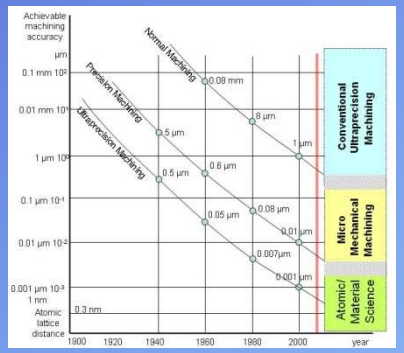
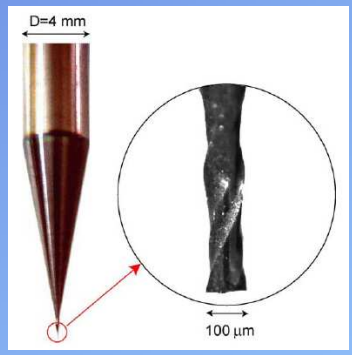
Innovative Manufacturing Processes

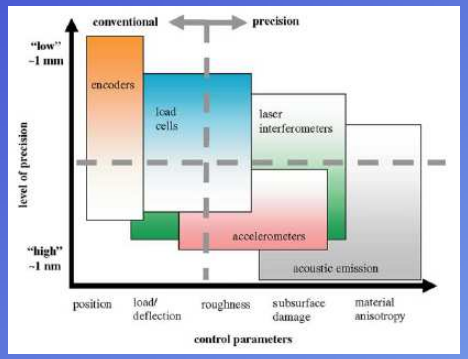
Tool Condition Monitoring (TCM) in Micro-Milling

Micro-milling utilizing smaller cutting tools developments and higher speeds as to meet machining trends for increasing accuracy and product miniaturization



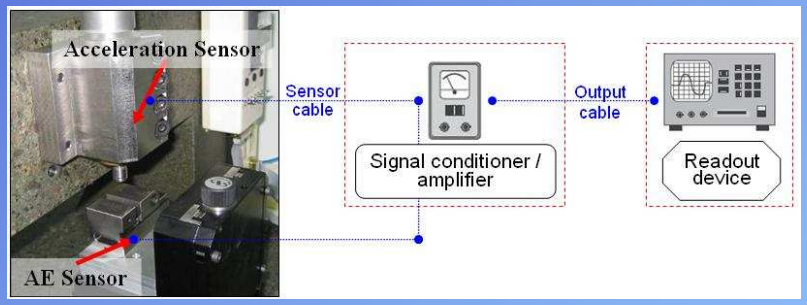


Major problems for micro-milling are unpredictable cutting tool life and premature tool failure



Two main TCM groups for Micro-milling:

- **Direct methods:**
  - **Optical sensing**
- **Indirect methods:**
  - **Cutting forces**
  - **Acoustic emissions (AE)**
  - **Tool/part vibrations**



Fusion of sensorial signals could be used for the TCM in micro-milling:

- **Acceleration sensor: spindle vibrations**
- **AE sensor: tool failure or chip breakage**

REF: Stavropoulos, P., K. Salonitis, A. Stournaras, J. Pandremenos, J. Paralikas and G. Chryssolouris, "Advances and Challenges for tool Condition Monitoring in Micro-Milling", Proceedings of the IFAC Workshop on Manufacturing Modelling, Management and Control, Budapest, Hungary, (November 2007), pp. 157-162.

Innovative Manufacturing Processes

Experimental Investigation of Micro-milling Process Quality

Micro-milling process quality is difficult and more challenging to be controlled. Measurement of the average surface roughness Ra (μm).

$$R_a = (1/L) \int |Y(x)| dx$$

Use of matrix of experiments L_9 (3^4):

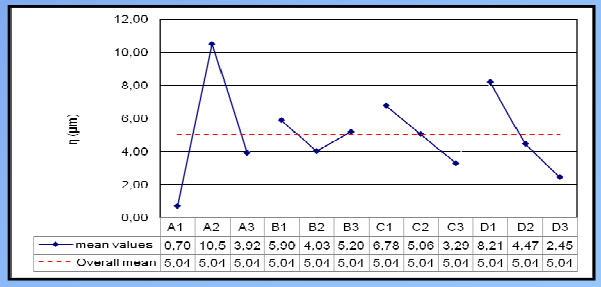
- **Determination of effects of main cutting parameters on the average surface roughness**
- **Optimum level values for minimum average surface roughness**

Factors affecting experiments:

A. Tool diameter (mm)
B. Rotational speed (RPM)
C. Feedrate (mm/sec)
D. Depth of cut (mm)

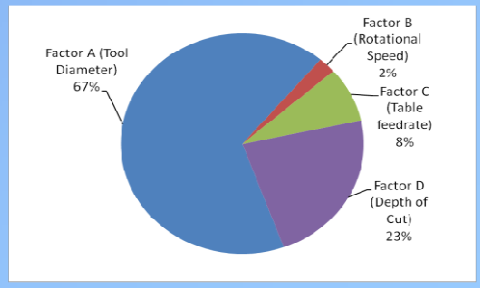
Calculation of signal-to-noise (S/N) ratio:

ηi = -10 log10(average of the squares of the Ra in the experiment i)



	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
mean values	0,70	10,5	3,92	5,90	4,03	5,20	6,78	5,06	3,29	8,21	4,47	2,45
Overall mean	5,04	5,04	5,04	5,04	5,04	5,04	5,04	5,04	5,04	5,04	5,04	5,04

Implementation of ANOM and ANOVA analyses for calculation of the optimum value of each factor, and their responsibility (%) on average surface roughness (μm)



REF: Stavropoulos, P., K. Salonitis, A. Stournaras, J. Pandremenos, J. Paralikas and G. Chryssolouris, "Experimental Investigation of Micro-milling Process Quality", Proceedings of the 40th CIRP International Seminar on Manufacturing Systems, Liverpool, U.K., (May-June 2007)