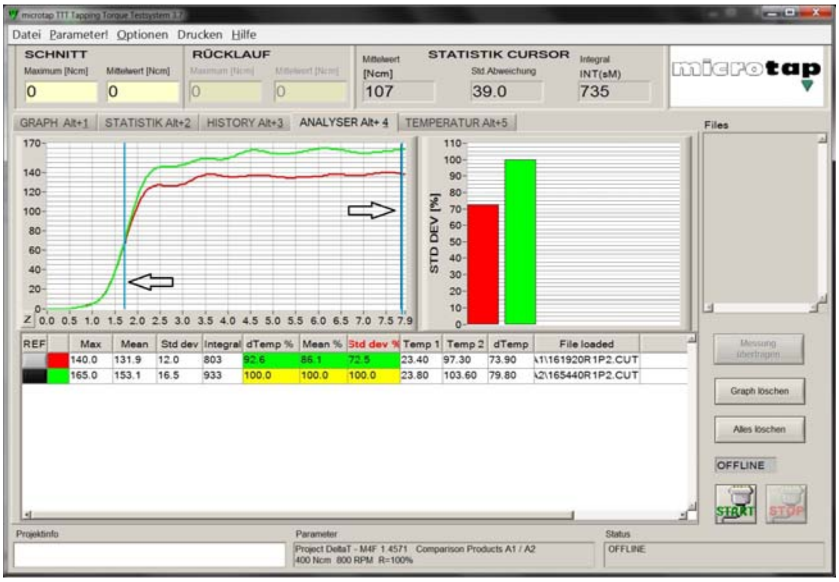
The “**Dual-Cursor**” function provides a flexible and more detailed analysis of the measurement graph.

Dual-Cursor in the Graph



The depicted measurement data can be localised and selected with the„Dual-Cursor“ in the graph as well as in the analyser and moreover be evaluated according to the various work and application fields.

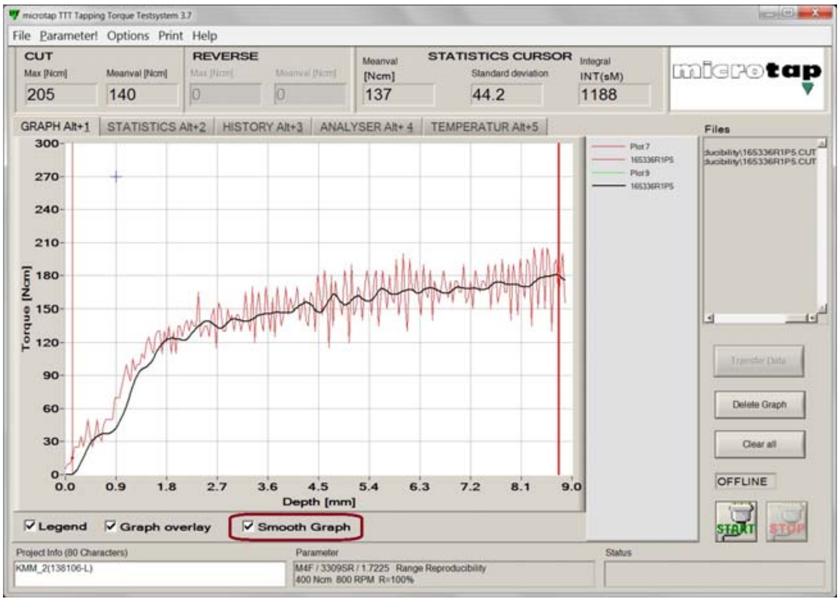
Function Bar Chart



The evaluation range of all statistic values provides a detailed consideration and appraisal of the measured values according to the various work and application fields and is also effective in the bar chart.

Smoothing and Overlay of Graph

The function “Graph-Smoothing” provides a flexible and application-oriented observation between raw data and smoothing.



Graph Smoothing

The function-button (On/Off) in the register „Graph“ provides a fast switch of the depiction to the unsmoothed raw data (Graph Smoothing).

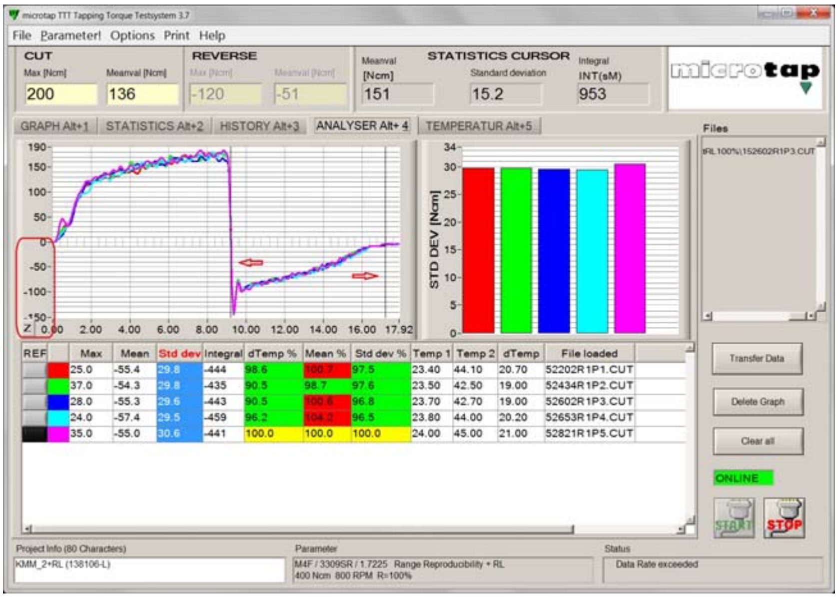
Overlay

With the “Overlay” all measurement graphs of a series of measurement are visible at a glance. The average value of a series of measurement (sum.cut) is overlapped in black.

Return-Travel Performance at a Glance

Return-Travel Function

When conducting return-travel (the return of the tool without load) it can be recognised – by sheer friction of interacting surfaces, especially with clamping materials – if with the lubricant resp. the applied additives (for low and high friction values) a good or a bad slippage capacity is given.



Return-Travel Torque Values and Analysis

The return-torque values are shown in the graph as minus-values, back to front. The depicted measurement data of the return-travel torque can be localised with the Dual Cursor and also in the Analyser.

Indication

Please note: With Return Travel "ON" the measurement values under load (when threading) may as such be influenced and even falsified by the values of return travel. (ON / OFF)

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Temperature Value Delta T (ΔT) at a Glance

Design

The **T**emperature-**S**ensor-**E**quipment **TSE** is furnished with a temperature measurement device incl. optics, fixation handle and accessories.

Features

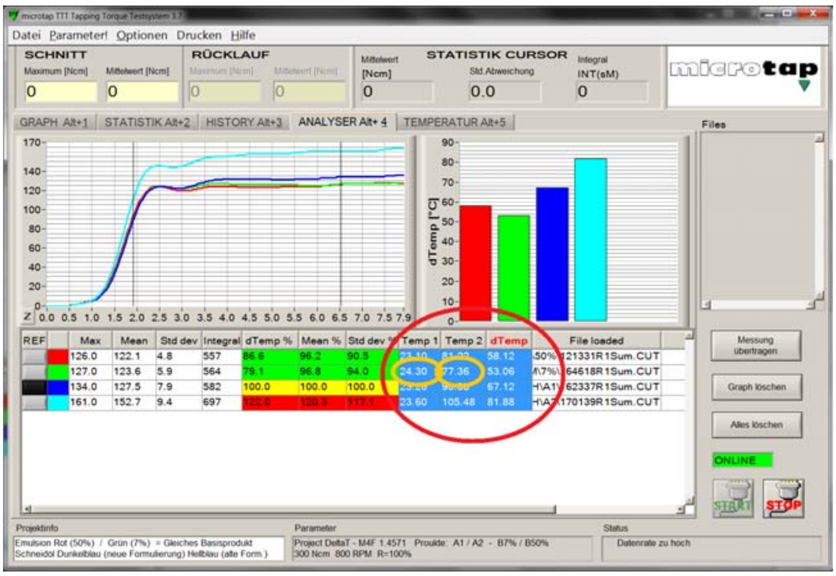
The data are fed into the Analyser of the **„Evaluation & Analysis Software“** Win**PCA** and directed towards an evaluation of the temperature difference Δ**T**.

With the Temperature Sensor the influence of the temperature on the tribologically relevant layers, which may be caused by additives, can be investigated economically and practically relevant.

Distance device for mounting location stick and laser

Limitations

The Temperature-Sensor-Measurement is primarily qualified for thread forming. As thread cutting however produces chips, these might cause pollution of the optics and falsify the measurement results. In case of strongly diverging data please clean optics and tool and repeat measurement before storage.



Temperature Value ΔT

… an important window into the tribologic mechanism of action

TTT Tapping-Torque-Test System

The TTT System as a Laboratory-Complete-System with Integrated X-Y-Positioning Table MPT

Start and Handling-Functions

- Start functions of the X-Y **M**anual-**P**ositioning-**T**able **MPT**:
  - Function-start with automatic fixation of position (setting ex works)
  - Start und deadlock at release of multifunction handle
  - Using the motor-stop-function, start with foot switch or start lever

Properties / Features

- Electromagnetic fixation for manual positioning of work piece, precise & quick
- Electromagnetic fixation not before tap point is reached
- Smooth-running cross-roller bearings realise centring with tapping tool

Advantages

- The various start functions as mentioned above provide selection of the specific mode, with which a user realises secure and precise measurement results
- Smart, quick and aligned positioning of work piece and accurate centring at the same time

Benefits

- Threads, unaligned, tilted and cut or formed across are avoided
- Measurement mistakes caused by unaligned centring are avoided
- Efficient, quick and precise production of high-grade threads / series of measurements and effective laboratory results

TTT System

General Win**PCA3 Applications**

Synchronisation Joint Laboratories

- All measurement-data parameter-settings can be stored and recalled for project-related or further use, e.g. securing repeatable guidelines for generation of measurements series, notably for synchronisation in participating joint laboratories
- Specific measurement-data parameter-setting (*.par), related to project, and operator configuration (*.cfu)
- Facile assortment of measurements (*.cut or sum.cut) for analytic and comparing evaluation without external software programmes
- Clear colour coding enhance assignment and display of graphs and analysis including plot and file-name
- Facile selection of measurement values to be compared in bar charts, in the analyser, also related to Dual Cursor
- Percentile assignment of all statistic values for efficient comparison e.g. with a reference, a single product or development steps and / or market and competitor products

Software Optimisation starting with WinPCA2.5

- Integrated Analyser
- Selectable take-over and storage of data recordings (*.cut)
- Automated generation of an average value of a series of measurement (sum.cut)
- Definable number of measurements in a series
- Manual and automated generation of a sum.cut of individual series of measurements
- Depiction of the sum.cut with clear colours
- Overlaying of graphs for straight comparison. Colour coded assignment of various products, lubricants respectively tools and /or coatings
- Individual adaption of mark thickness, line management, ink density etc. for presentations
- Free space for project related notes and comments in Analyser
- Return Travel function ON / OFF

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Calculation Formula and Method of WinPCA

Measurement Formula

Torque measurements are compared acc. to process quality control and values displayed on the screen as a graph, with applied torque shown as a bar chart. The formulas used to find the Mean and the Standard Deviation are as follows:

Average (Mean Value) = $\sum_{i=0}^{n-1} x_i / n$ StDev = $\sqrt{\sum_{i=0}^{n-1} [x_i - ave]^2 / n}$

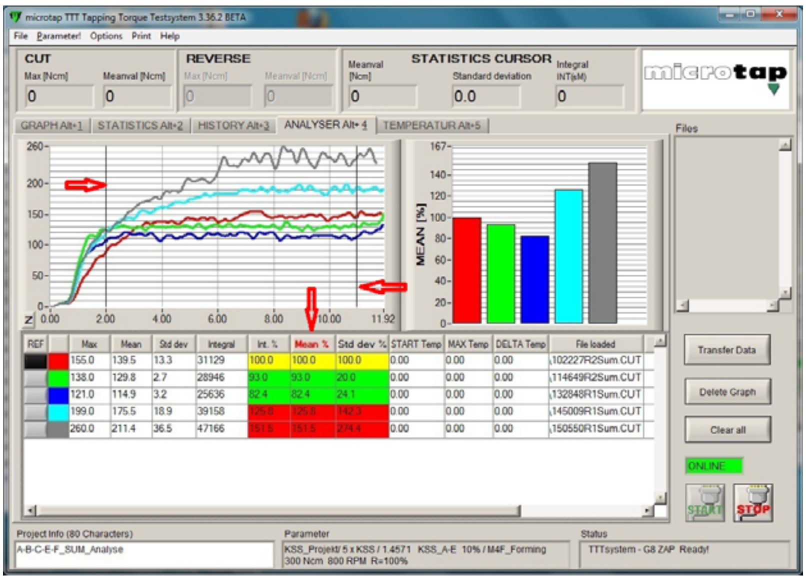
Mean Value / Arithmetic method
The expression is called arithmetic methods of n sizes

$a_1, a_2, \ldots, a_n$ $\qquad \chi_A = \frac{a_1 + a_2 + \ldots + a_n}{n} = \frac{1}{n} \sum_{k=1}^{n} a_k$

For two sizes a and b $\qquad \chi_A = \frac{a+b}{2}$

Analyser and Comparison Method

The max. Torque, the Mean Value-Torque, Standard Deviation and Statistics (according to Gauss), as well as the Integral and Delta T value are depicted according to Dual-Cursor in both, graph and bar chart.



The tabular evaluations show the difference (within range of cursor) of five measurements depicting the Mean Value in relation to reference (100 % / yellow).

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TTT Methods (Thread Forming and Cutting)

Thread Forming

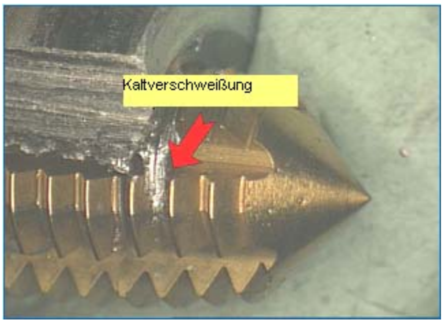
Thread forming has acquitted itself well as a standard measurement procedure in proof of effectiveness of lubricants.

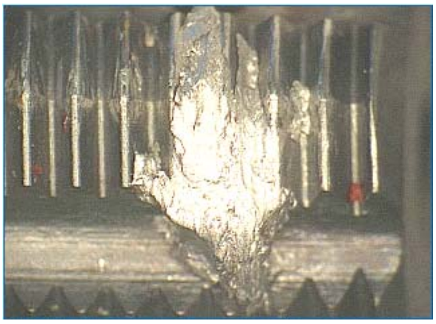
When cutting threads (substitution for machining), in contrast to forming threads (substitution for forming) lesser torque is required.

Fibre course at thread-**cutting** — Fibre course at thread-**forming**

Comparison of Thread Types

In comparing measurement values of thread forming and thread cutting (lesser torque) the functionality for high und low friction can be evaluated.





Cold Fusion

Cold fusion arises when the lubrication film is interrupted and the interacting surfaces go into fusion. In such a case the measurement tool is badly damaged and actually ruined.

Surface

When testing with a magnifier or a digital microscope even a layman can easily recognise the bad state respectively the wear of the tool (the digital-microscope is an option of the TTT System).

Built-Up-Edge

Also a built-up-edge (or break-outs) can likewise be recognised at the measurement tool with a microscope / magnifier.

For optimised assessment of the thread surface the thread should be cut open and thoroughly examined with a microscope.

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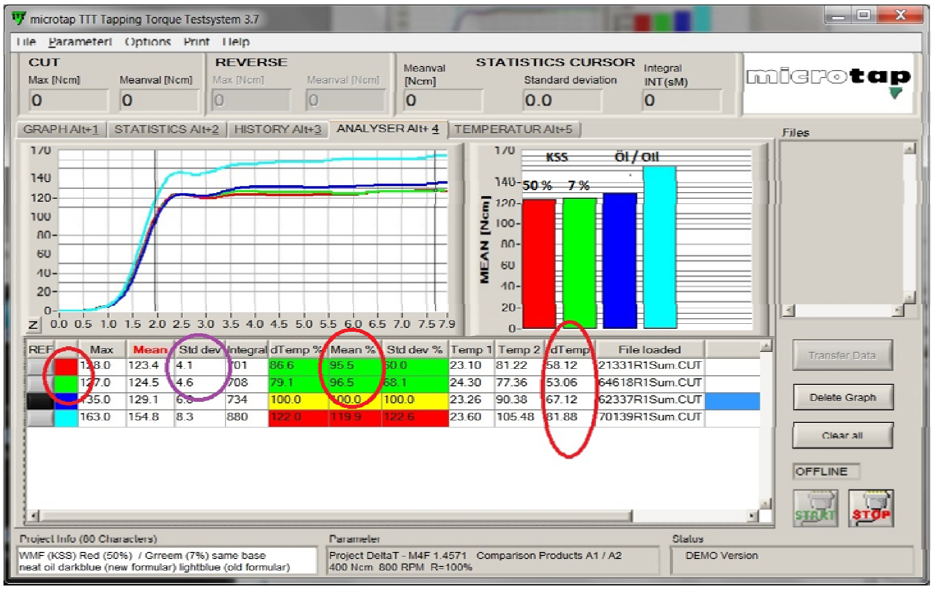
Performance Comparison Neat Oils and MWF’s

Practical Example

We compare the functionality of neat oils in direct practical comparison with water miscible MWFs using austenitic steel X6CrNiMoTi17-12-2 (V4A / 1.4571 / 316Ti) for thread forming with M4 at 800 rpm and 8mm depth.



Results and Analysis

Red and **green** in the bar chart are water miscible MWFs: with 50% (**red**) and 7% (**green**). Dark – and light blue are neat oils for corrosion resistant steel (Nirosta), where **dark blue** is an optimisation, which was refined from **light blue** according to customers demand. Here the difference between the oil products can be recognised most distinctly. In this example the dark blue product (optimised oil variant) is employed as a reference (100 %).

In the **tabular evaluation** we distinctly recognise via entire measurement data, that both the MWFs (marked green) score better. As a reference (yellow /100 %) we use the optimised neat oil. The old neat oil (light blue) is defeated in all measures, since it looses versus the reference (optimised product).

The comparison of MWFs concentrations, here 50% (**red**), 7% (**green**) significantly shows the impact of a higher amount of water (93%) in Δ**T**-value – but also the hereby caused higher standard deviation of 4.6 against 4.1 (10%).

Both the water miscible MWFs **red** and **green** come off well in all results compared to the pure neat oils **dark blue-** (the optimised oil variant) and **light blue**. The result however is not surprising. The development of MWFs significantly makes progress.

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TTT Methods , Know-How and Outlook

Carry-over-Effect

A common problem in dynamic measuring of lubricants is the so-called "Carry-over-Effect" which occurs when several series of measurements (with different lubricants) are (to be) performed with the same tool.

Here we talk about the carry-over respectively the transfer of chemically self-acting additives (surface-active substances) via tool from one lubricant into the other. Attention should be paid to the thereof resulting mechanism of action when in combination with certain temperatures (!) surface-active additives form so-called reaction layers during process, for example FeS (iron sulphides, pyrites). These layers may alter the crystalline structure of surfaces, change the electronic setting locally and enlarge the surface. Here it has to be assumed that (at least) in the moment of functioning they do not sit on top of the surface – as often is read in books – but rather generate a new surface themselves. Therefore it may not be possible to remove the residues of these additives from the tool with agents like gasoline, acetone and air pressure.

TTT Methods

The destination was to avoid such falsification. With a specially developed TTT Method the Carry-over-Effect can be discovered. The possible results may actually lead to new insights.

Measurement Tool-Compensation

With another TTT Method we additionally realise a compensation of tool wear in series of comparing measurements of a variety of lubricants with one tool only. That goes along with a significant cost reduction for measurement tools.

Integration of Customer-Logos

On request we integrate your customer logo into the WinPCA so that you are able to depict and pass on evaluations, internally and externally, under the name of your own company, without any external software.

Outlook

In close cooperation with TTT Customers we intensely and progressively engage in enhancing the TTT System and look forward to any kind of cooperation and suggestion.

If you have questions, please send an email to support@microtap.de. We are looking forward to assist you as quickly as possible.

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