Microfinishing – yesterday – today and tomorrow from Micron to Nano and Ångström

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April 2005

1. The single wheel lapping and polishing technique

Since 1960, when the author started to work in the lapping business, until present time (2005) the lapping technique has experienced an enormous improvement in quality.

At that time, a simple single wheel lapping machine equipped with the ingenious dressing device (dressing by the very friction of the dressing rings) proved a huge success whereas nowadays highest precision is requested (picture 1).

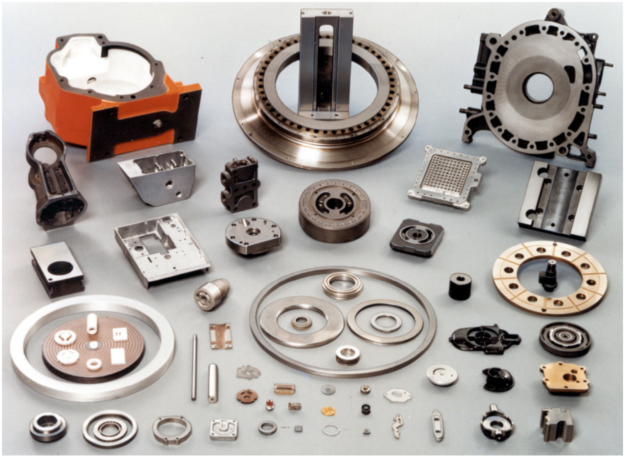
New technologies, such as the double wheel flathoning technique (developed by the author in 1980), have resulted in the so-called "clean lapping", offering high stock removal <u>and</u> high precision.

Picture 1

Single wheel lapping machine with 3 dressing rings.
The pressure plate allows parallel-machining at highest quality.

2. What will be decisive for the further existence of single wheel lapping machines ?

The increasing requests for dimensional tolerances, flatness and roughness can still be met by the single wheel machine techniques and can hardly be replaced by any other technique.



Picture 2

Lapped work pieces
Mostly for single wheel technique

An important increase in quality was obtained by using so-called "high-precision tools" such as diamond grit, vehicles, special working wheels (multi-metal) and polishing coatings. Without the lapping and polishing technique, CD/DVD and high-tech applications such as data systems, mobiles, space travel a.s.o. (picture 3) would hardly exist.

The possibilities of the lapping and polishing techniques are not exhausted yet, it is quite often due to lacking development in material techniques that qualities in the nano or angstrom range can't be obtained without problems.

Picture 3

Mirror polished injection mould made from steel.
Holder for CD injecting moulding die, surface in the Nano-range Ra 0.001 Mikron (10Å)

3. The double wheel lapping technique

In the middle of the 20th century, when the double wheel lapping technique had its first success and Hahn & Kolb already used bound grit wheels, the research for low wear tools and working wheels began.

Inserting diamond honing strips into the grooves of cast iron wheels gave the first positive results. The reinforced double wheel machines in C-execution (DLM 750/1985) and the cooperation with diamond wheel manufacturers (Diametal) brought the first big successes.

Soon, other manufacturers started as well to build this type of machine and the proper breakthrough was realized when working wheels made from synthetic material, ceramic-bound diamond and CBN were used in order to have a wheel perfectly adapted to the corresponding work piece material.

The double sided flathoning of ceramic control discs used in mixing faucets is exemplary. The obtained stock removal of up to 0.8 mm in less than 30 seconds for loads of 200 pcs, Ø 35 x 5mm, was revolutionary to everyone. Furthermore, the results of tolerance in thickness, flatness and roughness were so excellent, that only little polishing time was needed to obtain the required final quality (picture 4).

Picture 4

Flathoned ceramic discs
Sealing surface polished to Ra 0.01, flatness <2 lightbands 0.6 Micron

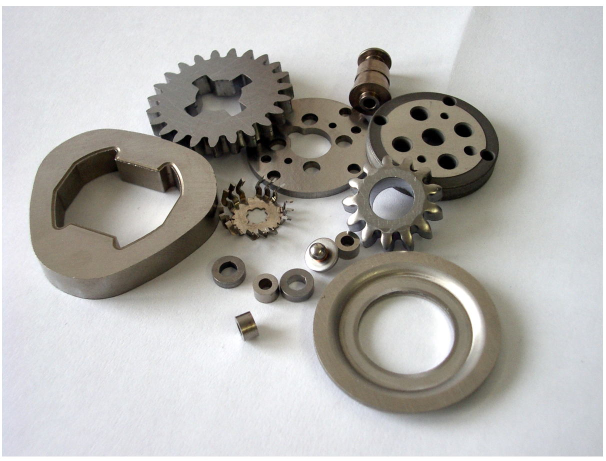
4. Stähli go their own way in machine building

Thanks to the newly developed DLM 705 bridge construction machine line the flathoning technique proves even more economic for the machining of series of flat pieces made from nearly all materials, from aluminum and steel to hard metal and hard ceramics.

Work pieces with thickness from less than 0.5 mm up to 50 mm and diameters from 1-200 mm are machined in the micron range. Stock removal rates up to 0.5 mm are common in astonishingly short cycle times from <1-10 minutes for 10-1000 pieces per load, according to work piece size, stock removal and machine type (pictures 5 + 6).

Picture 5

Production-Flathoningmachine DLM 705 with loading and unloading tables-



Picture 6

Sample pieces flathoning

5. More economic efficiency thanks to automation

For this purpose, helpful recourse was taken to the pin and toothed ring system with the so-called workpiece carriers, satellites respectively. 1 or 2 lowerable sections of the outer pin ring made loading and unloading possible, first manually then fully automatic.

The loading and unloading method of the sandwich-system (DLM-Stähli) with controlled gap between the working wheels provide 100% security that no workpieces lie superimposed or askew in the carrier or remain in the machine. Loading and unloading times are less than 30 seconds for 5 carriers (picture 7).

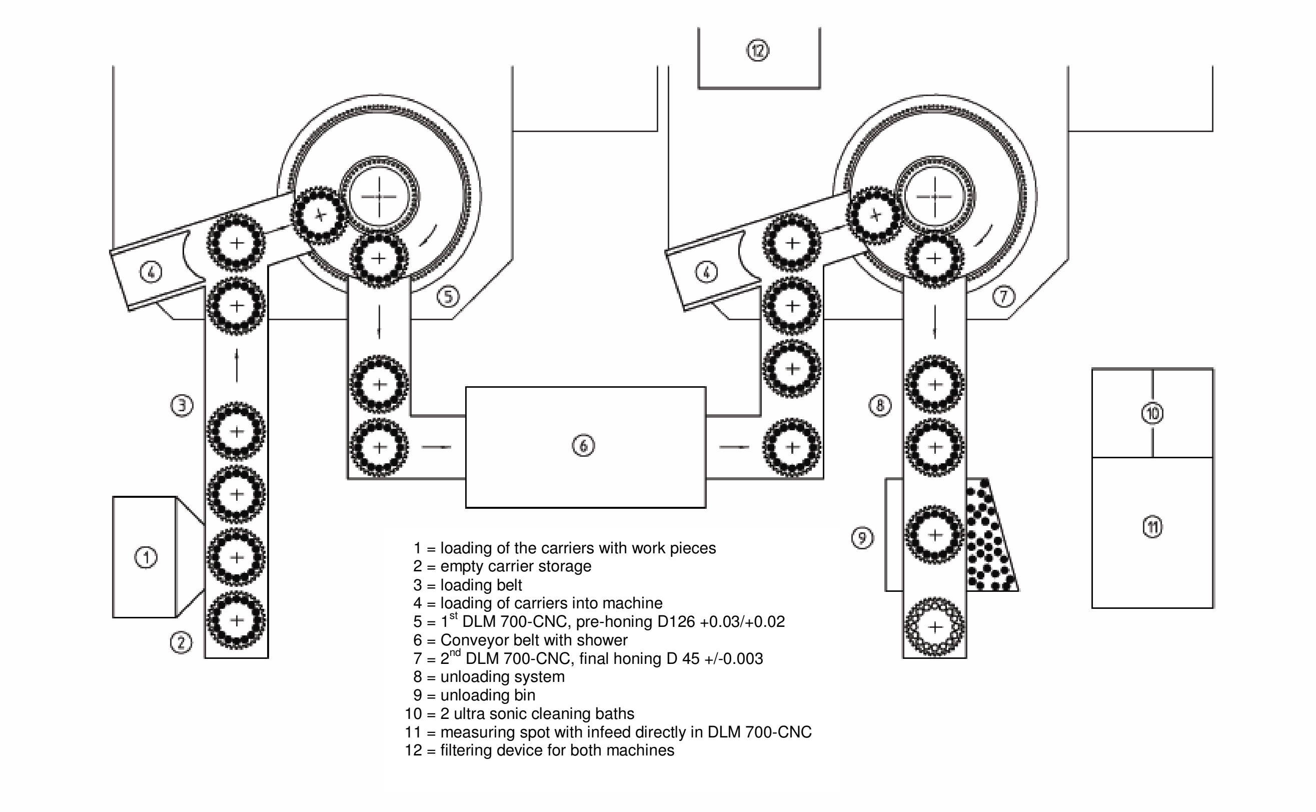
Picture 7

DLM 700
Fully automatic, pre-loaded waiting station, loaded and unloaded within 30 seconds

6. Interlinking – another step towards efficient production

The use of bound grit wheel in the flathoning technique results in metal-cutting machining entailing burrs on the work pieces. For specific deburring as a succeeding operation, a deburring machine equipped with a turning device for two sided deburring is appropriate. A direct transfer after the flathoning process is efficiently solved with Stähli machines.

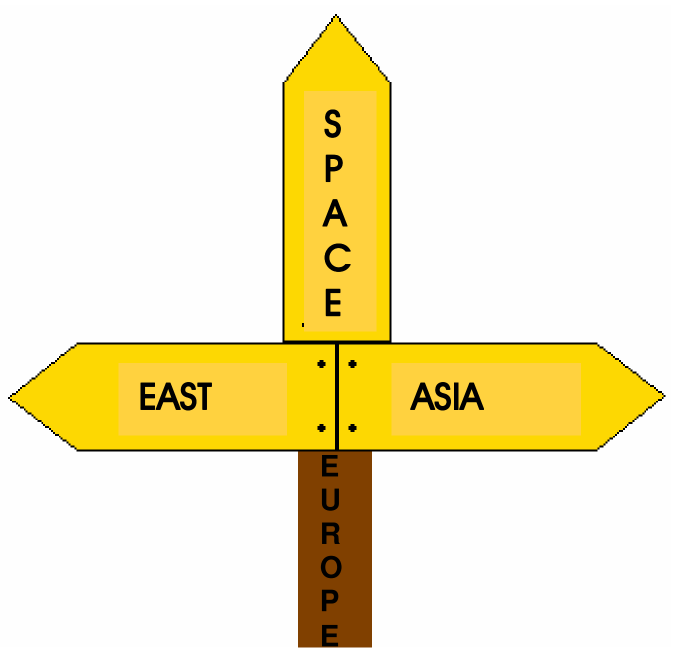
The request to interlink the two wheel flathoning process with the one wheel polishing process was successfully realized with Stähli machines thanks to developing the automation of one wheel polishing machines back in the year 2000. The interlinking of 2 two wheel flathoning machines with intermediate cleaning to prevent the spreading of the grit is represented in picture 8.



Picture 8

Linkage of 2 machines

7. Where does the journey of part processing go to? What is still feasable in Europe?



Picture 9

Very often, production is transferred from Europe to low cost countries. But the necessary technique as well as the know-how are preferably still developed at the headquarters or the inland, and then dislocated with new machines. A dislocation of so-called "old" machines does not seem to be economic. Only labor and social charges of the chosen location are decisive (picture 9).
This gives to us, the machine manufacturers, the new chance to make transit deliveries for machines and installation all over the world.

Together with the increasing improvement of the measuring technique the market requests more precise parts and thus more advanced production techniques.

The precision in measuring, from 0.01 mm to 0.001 mm (µ) and 0.00001 mm (nm) to 0.0000001mm (Å) (see chart picture 11) is very exacting to the machine constructing industry and processing know-how.

Stähli face up with the challenge and great endeavors are continuously taken together with technical colleges and universities for constant improvements and to bring new developments to the stage of production ripeness. Internal developments, assisted by daily experience gained from contract work, support the process.

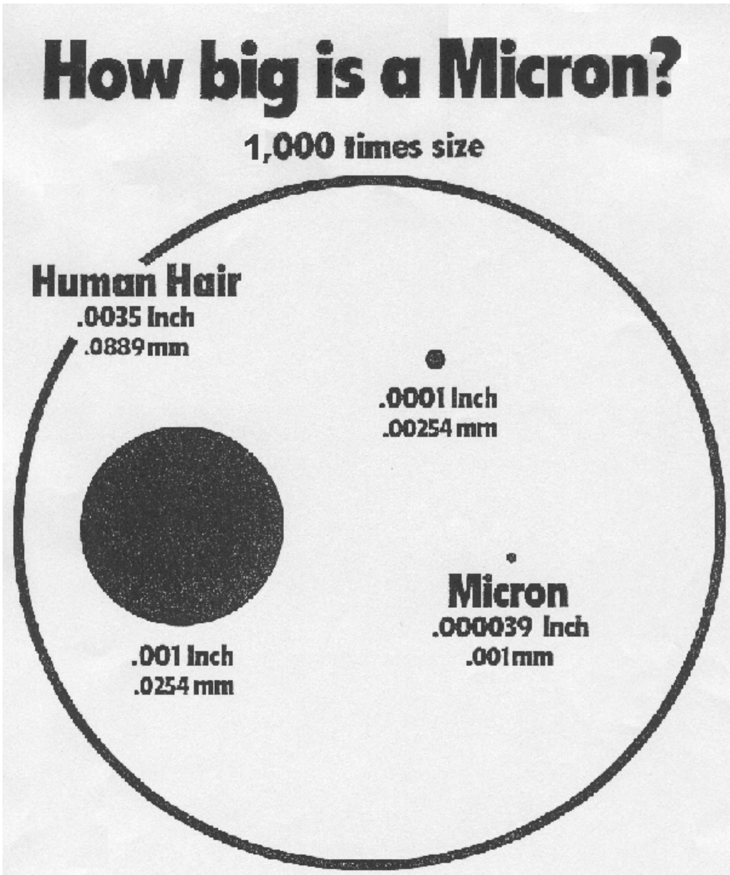
The quest for an extra performing two wheel flathoning machine with e.g. 75 kW driving power and speeds per wheel of up to 2000 min^{-1} for Ø 500 mm is taken up by Stähli. In this respect the diamond as well as the CBN wheel manufacturers are challenged. The journey already heads for cutting speeds of m/min. and thus into the range of the grinding technique with its cutting speeds of m/sec.

8. Space as an example for proportions in size.

In space the sun and the moon are well perceptible by their size. The stars are just luminous dots. But the infinite space still hides a indefinable amount of stars and systems.

We are just at the threshold of the infinite space. Technique and research respectively continue requesting precision up to the Ångström (see chart, picture 11).

The proportions in size of the techniques already reached and still to be reached are represented impressively in picture 10.



Picture 10

We will face up to the requirements . Only the lapping and polishing technique can go on this journey ….. we are highly motivated. Good luck on your journey, travel with us.

Nano-objects	1 nm = 10^{-9} m = 0,001µm = 10 Å Nanos = dwarf (greek)
0,25 nm	Metal atoms (Cu, Ni, Fe, Ta)
0,5 nm to 1 nm	small molecules, fullerenes (C_{60} -"football- molecule")
1 nm to 10 nm	nano crystals, molecules, nano spheres of face-creams and metallic paints, thickness of single layers of multilayers for radio optical components, width of the DNA helix (approx. 2.5 nm), width of transistor gates
10 nm to 100 nm	macro molecules, thickness of foliated gold (approx. 100 nm), lower physical limit of conventional photolithography (100 nm)
100 nm to 1'000 nm	shortest wave lengths of laser light (192 nm), spectral range of visible light (350 nm to 750 nm), coating of architectural and spectacle glasses, structural sizes of 256 MBit-Chip (approx. 250 nm), thickness of an iridescent oil film or a soap bubble, smallest dust particle, minimum structural width of saleable electronic components (approx. 500 nm), lower object limit for light microscopes (approx. 500 nm)
1'000 nm to 10'000 nm	bacteria, red blood-corpuscles, distance of the grooves of CD's (approx. 1'500 nm), thickness of single nervous tracts, hard material layers (TiN, WC), thick decorative coating
10'000 nm to 100'000 nm	thickness of kitchen aluminum foil (10µm to 15µm), hair (ca. 50µm), subfractional micro motors (pumps, valves; electro motors) (100µm to 200µm)

Picture 11