Lecture #32

ERDM

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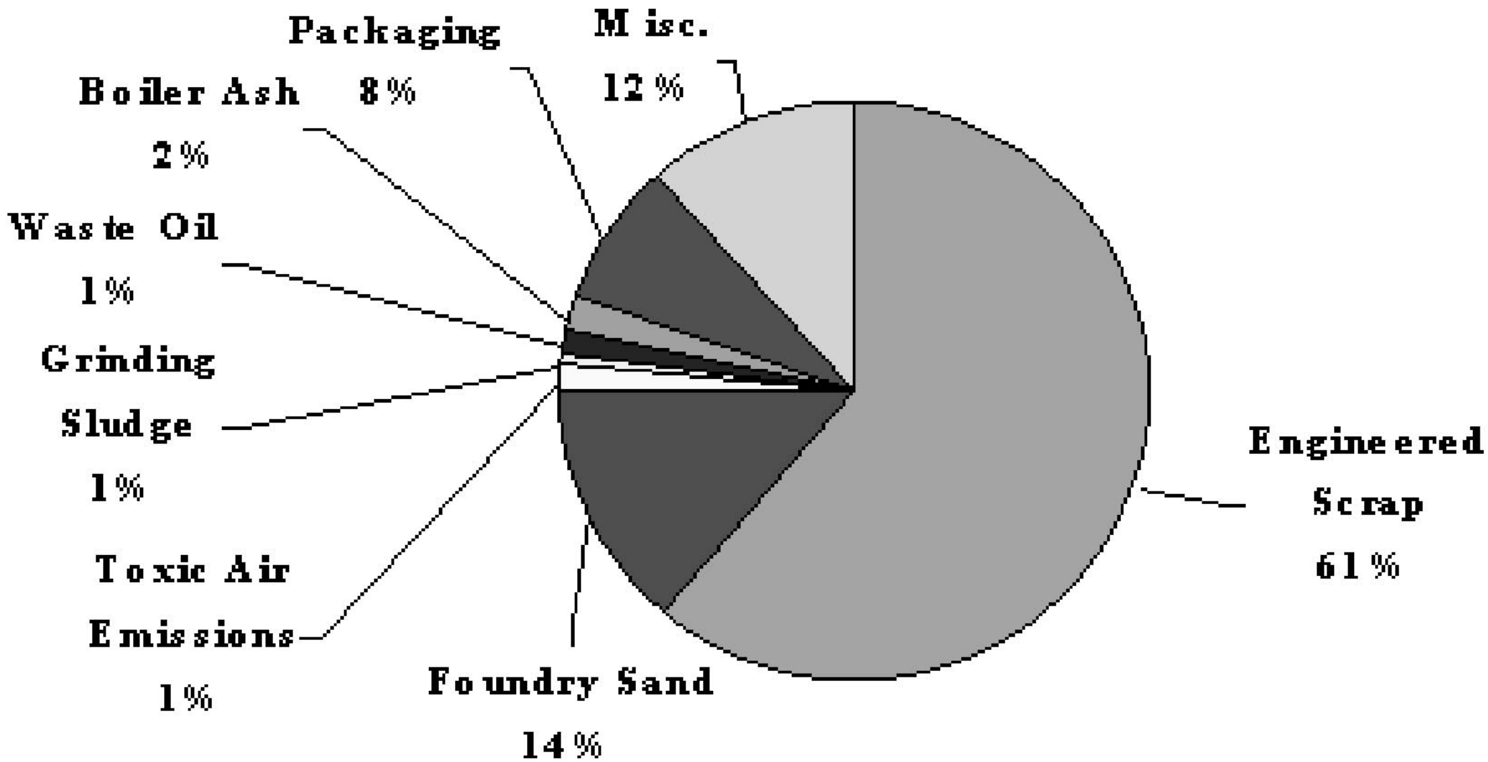
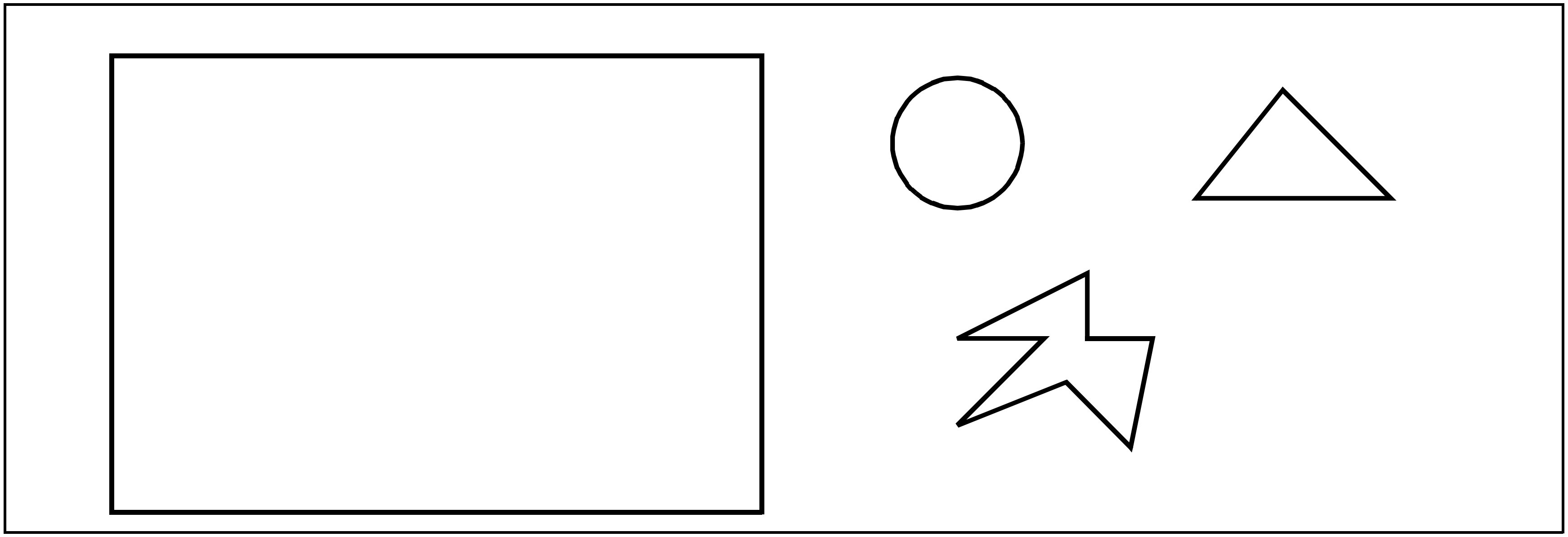
Sources of Solid Waste



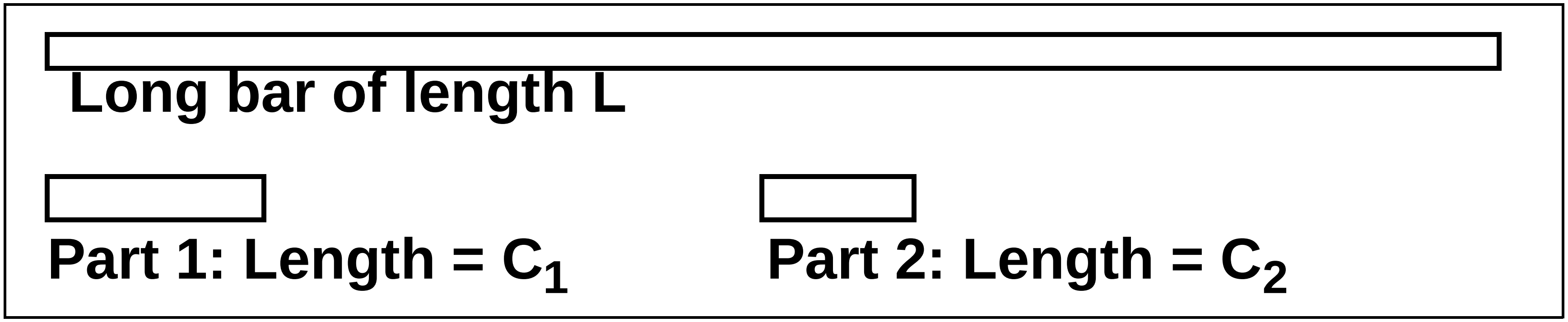
Minimizing Waste

http://techreports.isr.umd.edu/reports/1998/TR_98-8.pdf
See also web refs to Gilmore/Gomory Stock problem



How can we perform this blanking process so as to minimize scrap?

One-Dimensional Version



Let x_1 be number we cut of part 1 type (integer)

Let x_2 be number we cut of part 2 type (integer)

Max: $z = C_1 * x_1 + C_2 * x_2$

st: x_1 & x_2 non-negative

$C_1 * x_1 + C_2 * x_2 <= L$

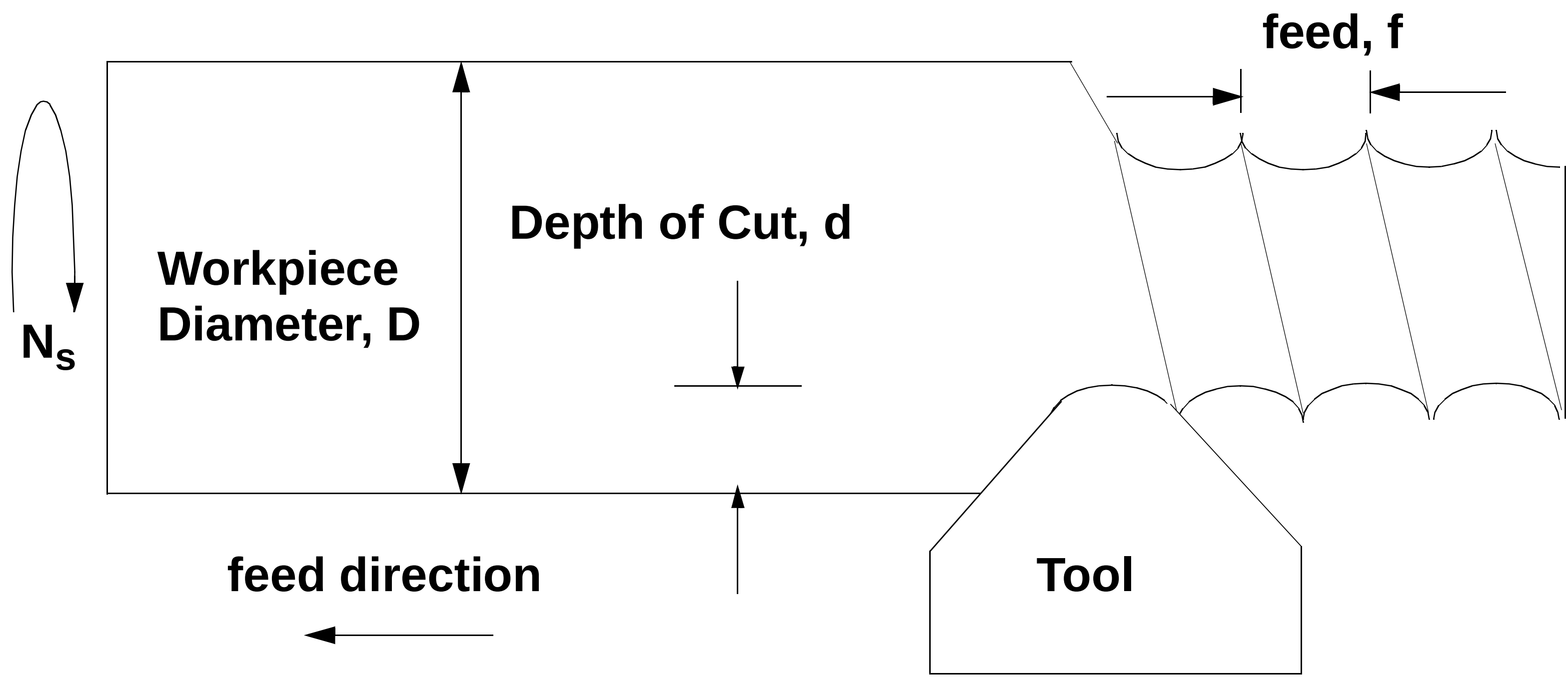
Relax integer requirement -- linear programming solution

Cutting Processes

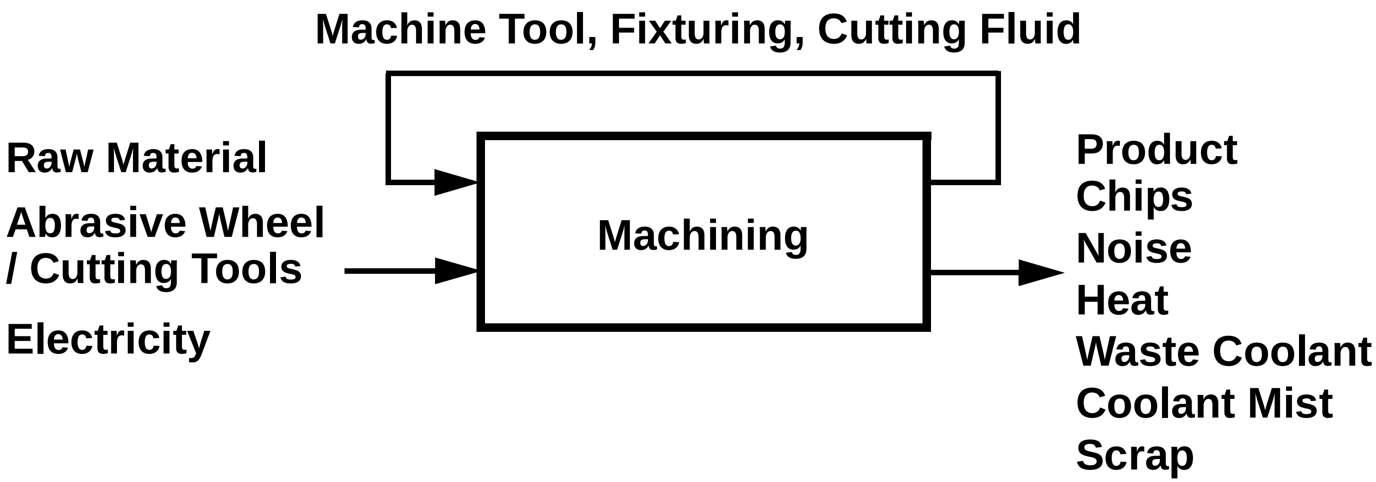
- Turning
- Shaping / Planing
- Boring
- Facing

- End Milling
- Face Milling
- Drilling
- Tapping
- Reaming

Turning Process



Input/Output View of Turning Process



Inputs: Workpiece, energy, cutting tools, cutting fluids, machine tool - lathe.

Outputs: Finished part, heat into tool/work/M-T, worn cutting tools, chips + cutting fluid coating, spent cutting fluid, cutting fluid mist, non-conforming finished parts, worn machine tools.

Characteristics with Environmental Concerns

- **Chips**
- **Cutting fluids**
- **Worn tooling**
- **Scrap parts**
- **Energy**

Need mechanistic models - predict these characteristics

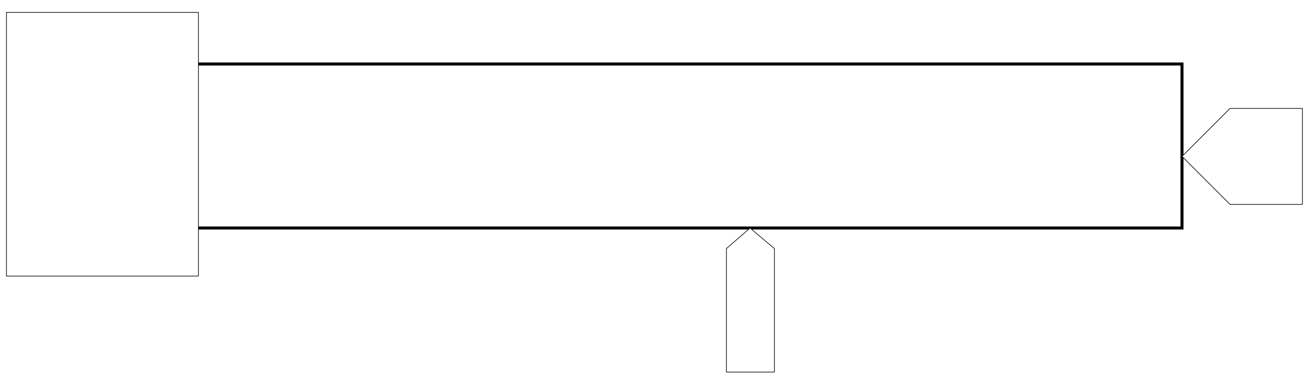
Turning Process Waste Streams

(how do we deal with them?)

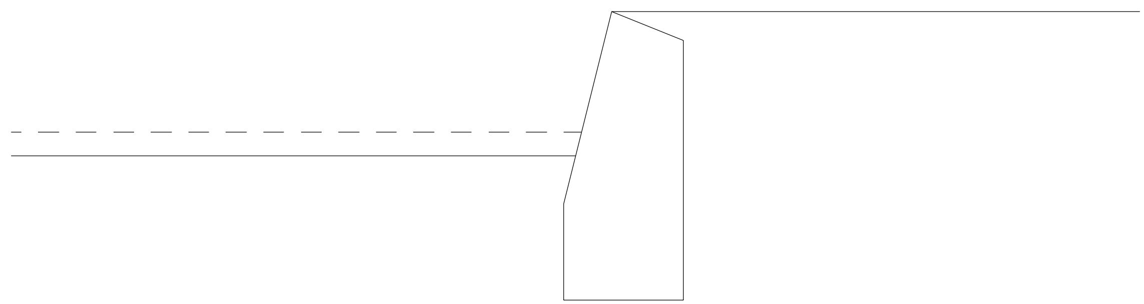
- **Scrap parts**
- **Worn cutting tools: regrind/resharpen the tools, recycle the material**
- **Chips + fluid: filter the chips/fluid, recycle the chips, avoid contamination**
- **Spent cutting fluid: recirculation system - contamination - additives to maintain system (biocides, corrosion inhibitors, oil) - waste treatment**
- **Fluid mist: mist collector - return to fluid system**

Quality Problem - Dimensional Errors

- **Static errors - misalignment of machine axes**
- **Control system - interpolation limitations, tracking errors**
- **Forced Deflections**

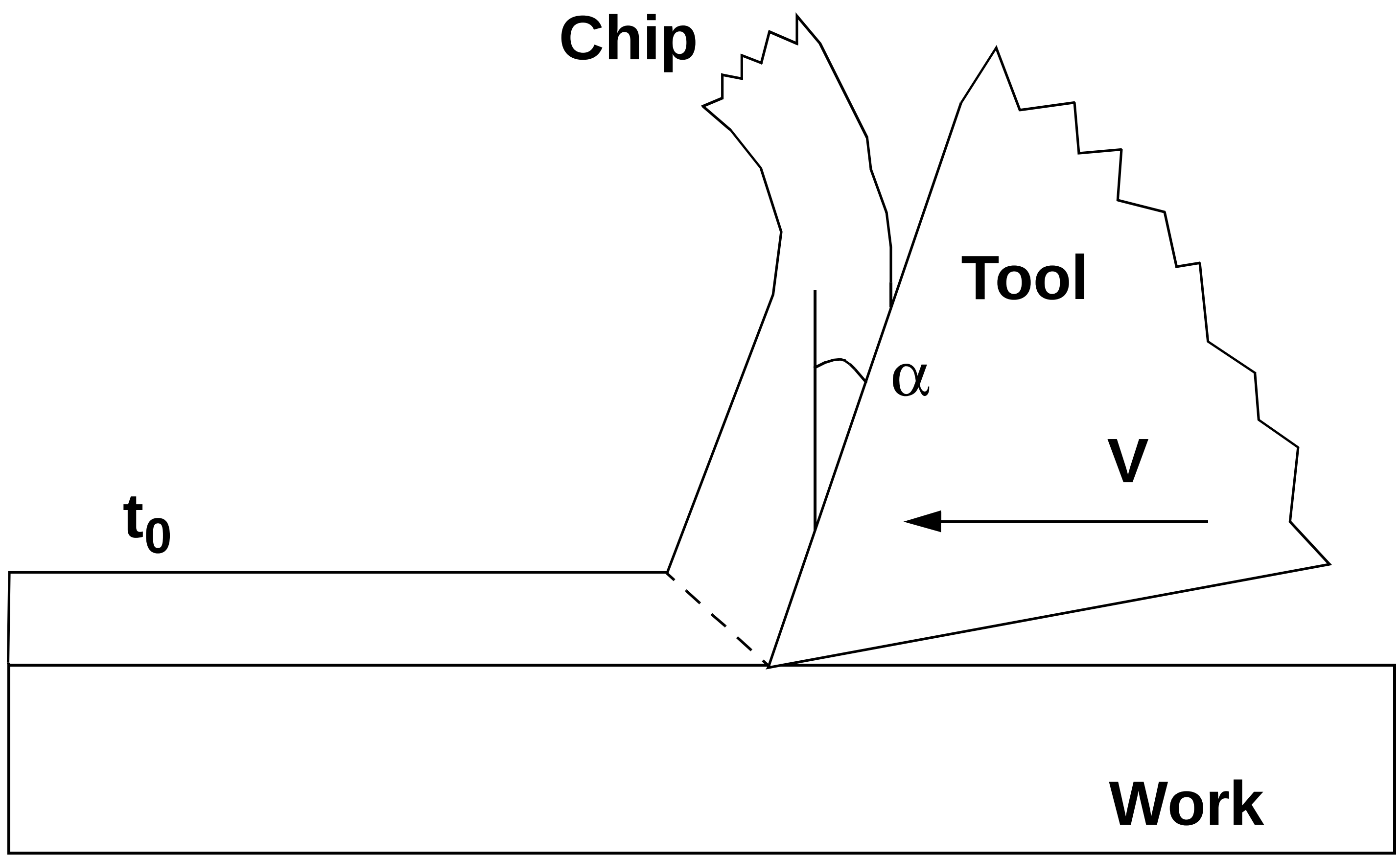


Dimensional Errors - cont.



- **Thermal deformations**
  - **of machine tool - quasistatic error**
  - **of workpiece**
- **Tool wear**

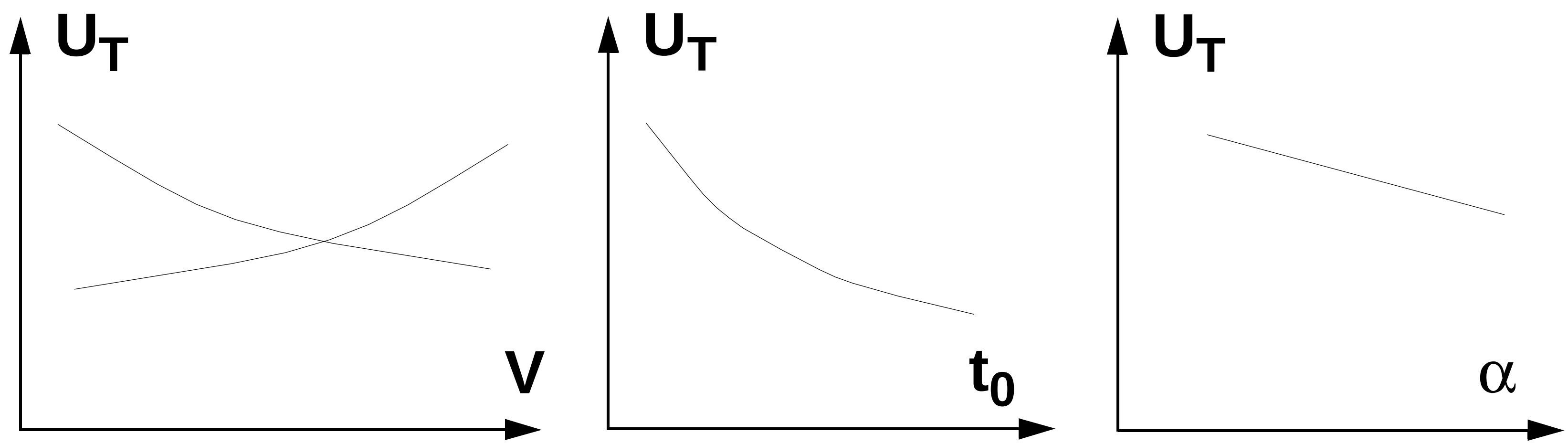
Orthogonal Cutting



Force Relations

$$F_c = U_T t_0 b$$

where, U_T **is the specific cutting energy**



Power & Energy

Material Removal Rate

$$MRR = Vbt_0$$

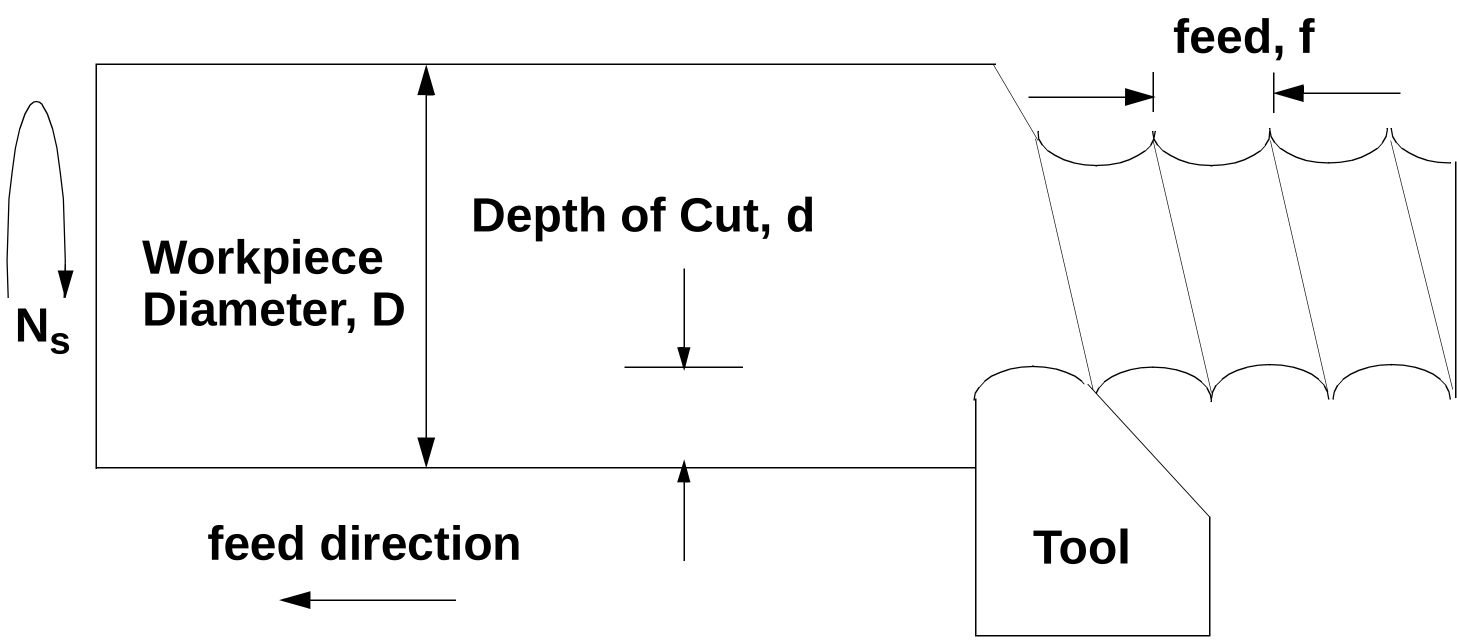
Energy (= Spec. Cutting Energy * Volume)

$$Energy = U_T bt_0 L$$

Cutting Power

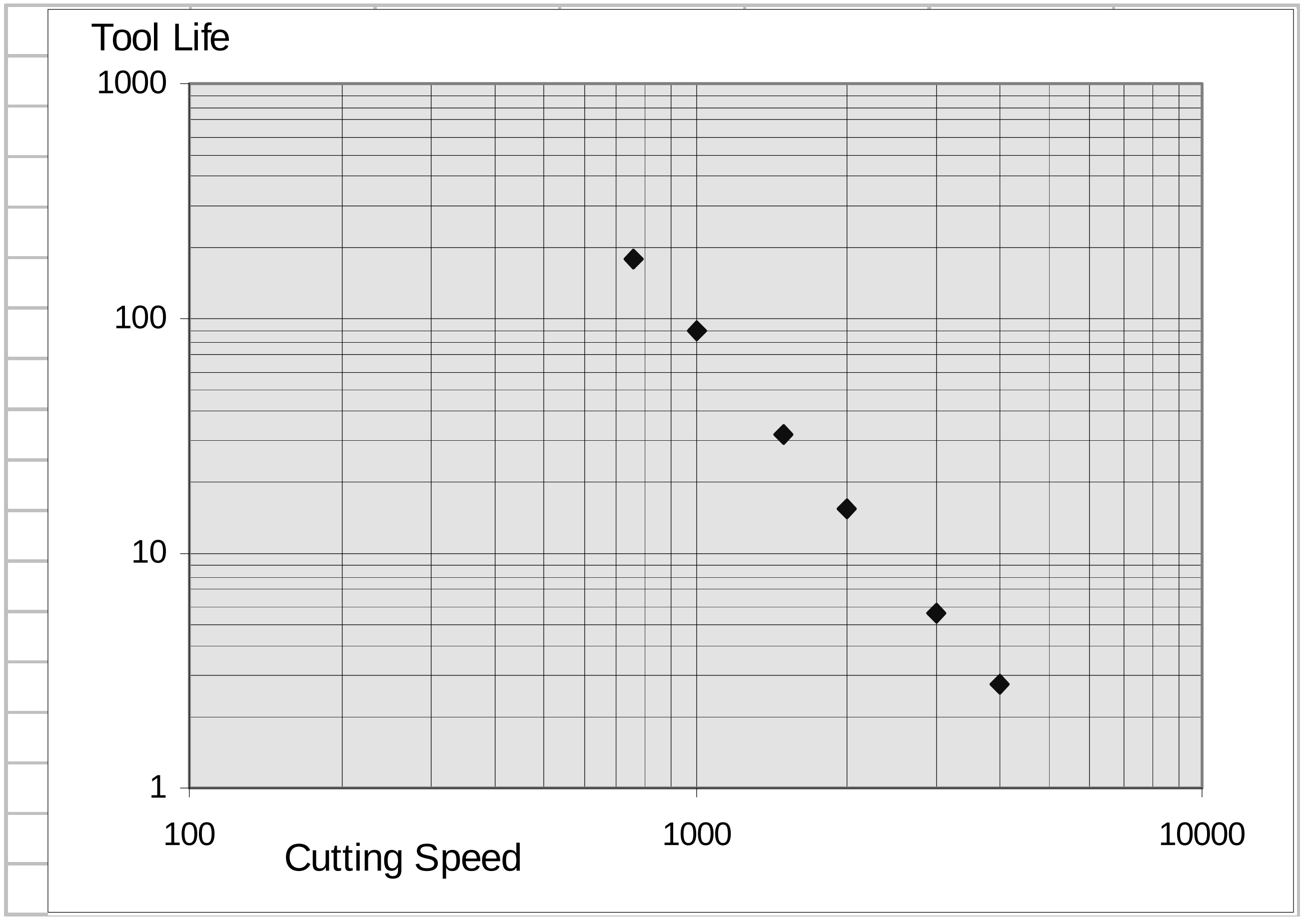
$$Power = U_T bt_0 V = U_T (MRR)$$

Turning Process



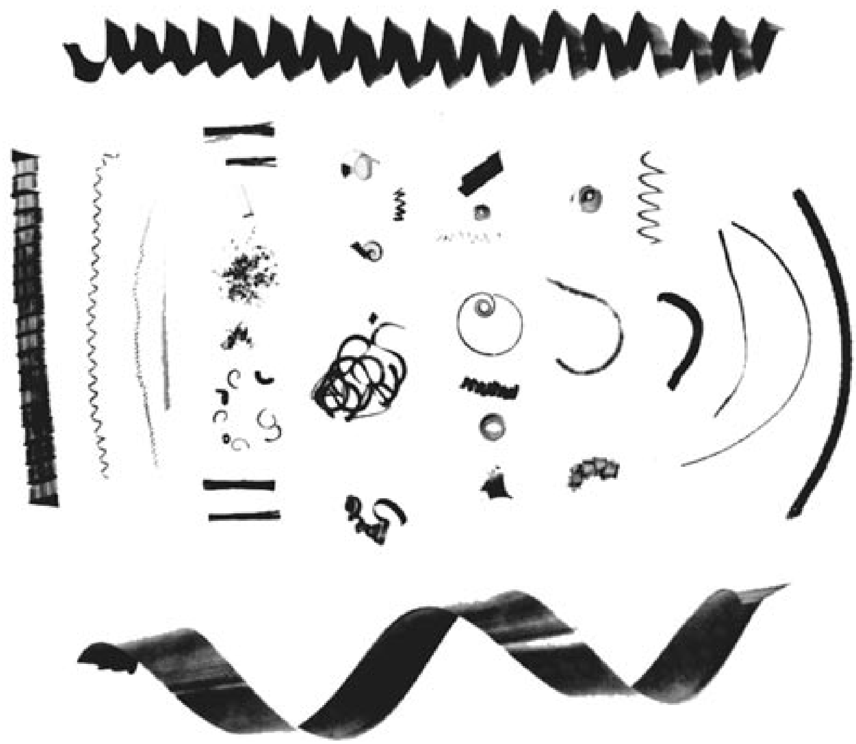
$$t_0 = f \qquad b = d \qquad V = \pi D N_s$$

Tool Wear



What About the Chips

- **A paradox.... We didn't want them, but we deliberately performed an operation to create them!!**



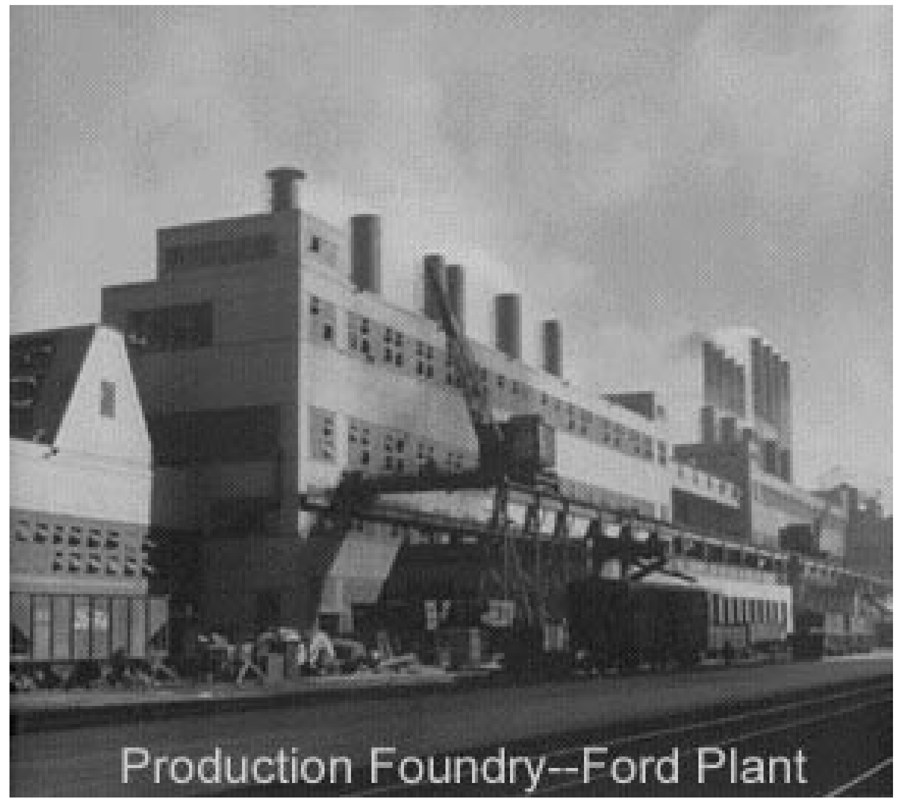
Source: MIT

What chip shapes are easiest to handle in an automated system?

Chip Handling

http://www.people.virginia.edu/~mwk2c/sheeler/sh1927.html
Michael Kidd

www.jorgensenconveyors.com



More on Chips

- What makes free machining steel, free machining?
- Chips contaminated with fluid
- Chips of different types mixed together
- AAP St. Marys Ohio: Aluminum wheel machining
  - A typical wheel at the plant loses up to 40% of its weight in the machining process
  - Waste chips: around one million pounds of aluminum per month -- 6,000 tons per year

St. Mary's Chips

- Previously, contaminated chips transported by truck from the plant to a third-party recycling center. Chips cleaned, re-melted, and reformed into aluminum ingots. Ingots transported back to plant, melted again, and poured into molds.
- Chip reclamation process moved in-house. Eliminate transport and re-melt
- New approach reduces the energy consumption by 15.6 billion BTUs. Aluminum waste has been reduced from 8% to 1.5%
- Cost savings of $1.60 per wheel (100k wheels/month): $1.9 million per year. 18 months payback.