Incremental Forming Processes

Con attrezzature dedicate

- Processi tradizionali
  - Spinning (imbutitura al tornio)
  - Rotary swaging

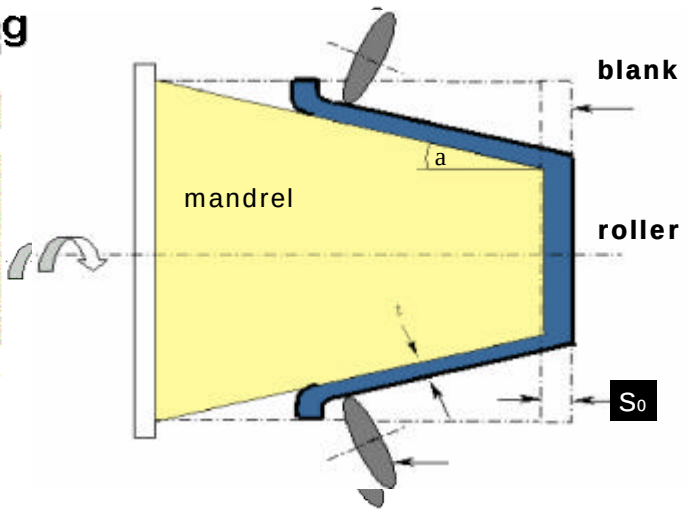
Senza attrezzature dedicate

- Processi innovativi
  - Dieless incremental forming

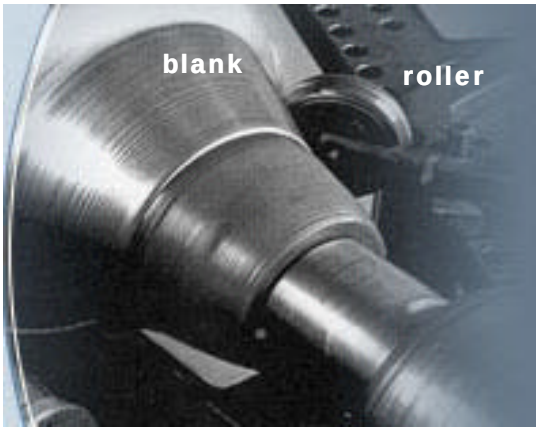
Spinning

Cone spinning

Imbutitura al tornio da lastra



Cone Spinning

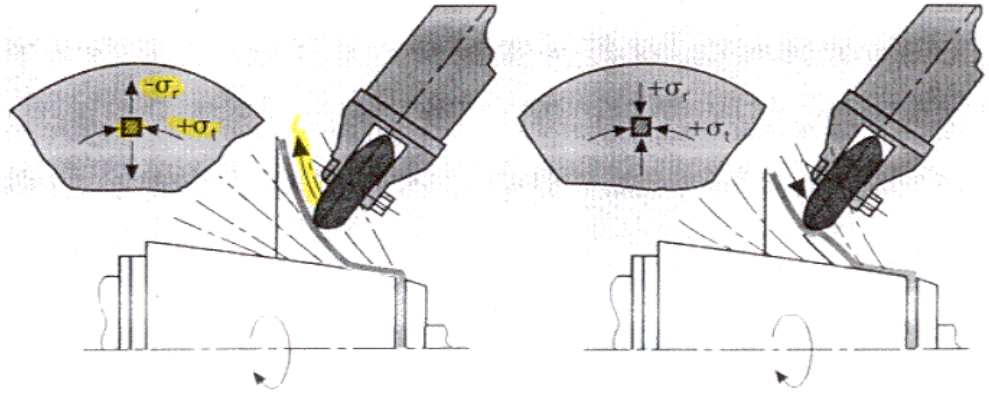


Spinning

Spinning

Cone spinning

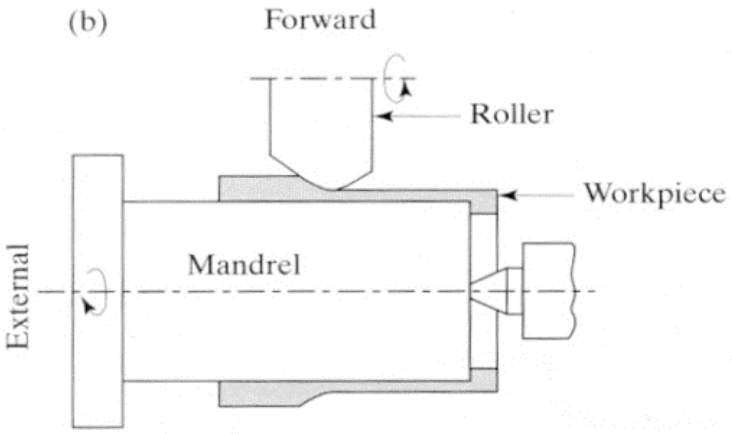
stato di sforzo



Spinning

Tube spinning

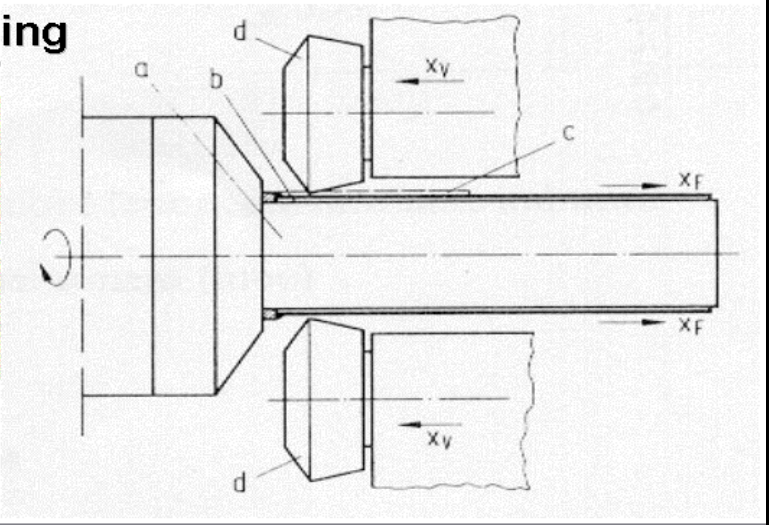
Imbutitura al tornio da tubo (concorde)



Spinning

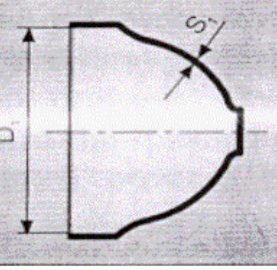
Tube spinning

Imbutitura
al tornio
da tubo
(discorde)



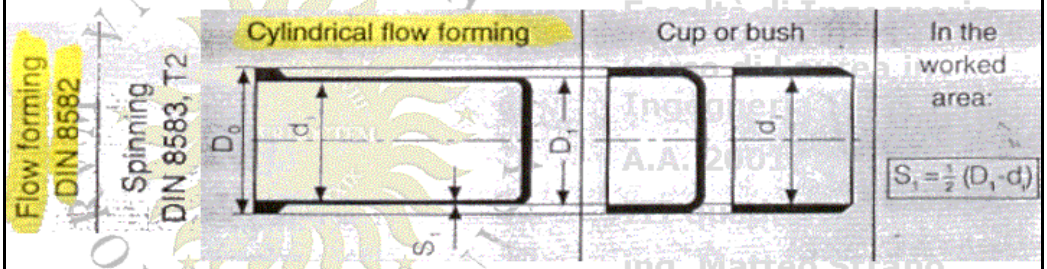
Spinning

Nomenclatura
norme DIN

Standard		Process	Starting blank	Wall thickness
Compression forming DIN 8582	Tension forming DIN 8584, T4	Spinning 	 Disc blank $D_0 > D_1$	Approx. constant: $S_1 = S_0$

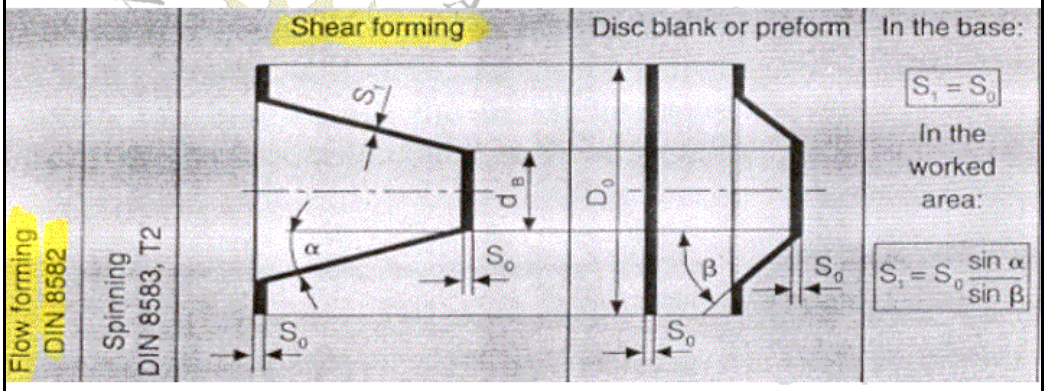
Spinning

Nomenclatura norme DIN

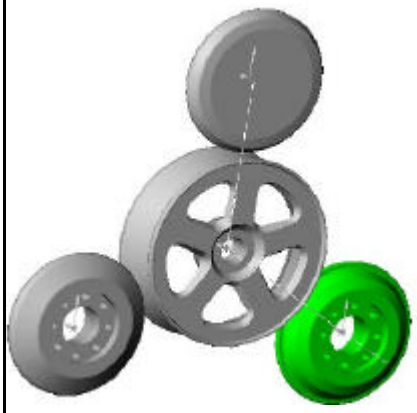


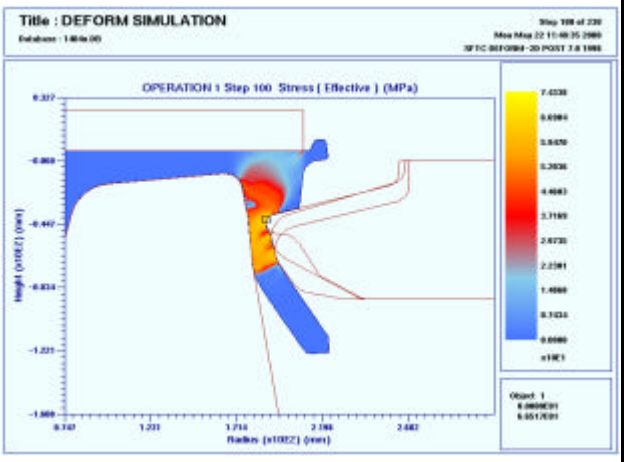
Spinning

Nomenclatura norme DIN



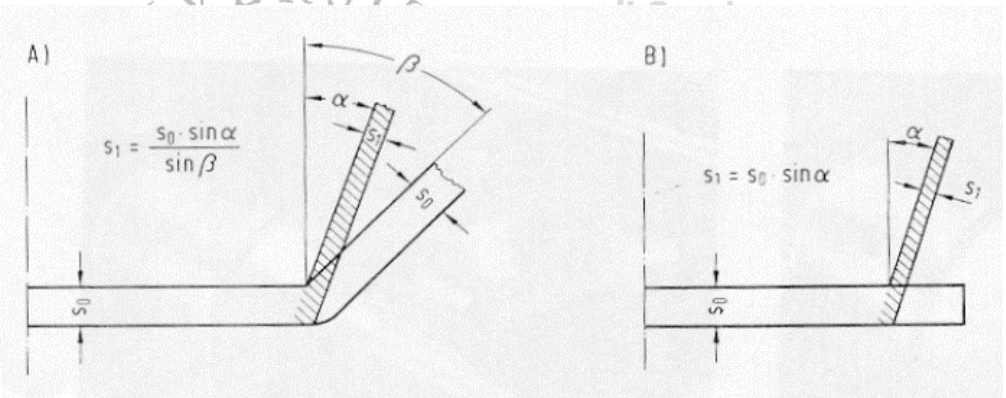
Flowforming



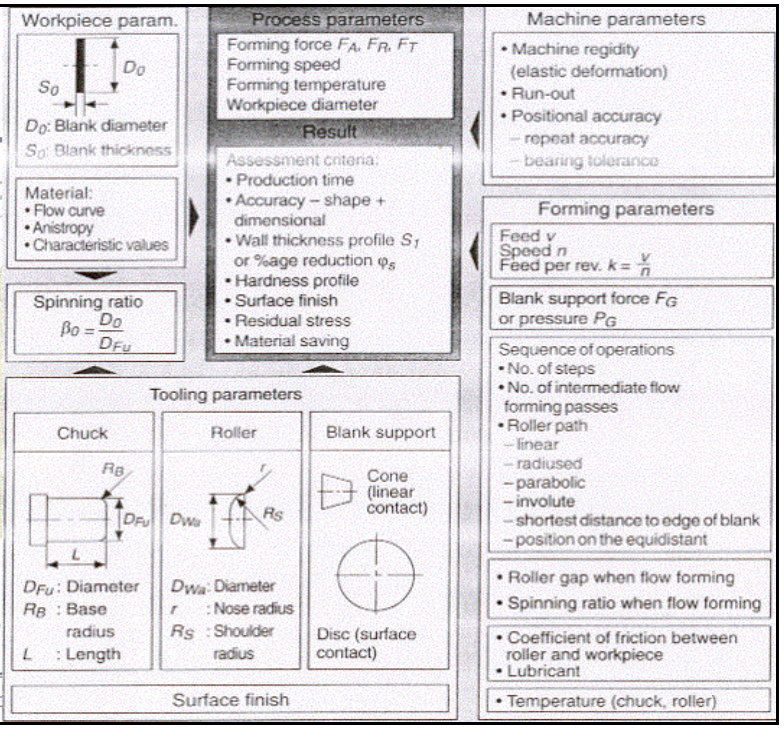


Spinning

La legge del seno

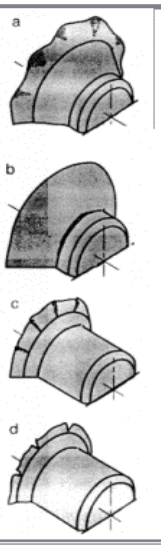


Spinning
Parametri di processo



Spinning

Cone spinning
Tipi di difetti



Wrinkling
compressione tangenziale

Splitting
trazione radiale

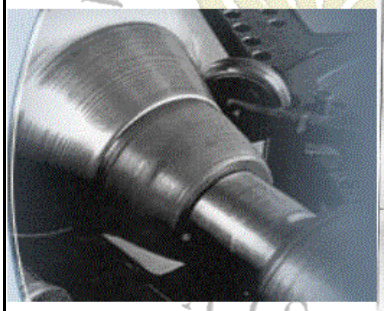
Splitting
compressione tangenziale

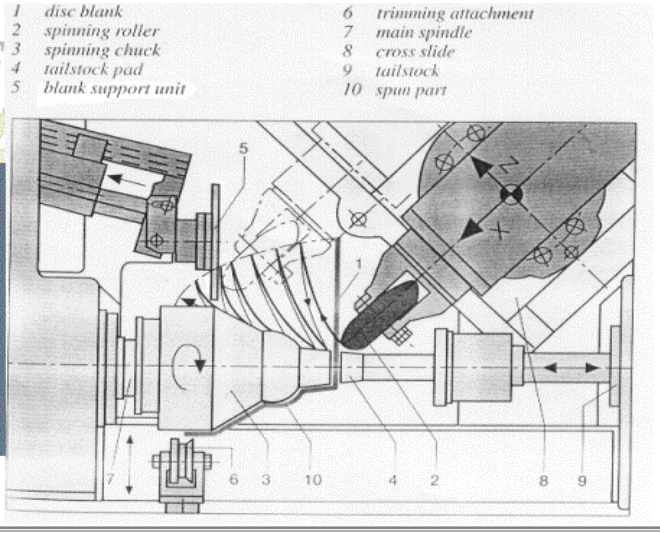
Splitting
trazione tangenziale

Spinning

Cone spinning

Il sistema





Spinning

Cone spinning

Il sistema

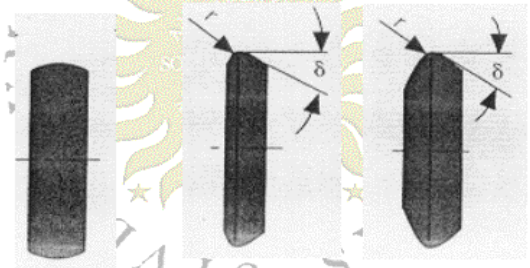
Le matrici

Spinning

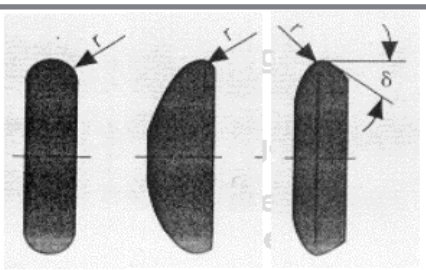
Cone spinning

Il sistema

I rulli



finitura Shear forming



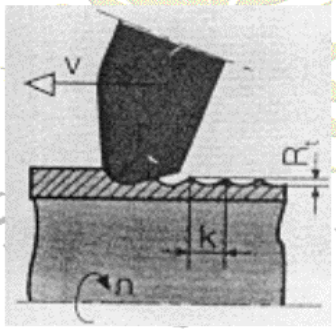
Tornitura da lastra a spessore costante

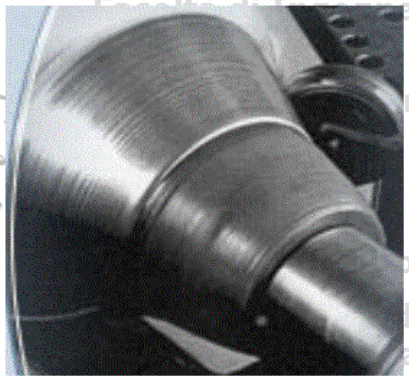
Short runs can be produced on soft tooling (phenolic or mild steel tools) whereas longer runs or more complex shapes may require hardened tools

Spinning

Cone spinning

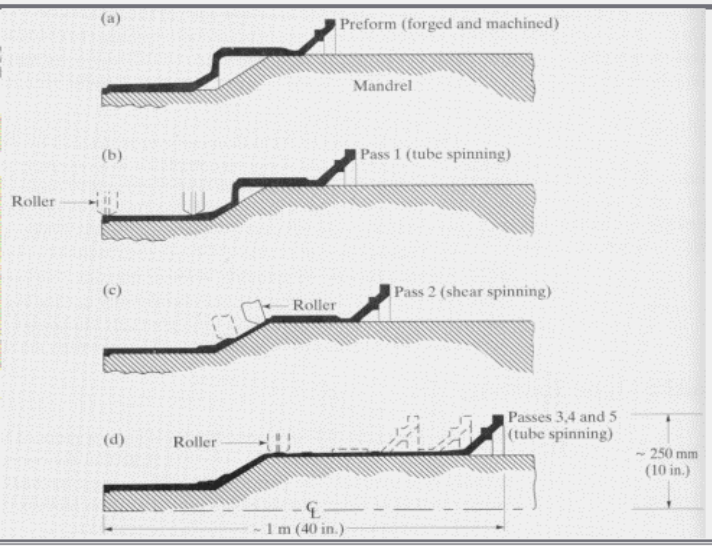
Influenza sulla finitura superficiale





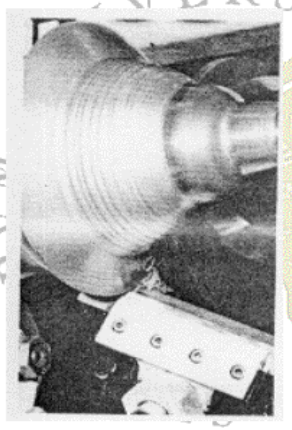
Spinning

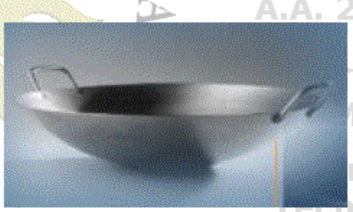
Example of application



Spinning

Spun products





Spinning

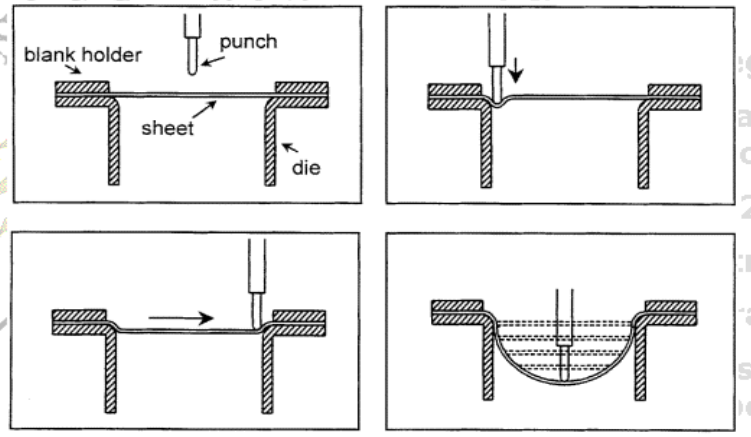
- Advantages
  - tooling is relatively inexpensive due to its simplicity and composition.
    - This simplicity translates into short lead times for new parts
    - Design changes can usually be made at a minimum of expense
    - The factors above combine to make spinning ideal for prototypes
  - Spinning is typically a cold working process; therefore, spinning increases the tensile strength of the material.
  - Due to the method of forming, repeated passes with a roller or hand tool, the spun metal product typically exhibits high strength characteristics and high formability

Spinning

- Limitations
  - Extreme tolerancing requirements may dictate the use of secondary operations.
  - Manual spinning is more labor intensive than automatic spinning or other forming processes such as drawing.
  - The uniformity of a manually spun part is closely associated with the skill of the operator.

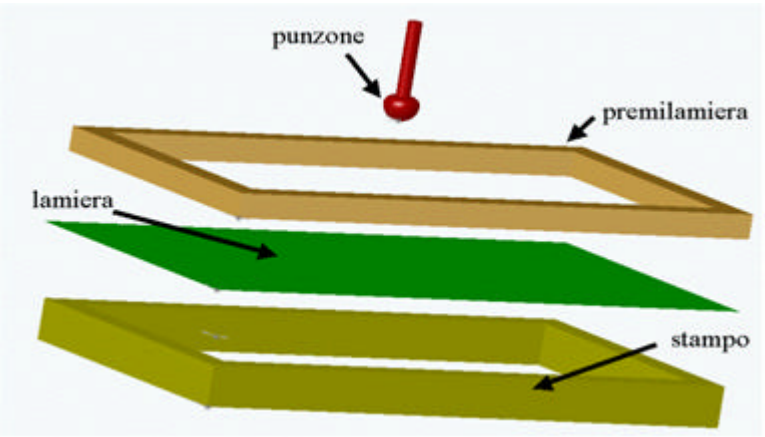
CNC incremental forming

- Schema del processo



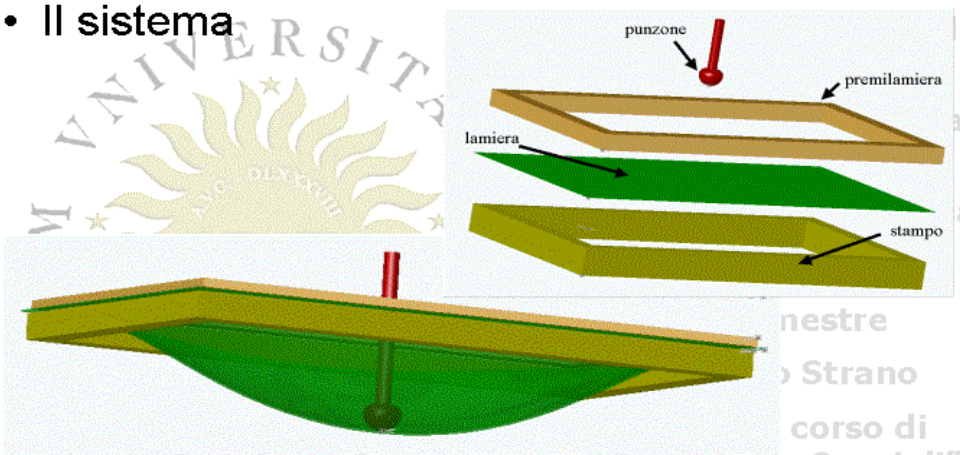
Dieless incremental forming

Setup



CNC incremental forming

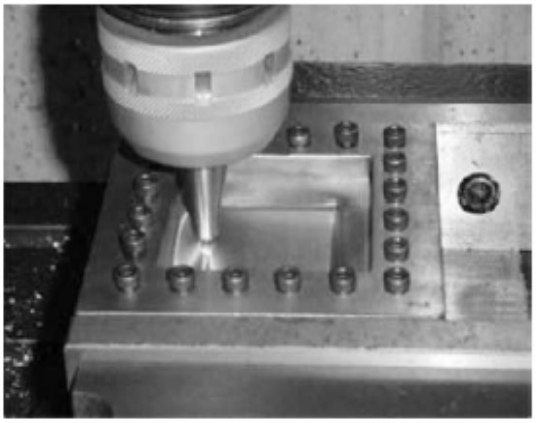
- Il sistema



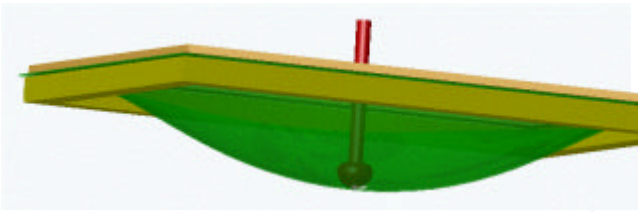
CNC incremental forming

- Il sistema

Esempi



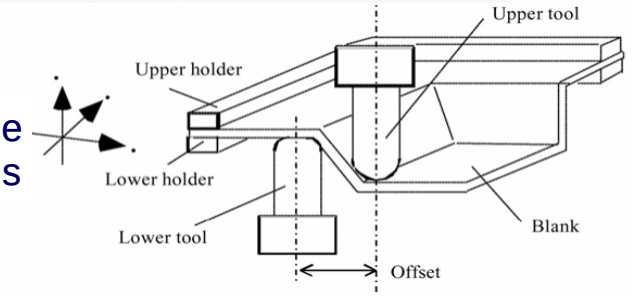
Dieless incremental forming



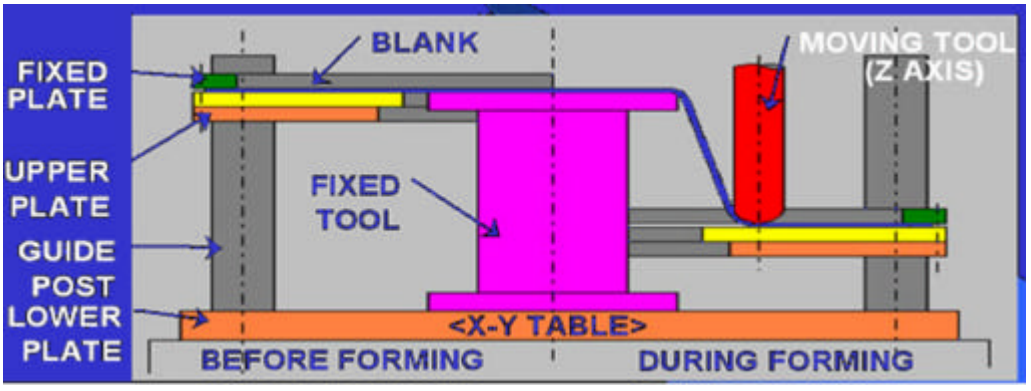
single roller

vs.

multiple rollers



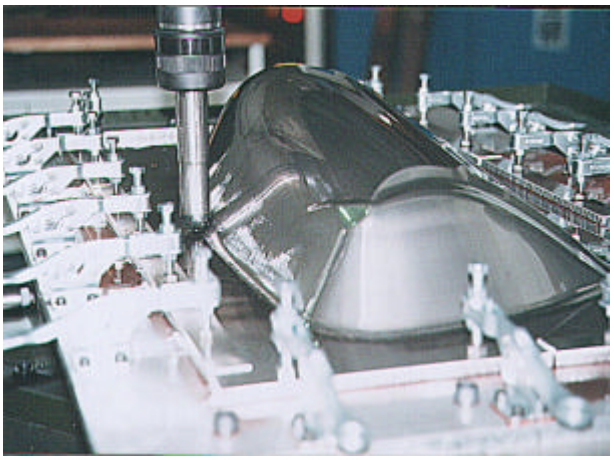
Dieless incremental forming



CNC incremental forming

- Il sistema

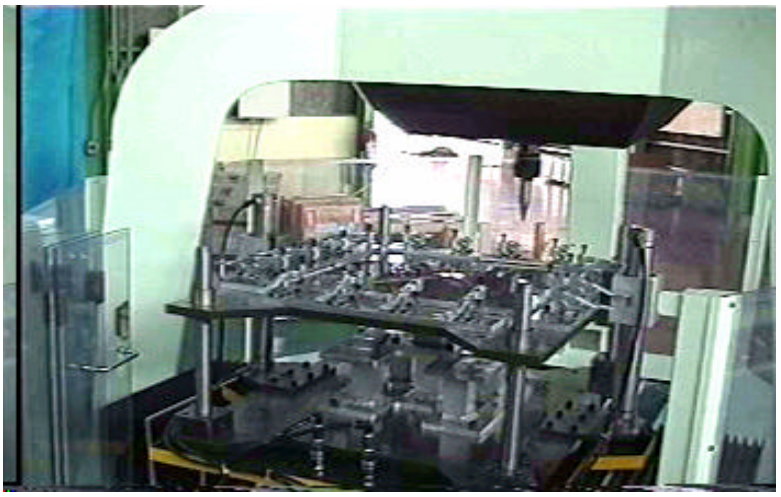
Esempi



CNC incremental forming

- Il sistema

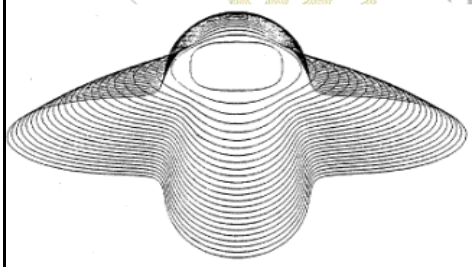
Esempi



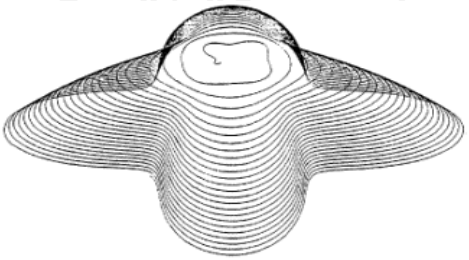
CNC incremental forming

Generazione delle traiettorie

- Single pass



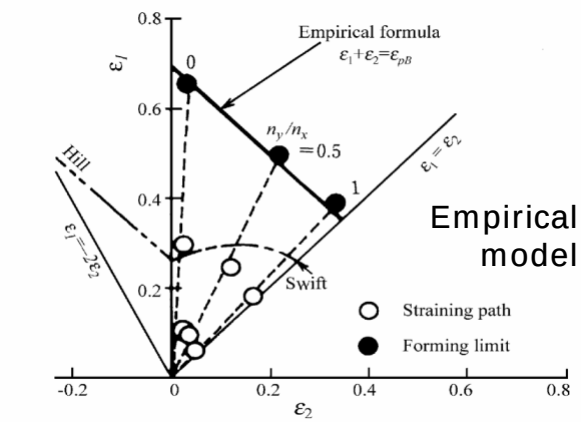
2 assi 1/2



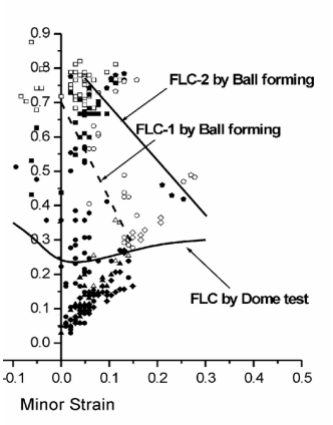
spirale

Dieless incremental forming:

Forming limits



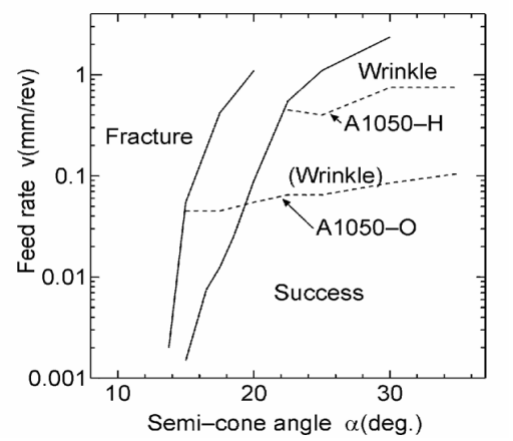
Empirical model

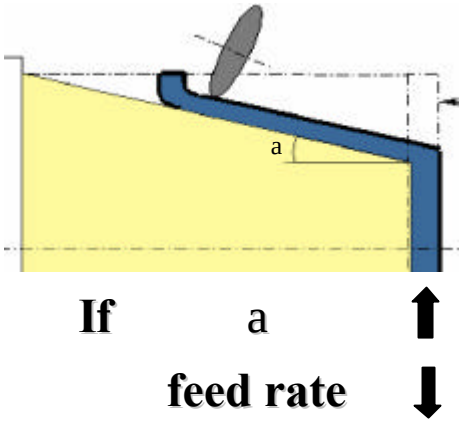


Experimental tests on aluminum

Dieless incremental forming:

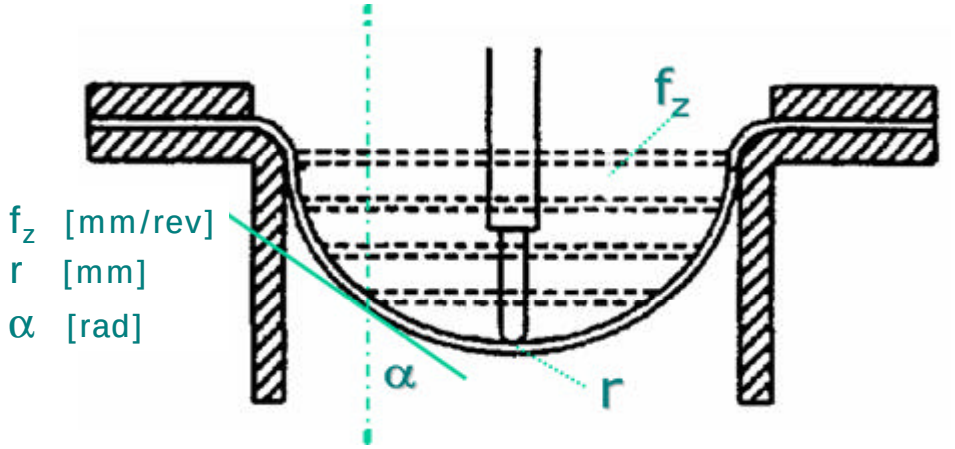
Effect of step size for cone spinning





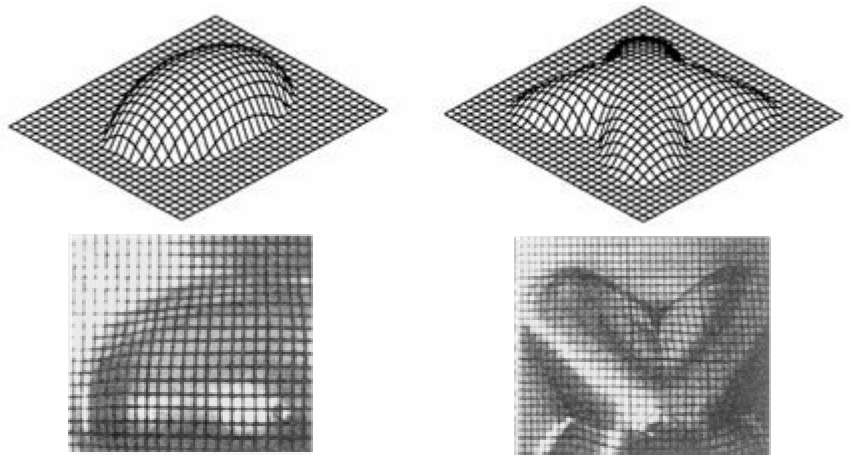
Dieless incremental forming:

Main process parameters



Dieless incremental forming:

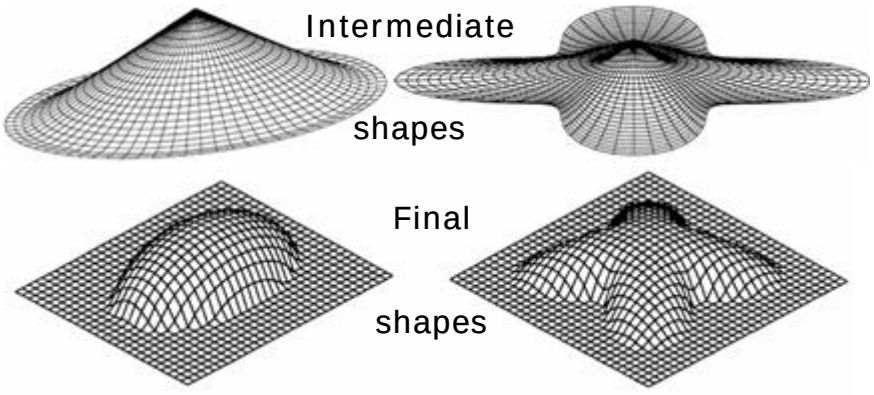
pure shear deformation



Dieless incremental forming:

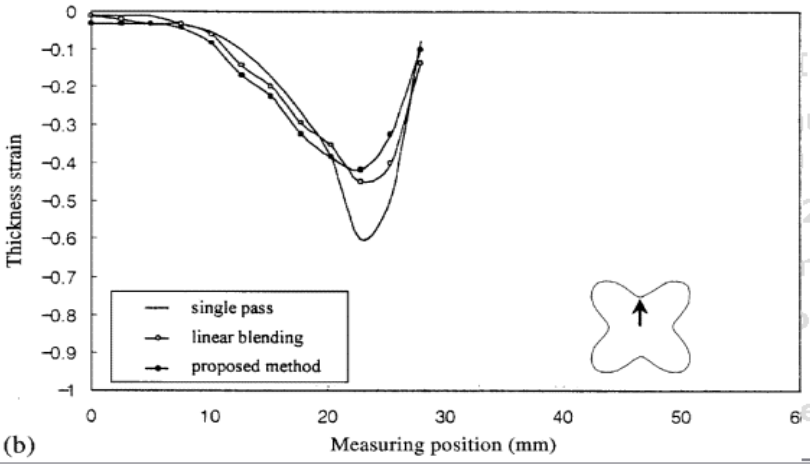
Single pass vs. multiple pass

– Effect of slope, (a)



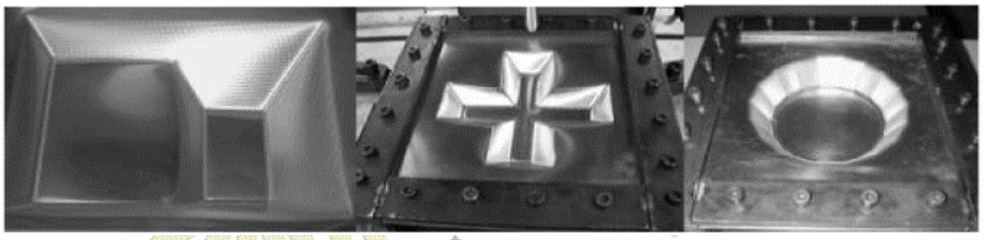
CNC incremental forming

Generazione delle traiettorie



CNC incremental forming

Esempi di parti



CNC incremental forming

Esempi di parti

CNC incremental forming

Vantaggi principali

- alta formabilità
- Assenza di stampi e attrezzature dedicate

Svantaggi principali

- Lentezza del processo
- Notevole difficolta di determinazione di traiettorie ottimizzate

Conclusions

- Dieless incremental forming:
  - is an effective way of producing prototype and small batches sheet metal parts
  - can be used as an economic way of preforming shapes for subsequent operations
  - formability is greatly increased by localized and incremental deformation
  - tool paths can be optimized in order to further improve the process capabilities