



Incremental Forming Processes

Con
attrezzature
dedicate

Senza
attrezzature
dedicate

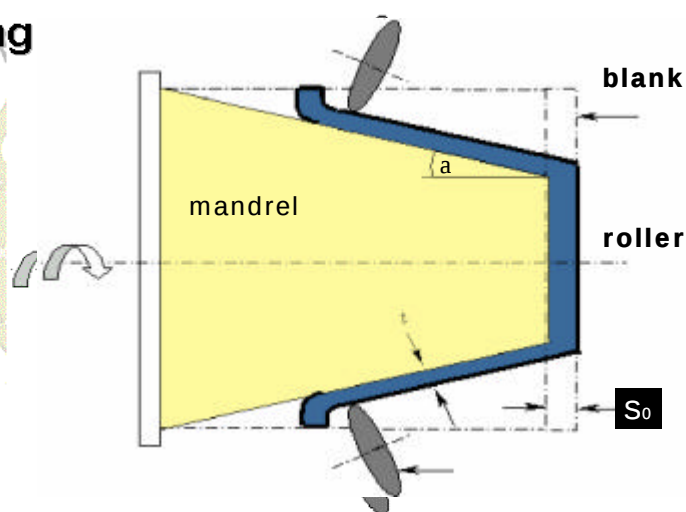
- Processi tradizionali
 - Spinning (imbutitura al tornio)
 - Rotary swaging
- Processi innovativi
 - Dieless incremental forming



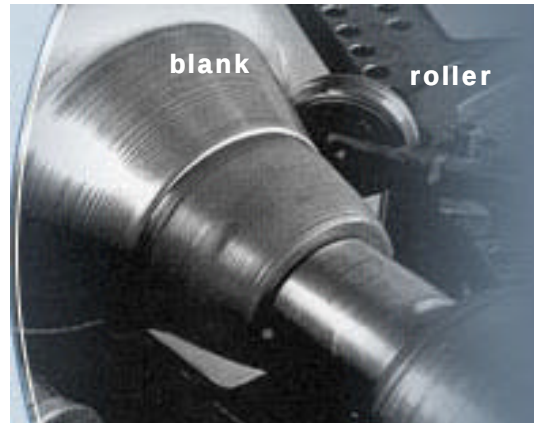
Spinning

Cone spinning

Imbutitura
al tornio
da lastra



Cone Spinning



Spinning

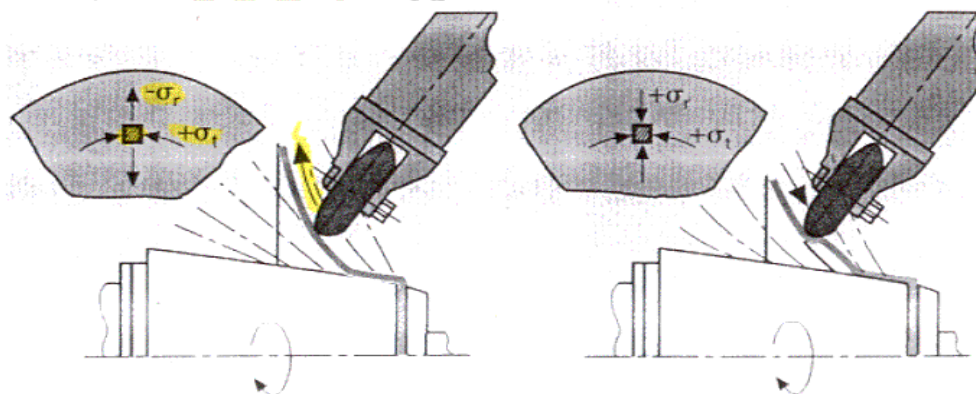




Spinning

Cone spinning stato di sforzo

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Processi di formatura incrementale

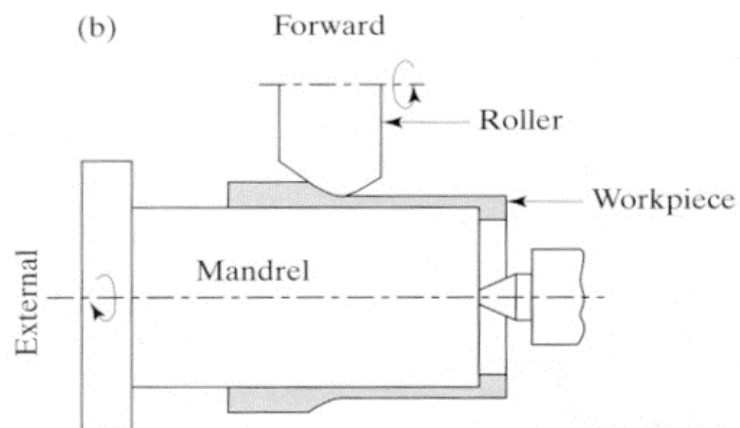
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Spinning

Tube spinning Imbutitura al tornio da tubo (concorde)

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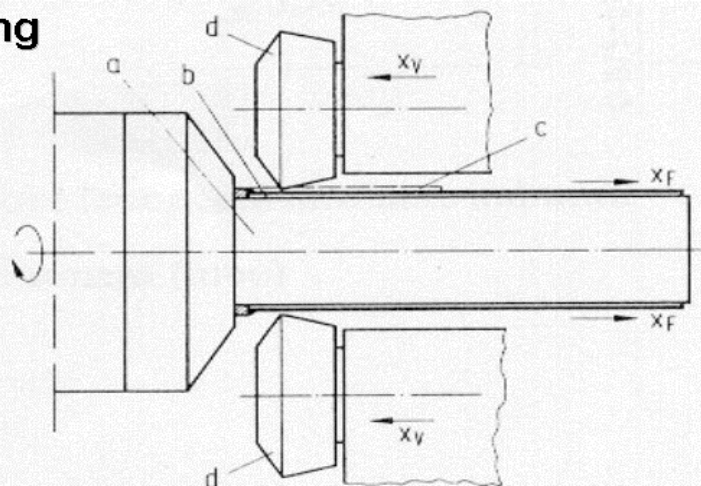
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Spinning

Tube spinning

Imbutitura
al tornio
da tubo
(discorde)



Spinning

Nomenclatura norme DIN

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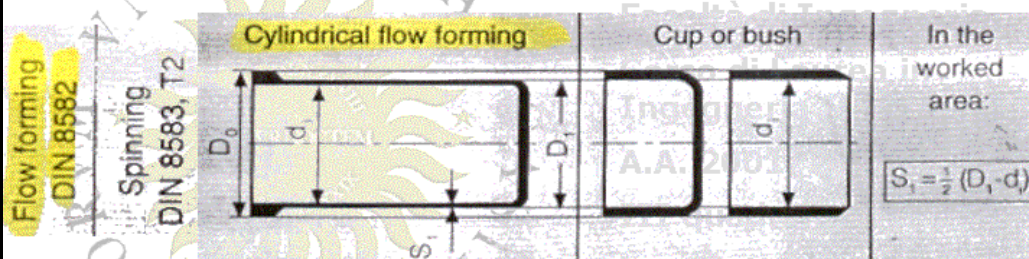
Standard	Process	Starting blank	Wall thickness
Compression forming DIN 8582 Tension forming DIN 8584, T4	Spinning 	 Disc blank $D_0 > D_1$	Approx. constant: $S_1 \approx S_0$



Spinning

Nomenclatura norme DIN

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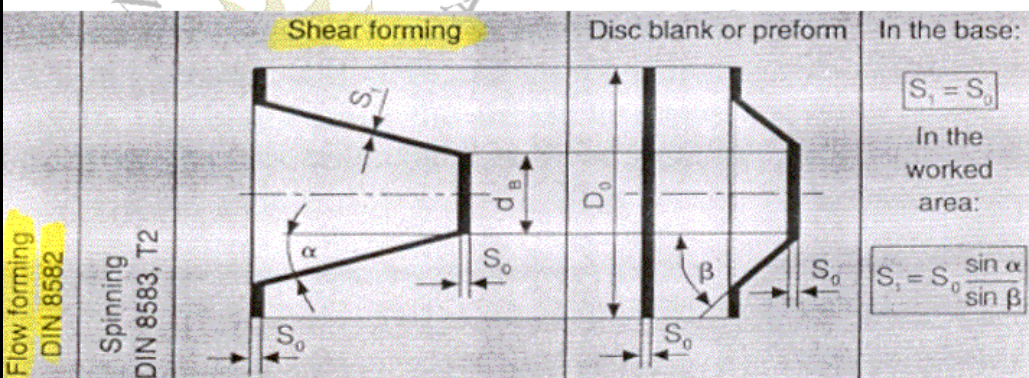
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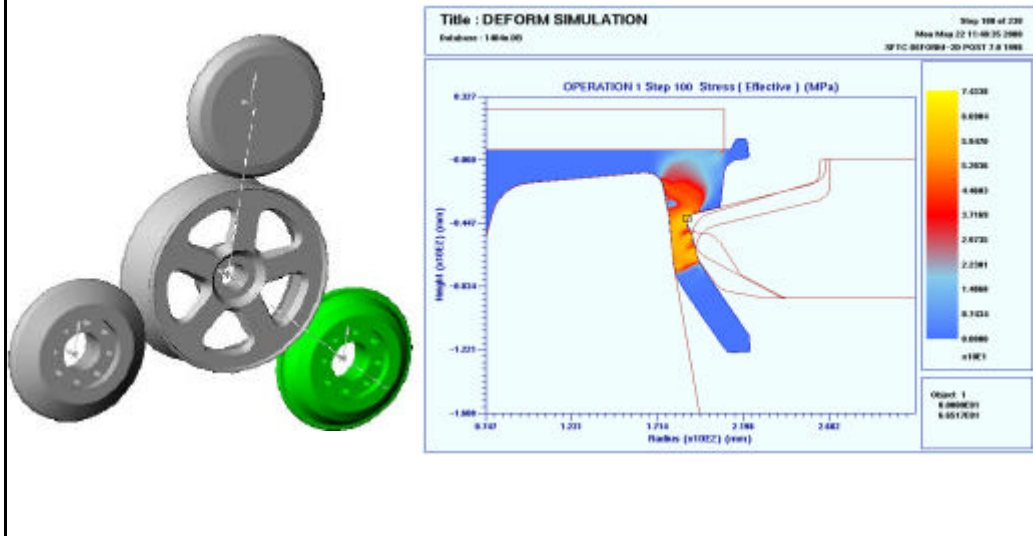
Spinning

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Flowforming



Spinning

La legge del seno

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Diagram A shows a cross-section of a workpiece being spun. The initial thickness is s_0 and the final thickness is s_1 . The angle of the tool is α and the angle of the workpiece is β . The sine law is given by:

$$s_1 = \frac{s_0 \cdot \sin \alpha}{\sin \beta}$$

Diagram B shows a similar cross-section with the initial thickness s_0 and the final thickness s_1 . The angle of the tool is α . The sine law is given by:

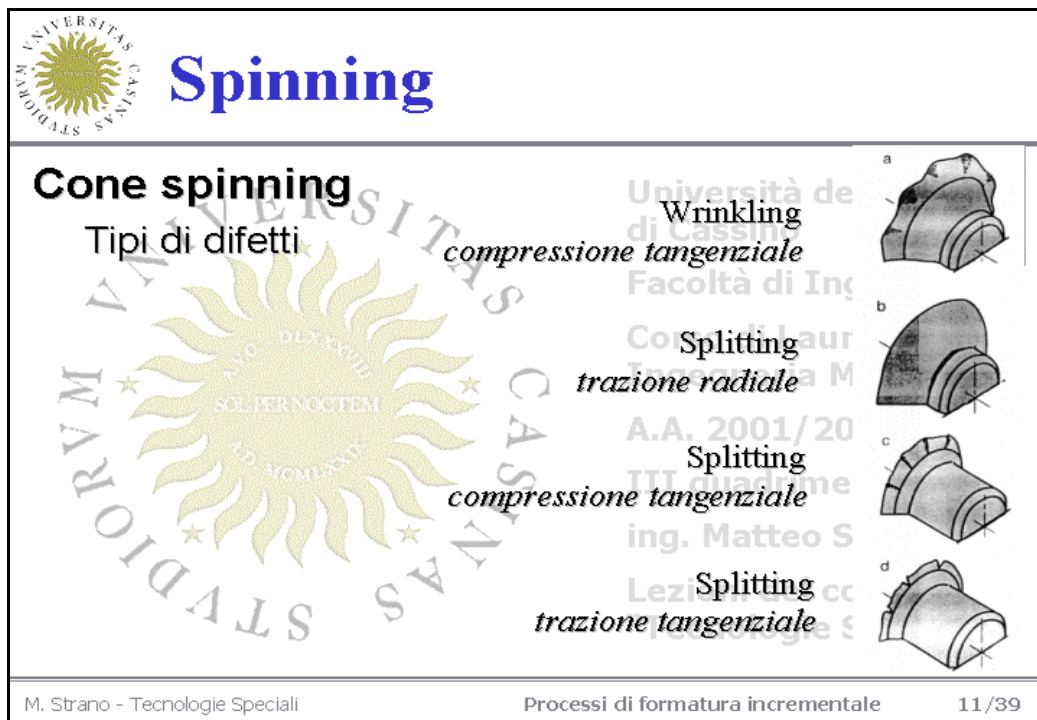
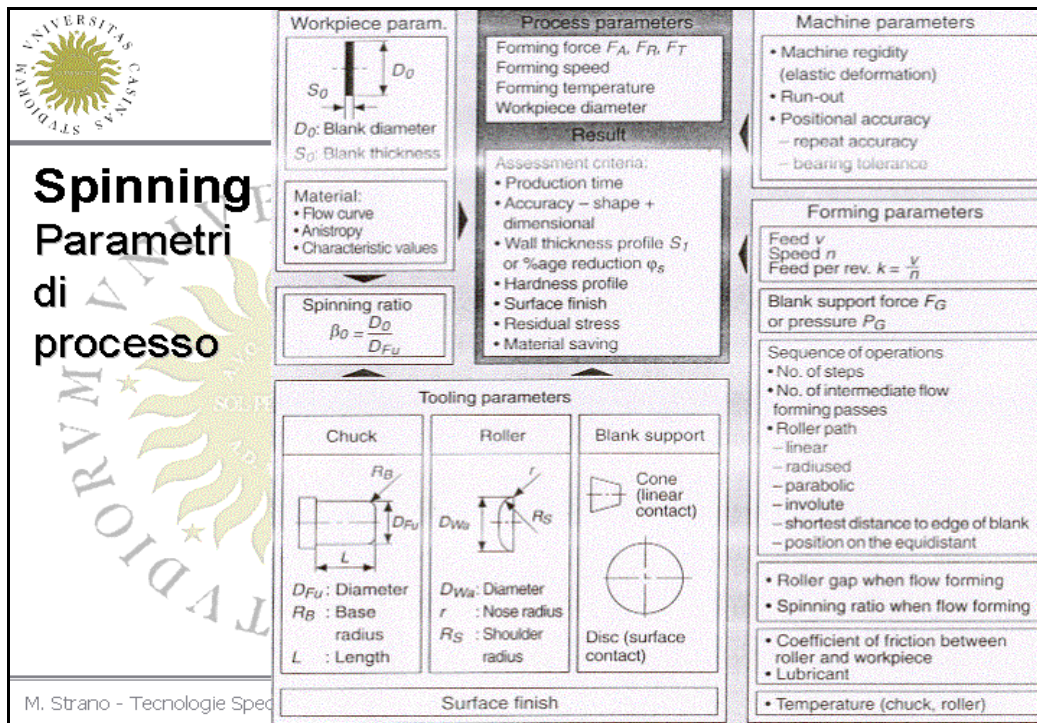
$$s_1 = s_0 \cdot \sin \alpha$$

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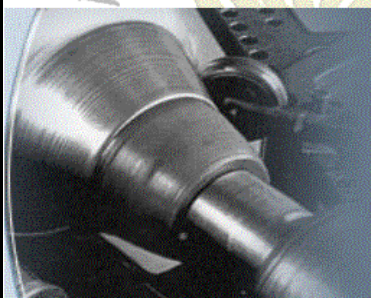
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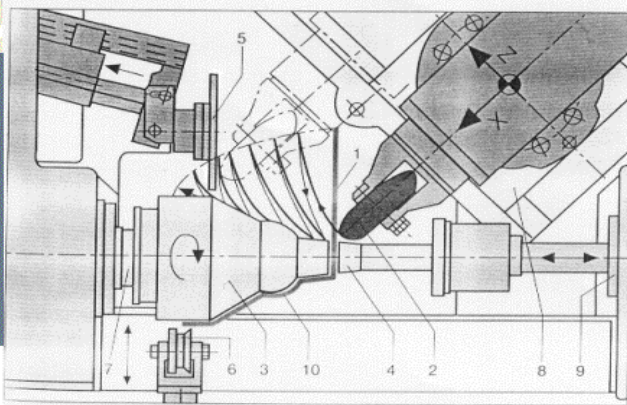
Spinning

Cone spinning Il sistema



- 1 disc blank
- 2 spinning roller
- 3 spinning chuck
- 4 tailstock pad
- 5 blank support unit

- 6 trimming attachment
- 7 main spindle
- 8 cross slide
- 9 tailstock
- 10 spun part



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Processi di formatura incrementale

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Spinning

Cone spinning Il sistema Le matrici



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Processi di formatura incrementale

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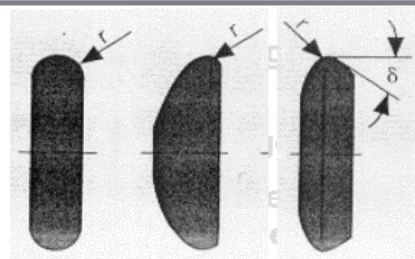
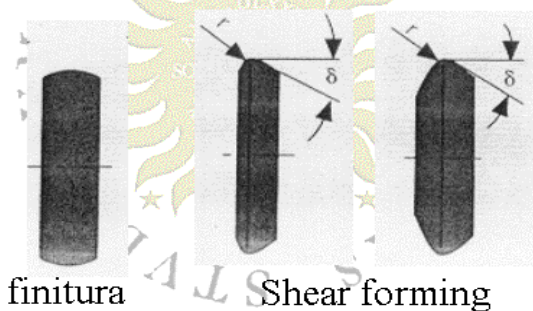


Spinning

Cone spinning

Il sistema

I rulli



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

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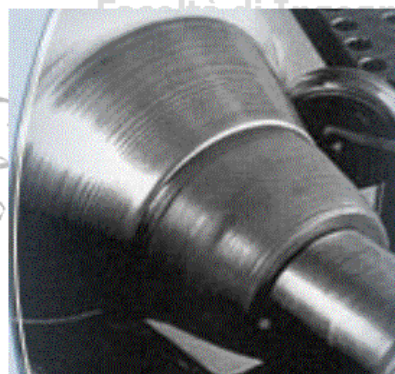
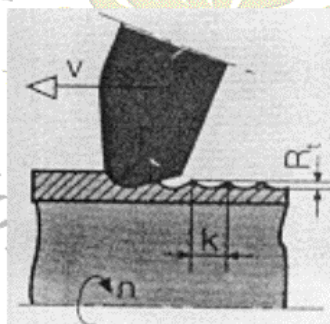
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Spinning

Cone spinning

Influenza sulla finitura superficiale



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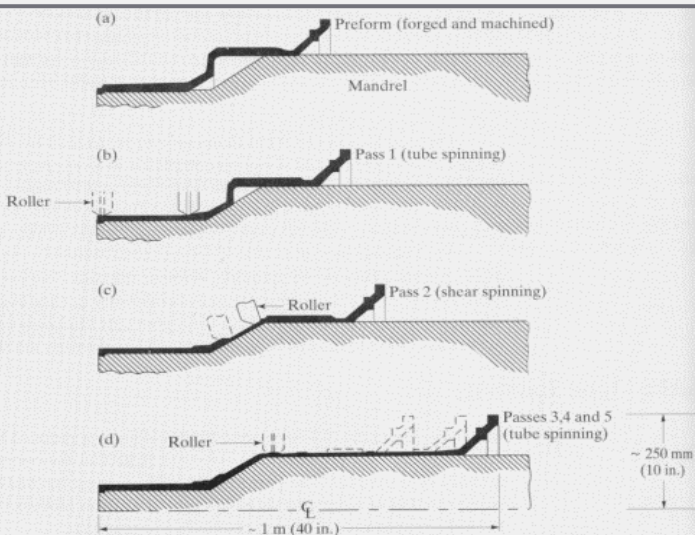
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Spinning

Example of application



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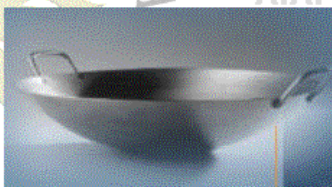
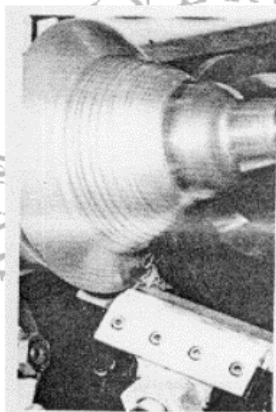
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Spinning

Spun products



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Quadrimestre
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Processi di formatura incrementale

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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

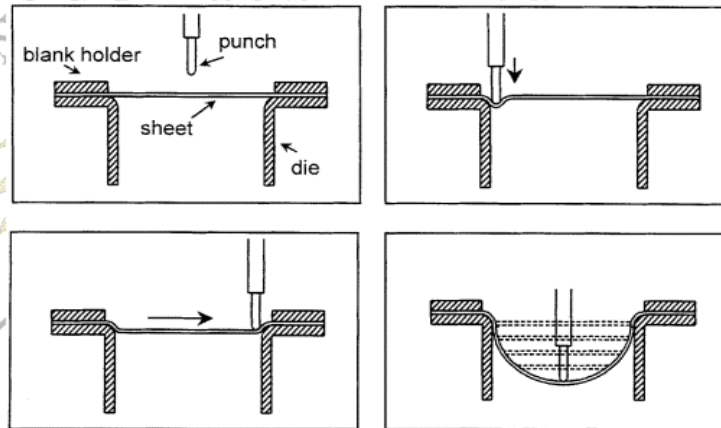
- **Limitations**

- 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



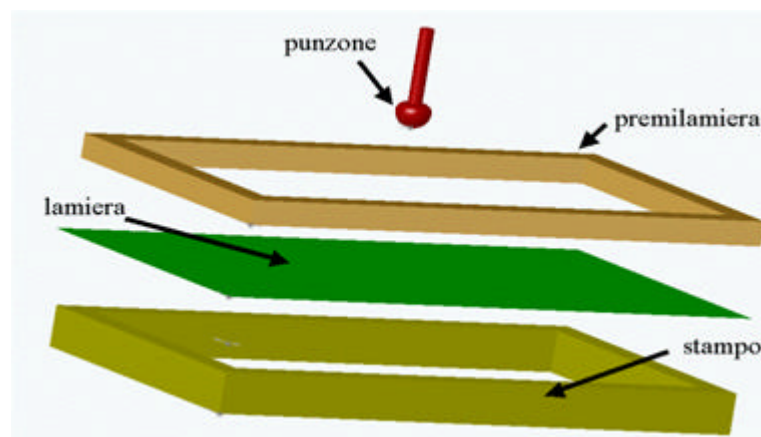
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Processi di formatura incrementale

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Dieless incremental forming

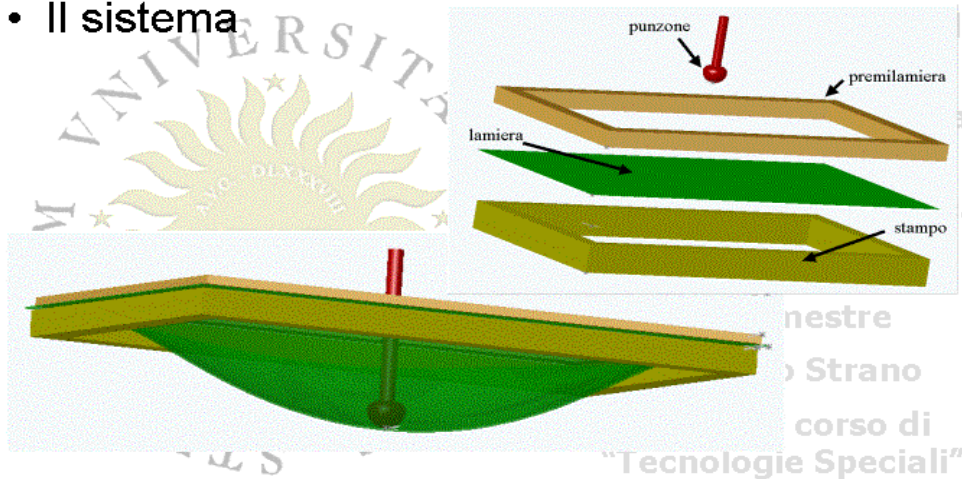
Setup





CNC incremental forming

- Il sistema



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Processi di formatura incrementale

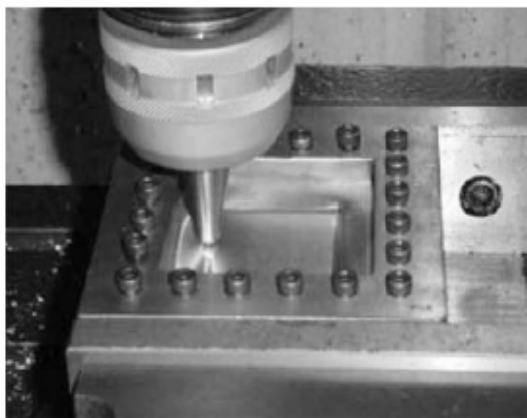
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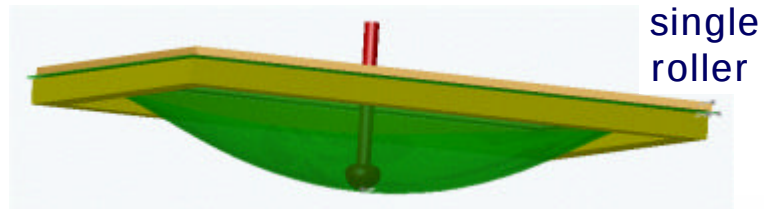
CNC incremental forming

- Il sistema

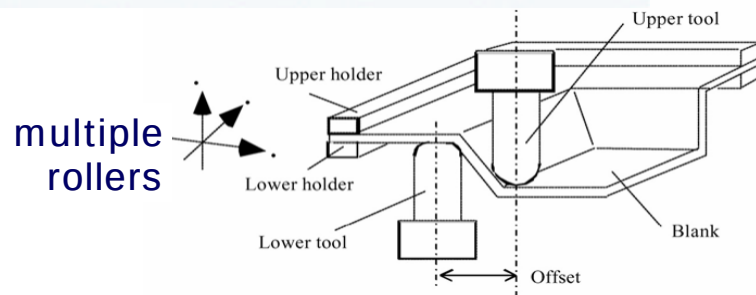
Esempi



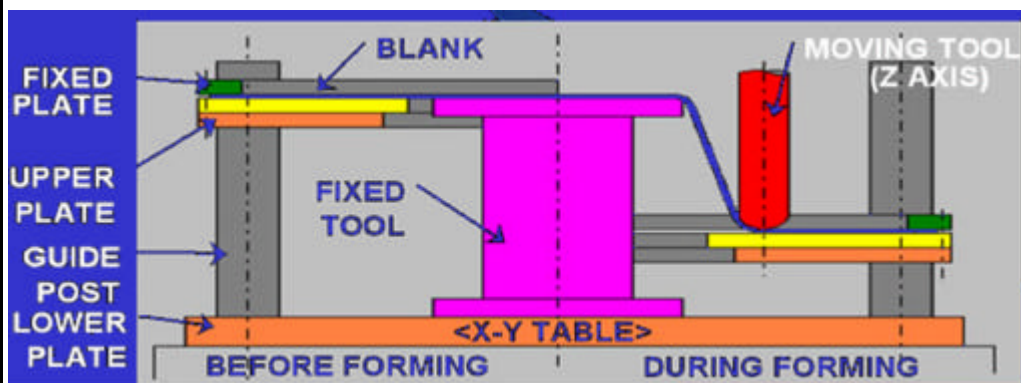
Dieless incremental forming



VS.



Dieless incremental forming

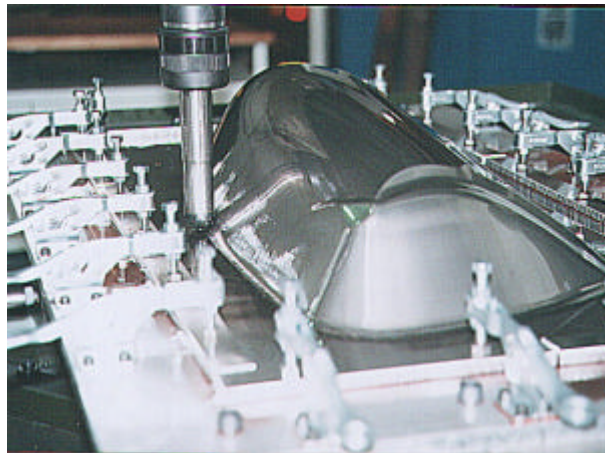




CNC incremental forming

- Il sistema

Esempi



CNC incremental forming

- Il sistema

Esempi

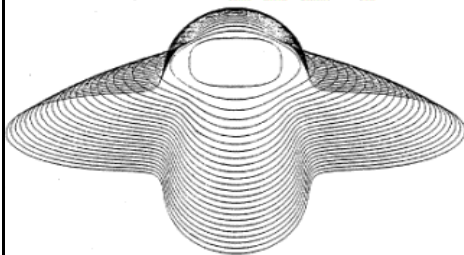




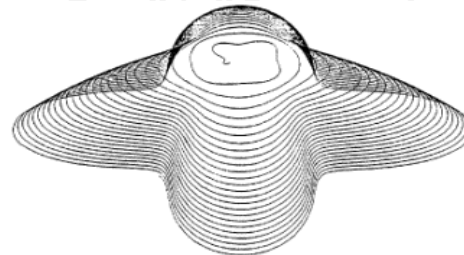
CNC incremental forming

Generazione delle traiettorie

- Single pass



2 assi 1/2



spirale

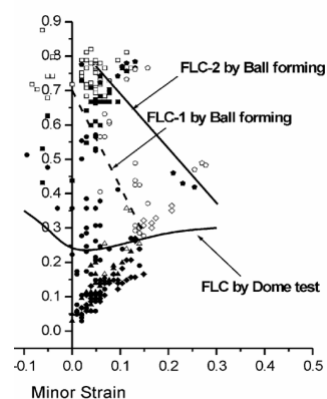
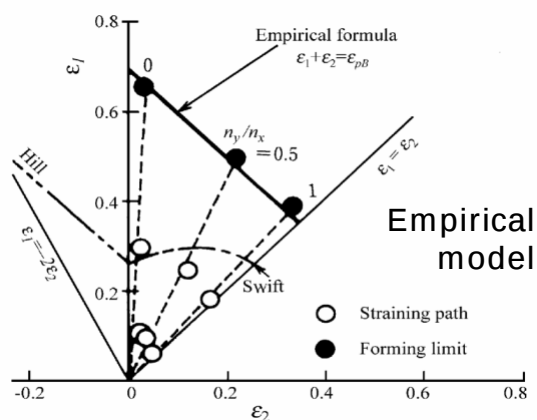
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Processi di formatura incrementale

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Dieless incremental forming:

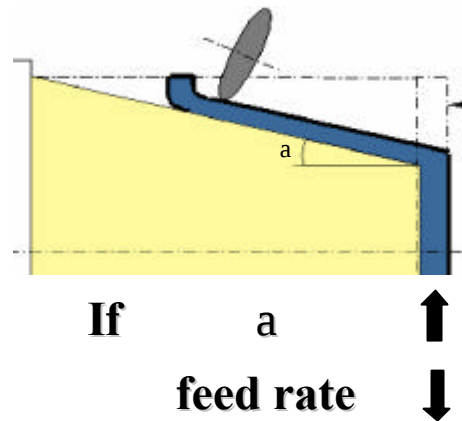
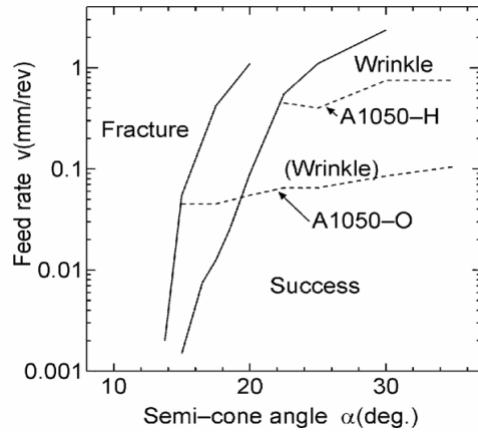
Forming limits



Experimental tests
on aluminum

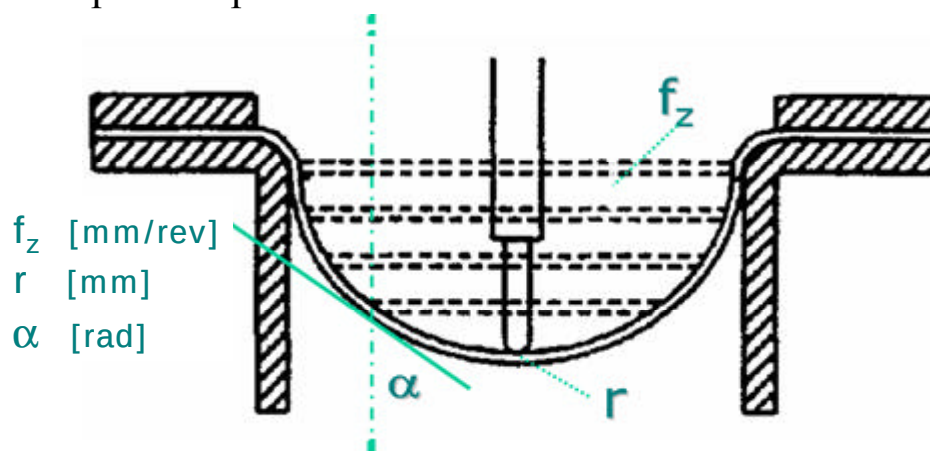
Dieless incremental forming:

Effect of step size for cone spinning



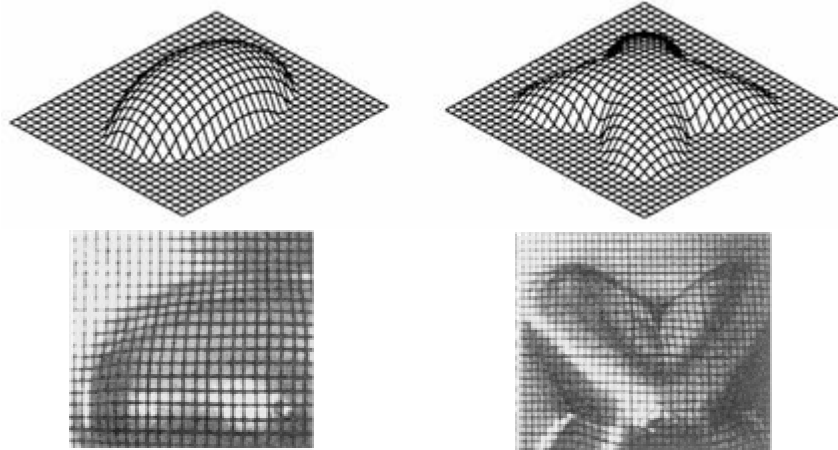
Dieless incremental forming:

Main process parameters



Dieless incremental forming:

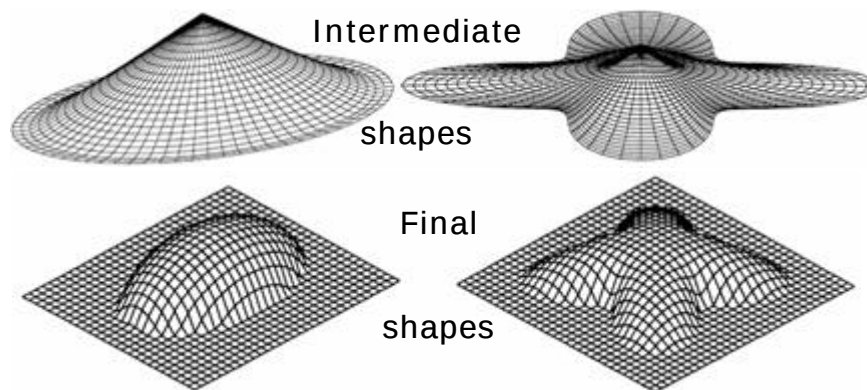
pure shear deformation



Dieless incremental forming:

Single pass vs. multiple pass

– Effect of slope, (α)

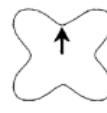
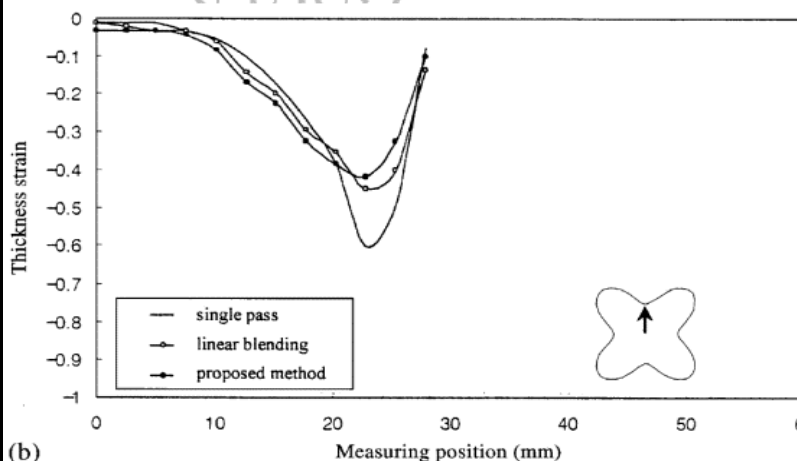




CNC incremental forming

Generazione delle traiettorie

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(b)

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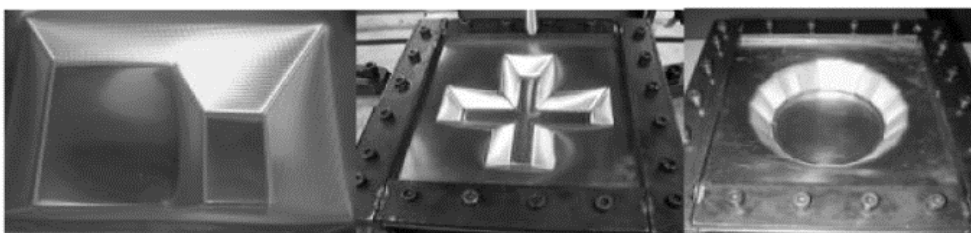
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CNC incremental forming

Esempi di parti

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Processi di formatura incrementale

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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 difficoltà di determinazione di traiettorie ottimizzate

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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