Geometrical Optimization of Broaching Tools by Leveling the Cutting Forces

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Outline

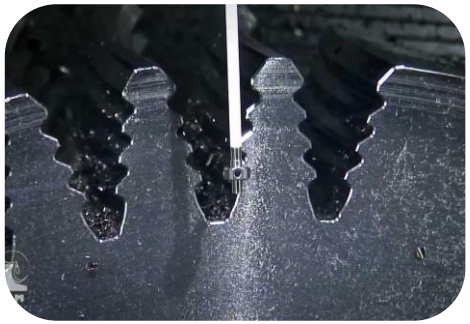
- Introduction
- Cutting parameters
- Objectives
- Broaching Mechanics
- Modeling
- Simulation results
- Conclusion

Introduction

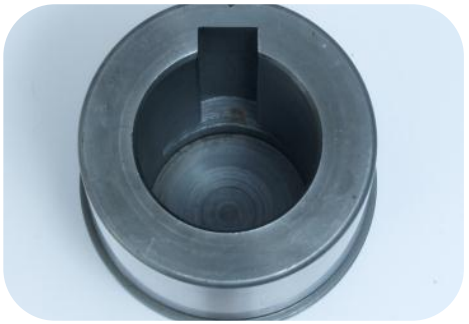
Internal broaching

External broaching

Non-circular Internal holes

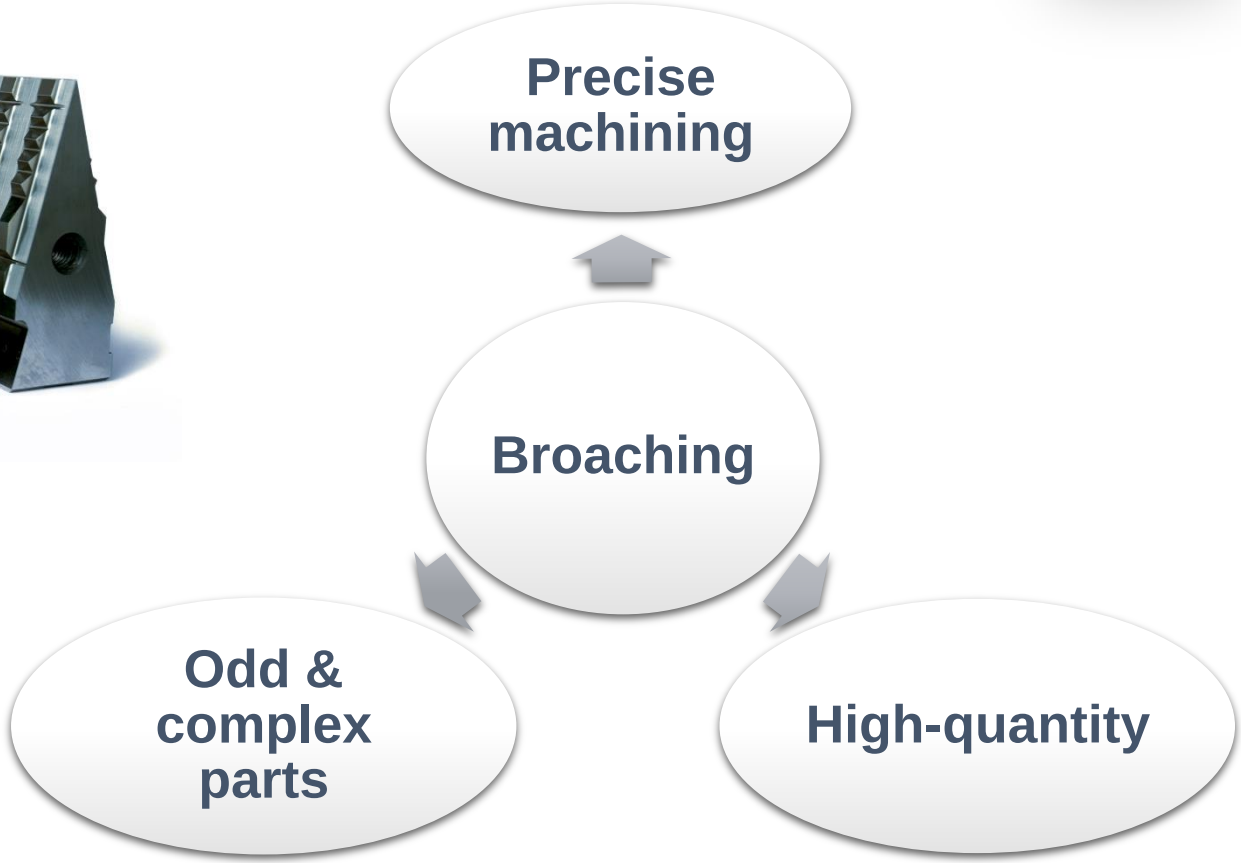


Turbine disc Fir-tree slots

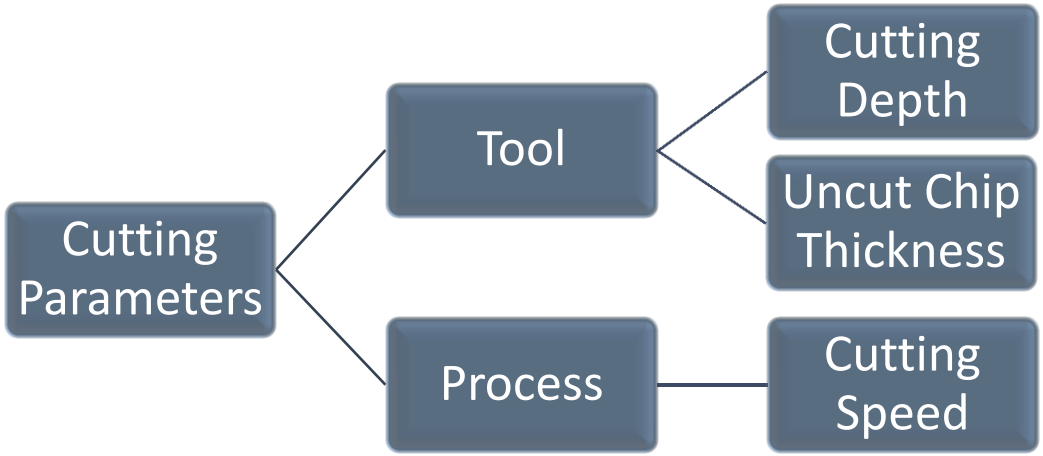


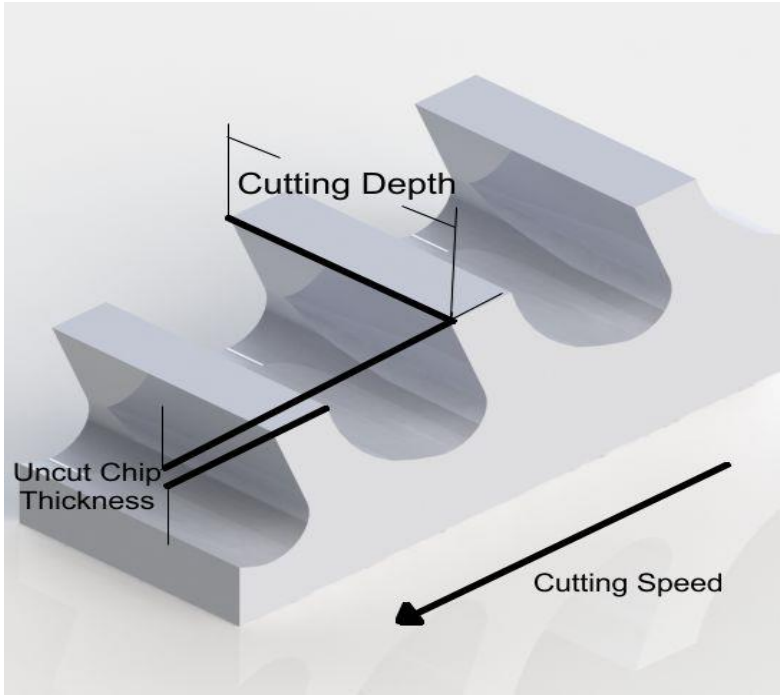
keyways

Introduction

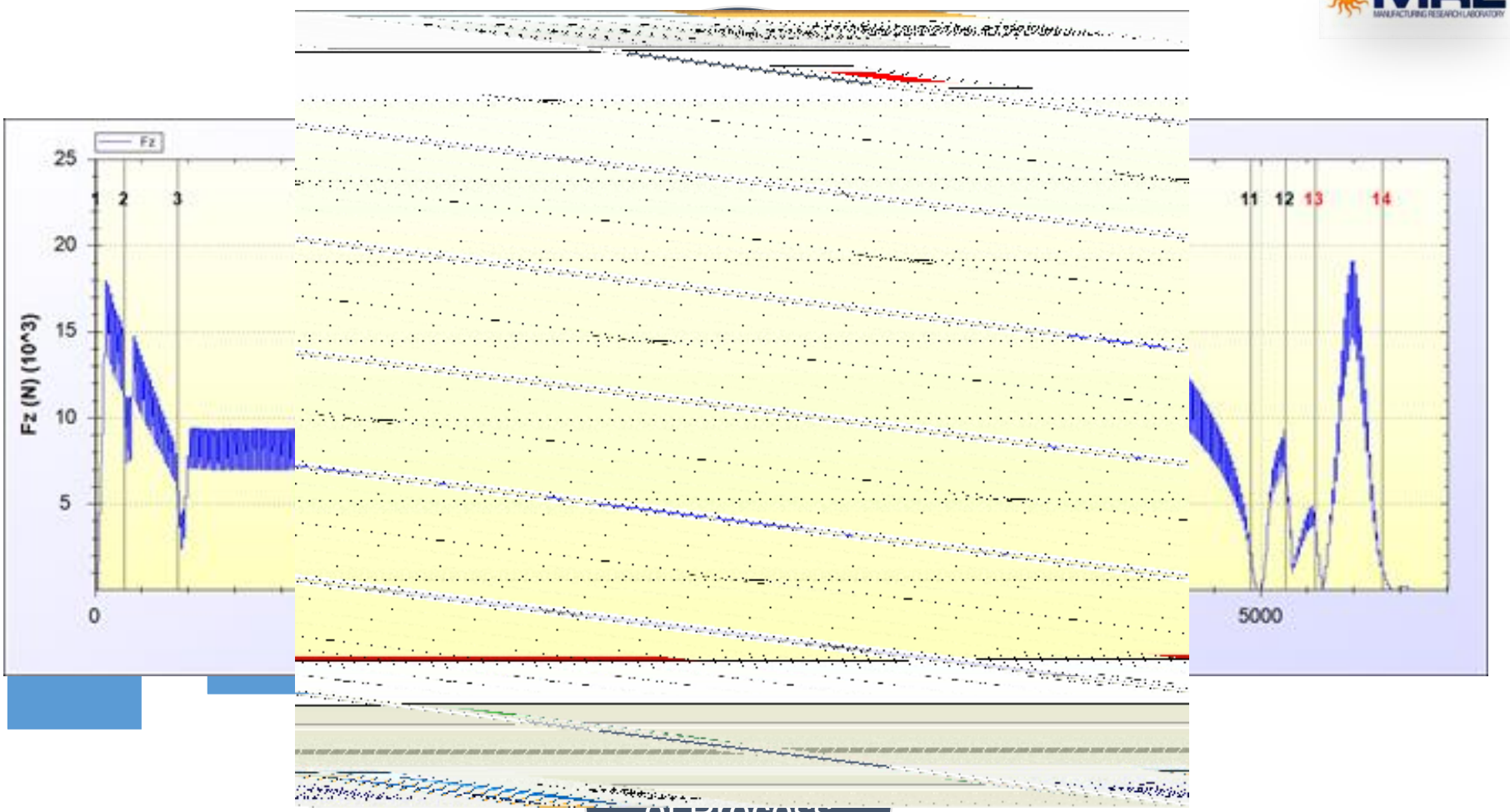


Cutting parameters in Broaching





Objective



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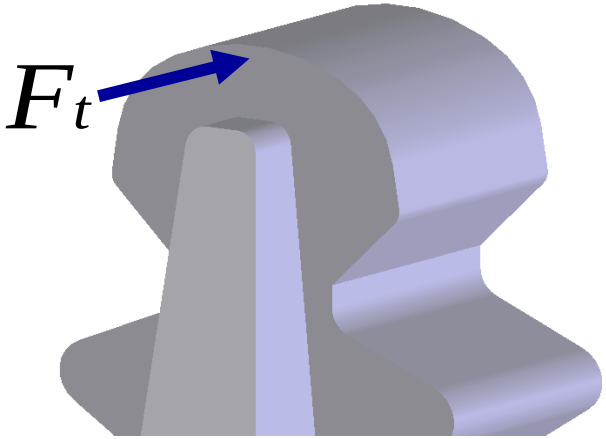
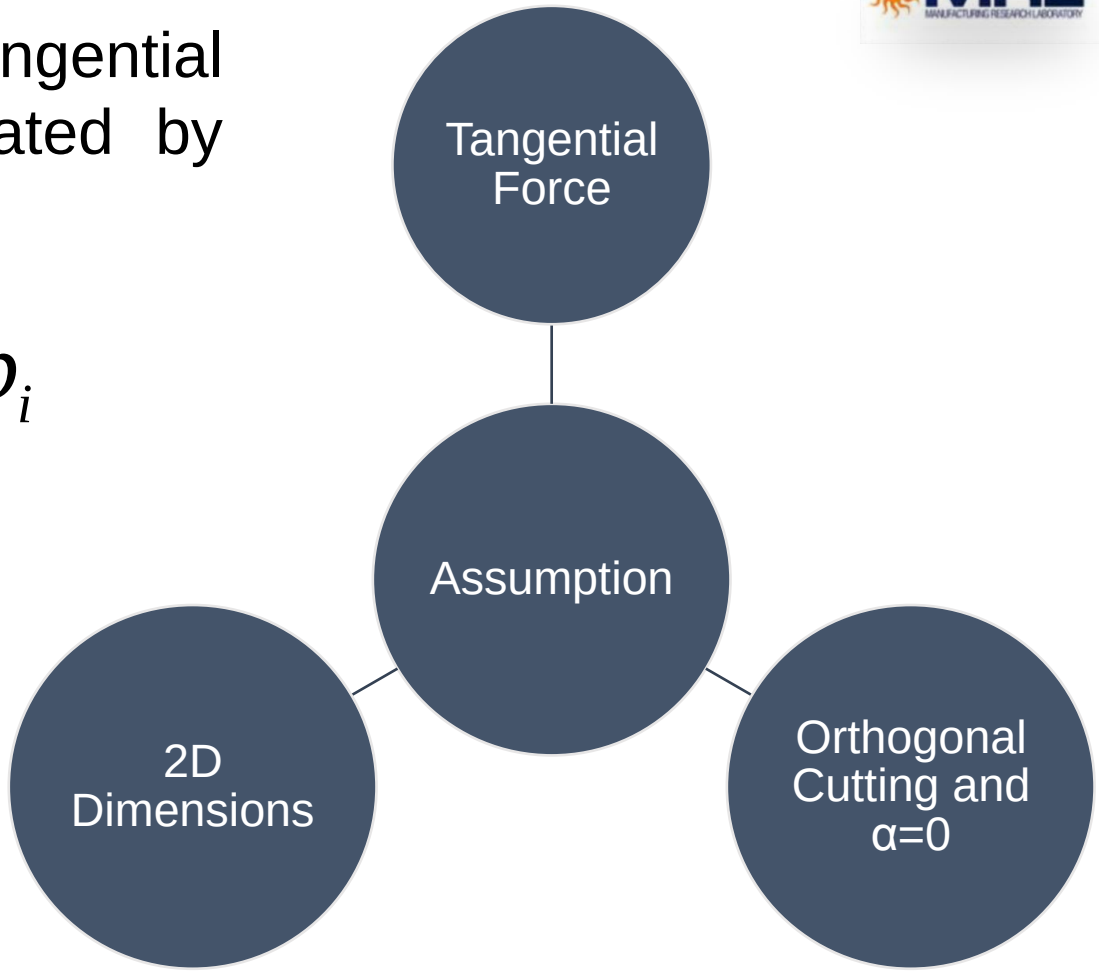
Broaching Mechanics

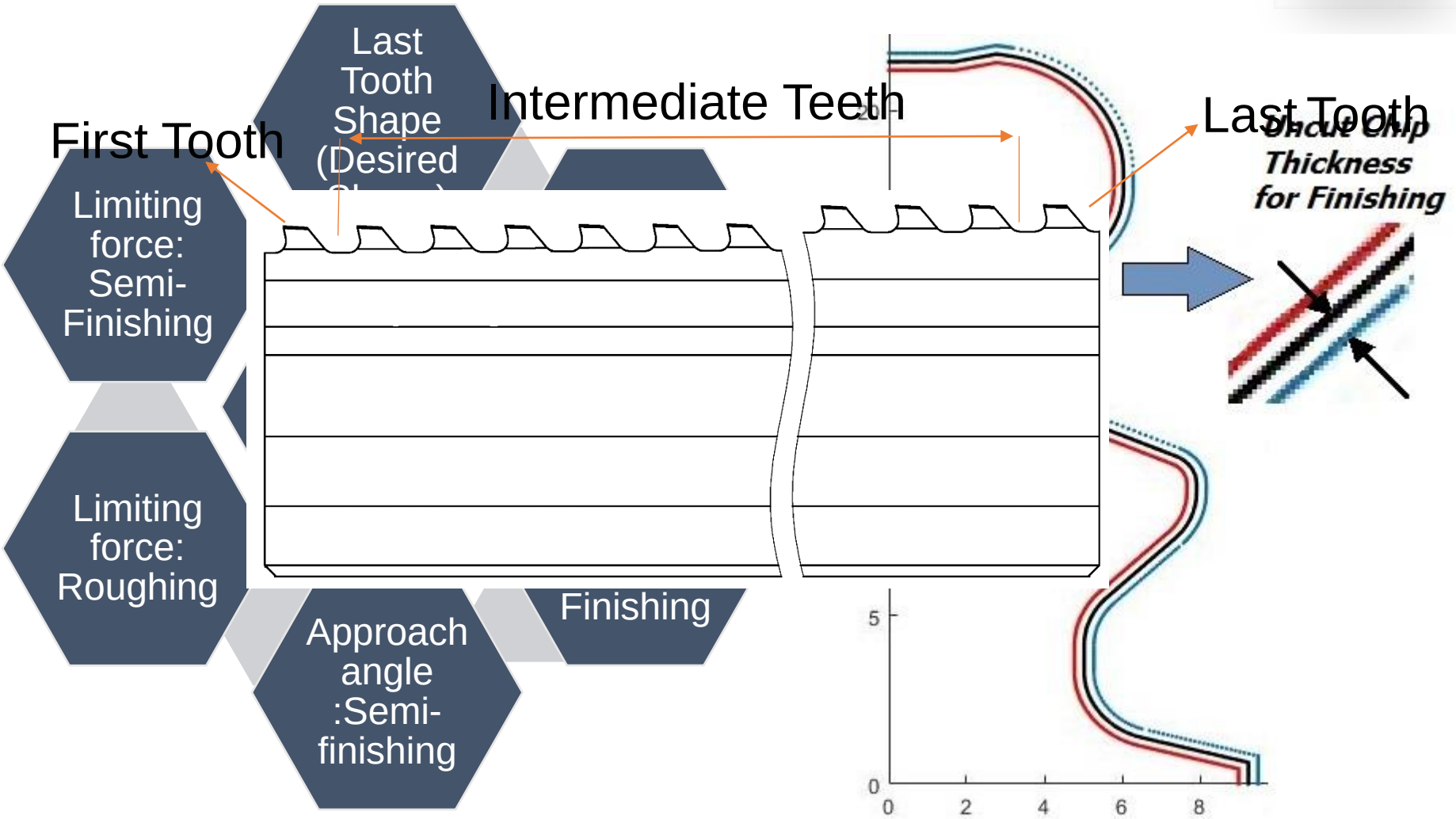
Broaching force in tangential direction can be calculated by following formula:

$$F_t^i = K_{tc}^i f_i b_i + K_{te}^i b_i$$





Modeling of Intermediate Teeth



Intermediate Teeth Generation

Finishing Teeth

+

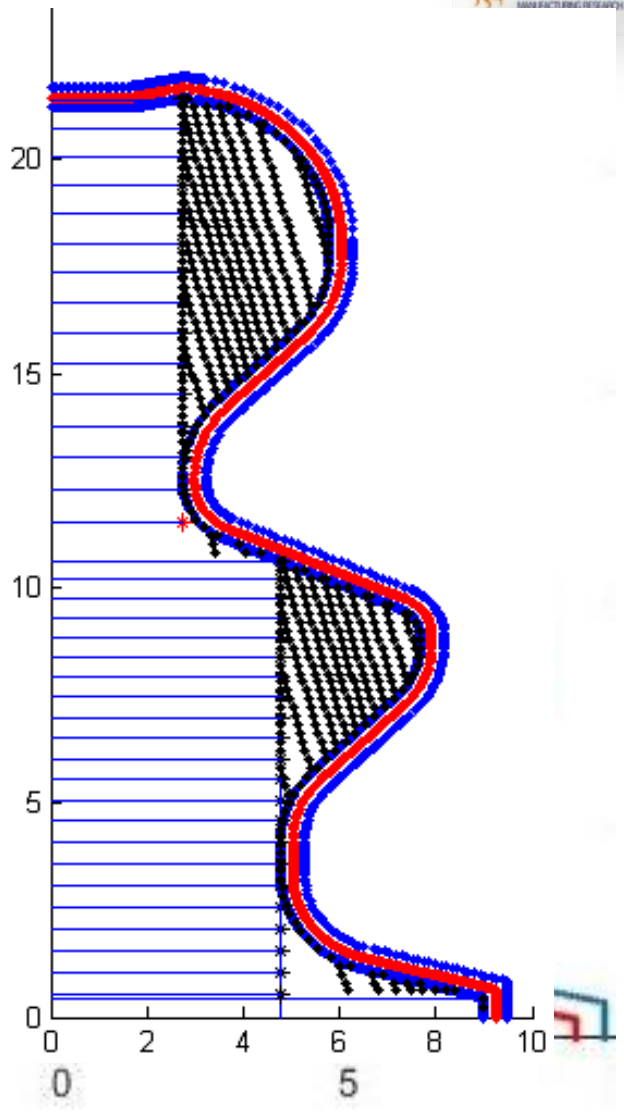
Roughing teeth

+

Semi-finishing Teeth

→

Broaching Tool



Generating Finishing Teeth

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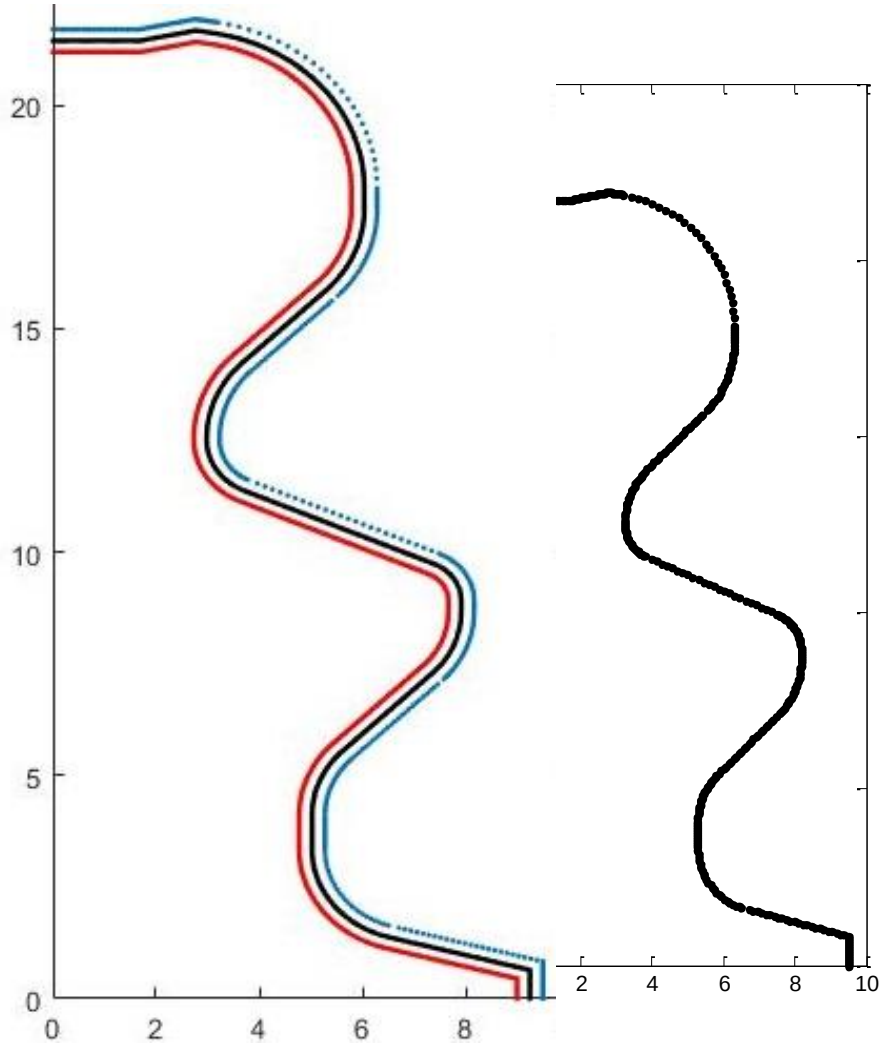
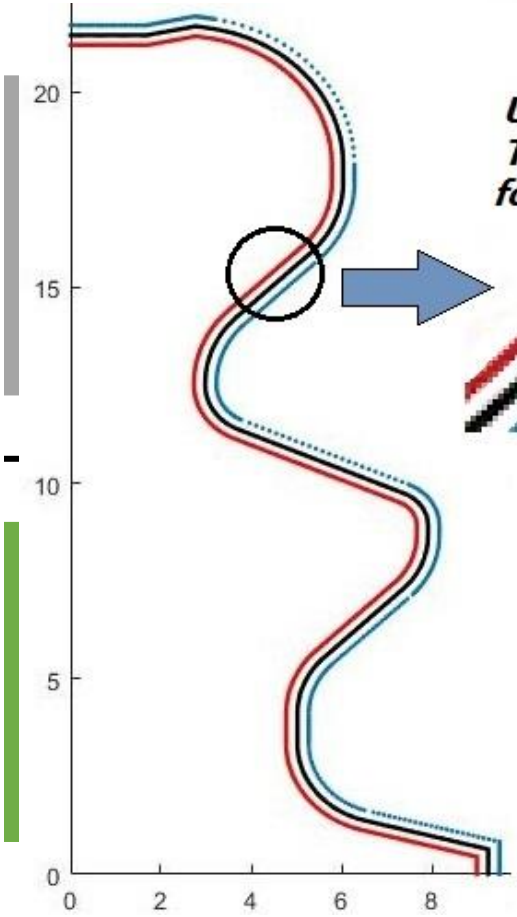
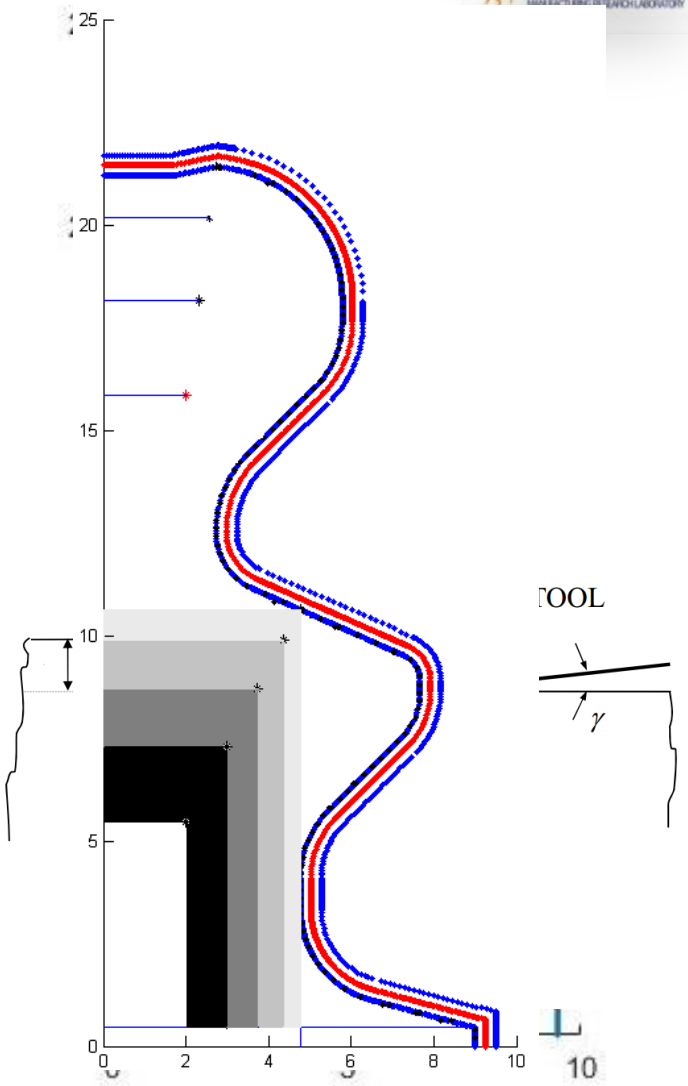




Generating Roughing Teeth

Parameters	Equation
Rake angle (°)	$\alpha = 0^\circ$
Shear Stress (Mpa)	$\tau_s = 543$
Friction angle (°)	$\beta = 18.98 + 0.0788 \times \alpha$
Shear angle (°)	$\phi = \tan^{-1}\left(\frac{r_c \cos(\alpha)}{1 - r_c \sin(\alpha)}\right)$, $r_c = c_0 h^{c_1}$, $C_1 = 0.239 - 0.0069 \times \alpha$, $c_0 = 0.985 - 0.0024 \times \alpha$
cutting force coefficient at the tangential direction (N/mm)	$K_{tc} = \frac{\tau_s}{\sin\phi} \frac{\cos(\beta - \alpha) + \tan\iota \tan\eta \sin\beta}{\sqrt{\cos^2(\phi + \beta - \alpha) + \tan^2\eta \sin^2\beta}}$
Edge cutting force coefficient at the tangential direction (N/mm)	$K_{te} = 50.8$

h assumption for calculating Ktc → Generating Roughing Teeth and *h* calculation iteratively



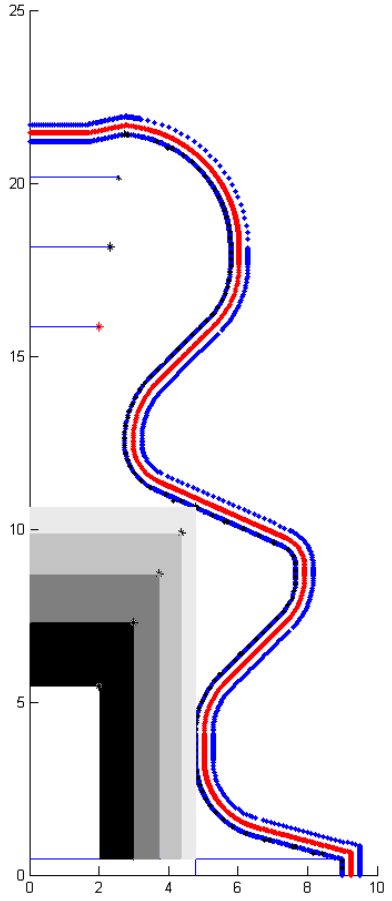
Generating Roughing Teeth

- All the teeth are constructed by considering the force level by adopting edge force model.

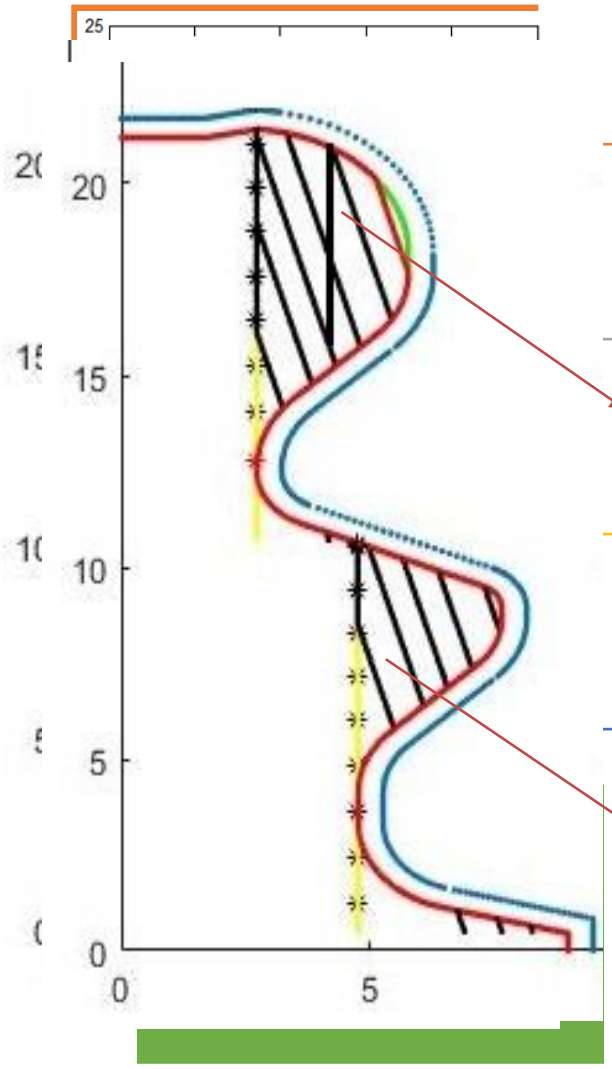
$$F = K_{tc} \times A_{tooth} + K_{te} \times L_{tooth}$$

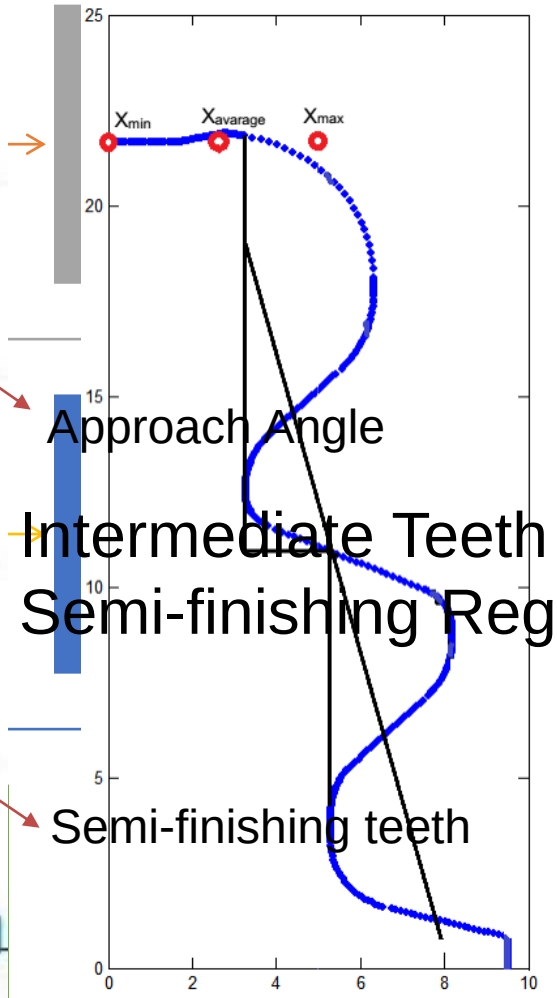
- The area which considered for calculating cutting forces is subtraction of new area with the area which has been removed by previous tooth.

- This process continues to each critical points



Generating Semi-Finishing Teeth





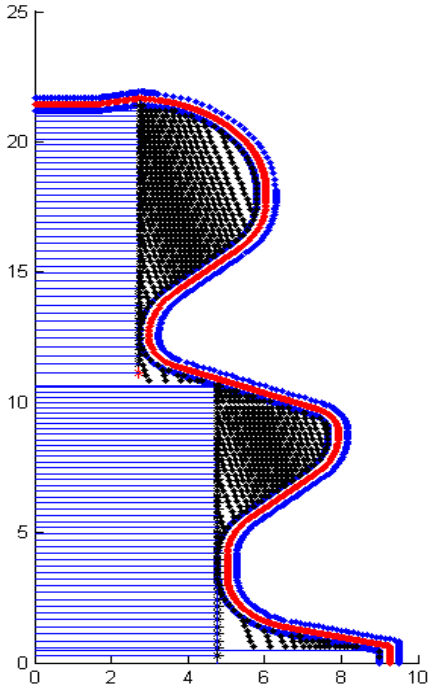
Approach Angle

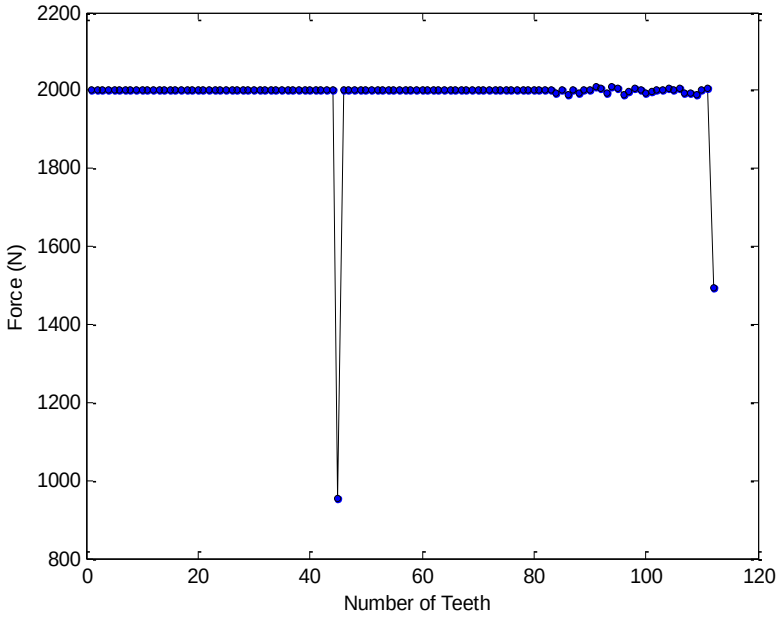
Intermediate Teeth in Semi-finishing Region

Semi-finishing teeth

Simulation Results

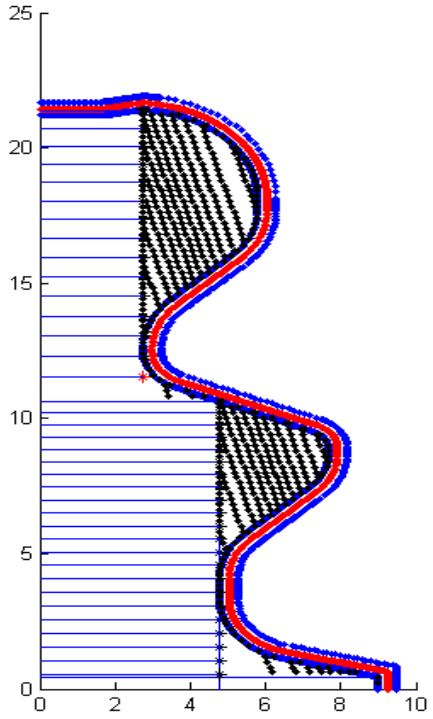
- Limiting forces in two Roughing and Semi-Finishing region is 2000 (N)
- Number of Teeth: 116

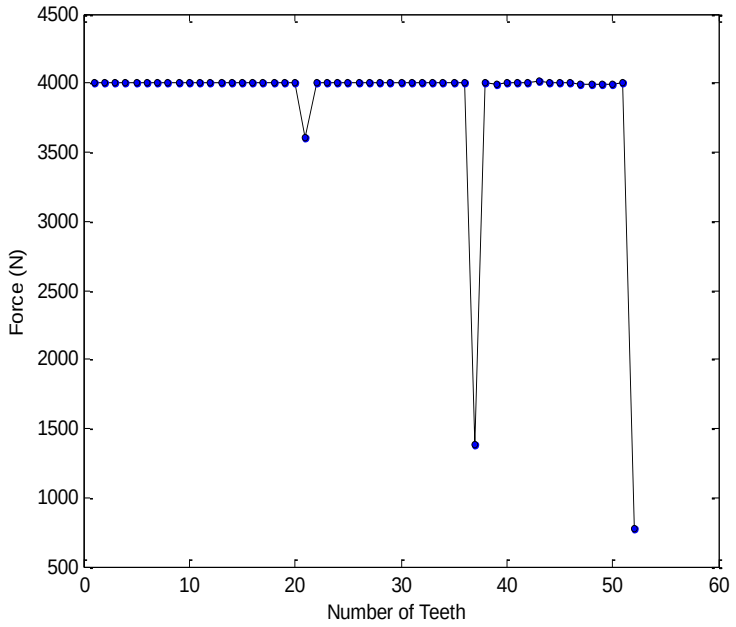




Simulation Results

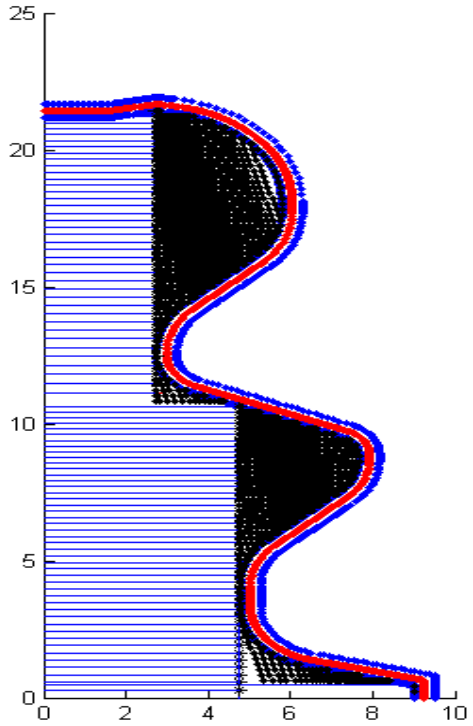
- Limiting forces in two Roughing and Semi-Finishing region is 4000 (N)
- Number of Teeth: 52

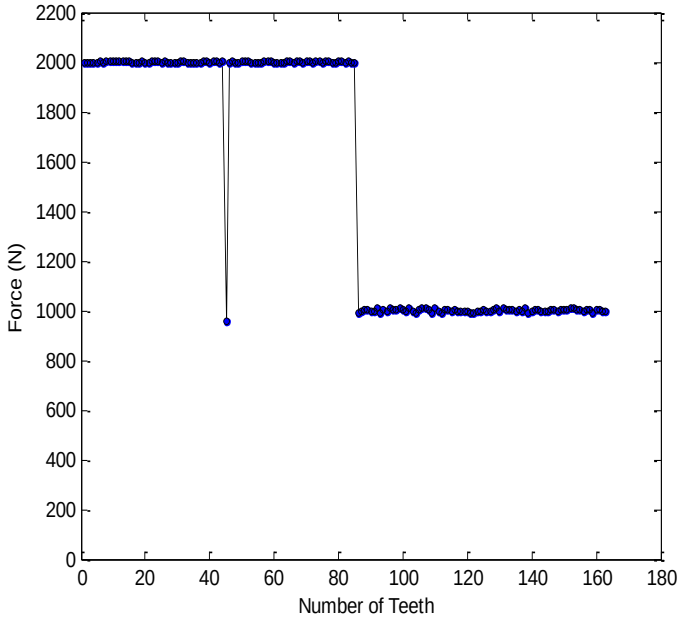




Simulation Results

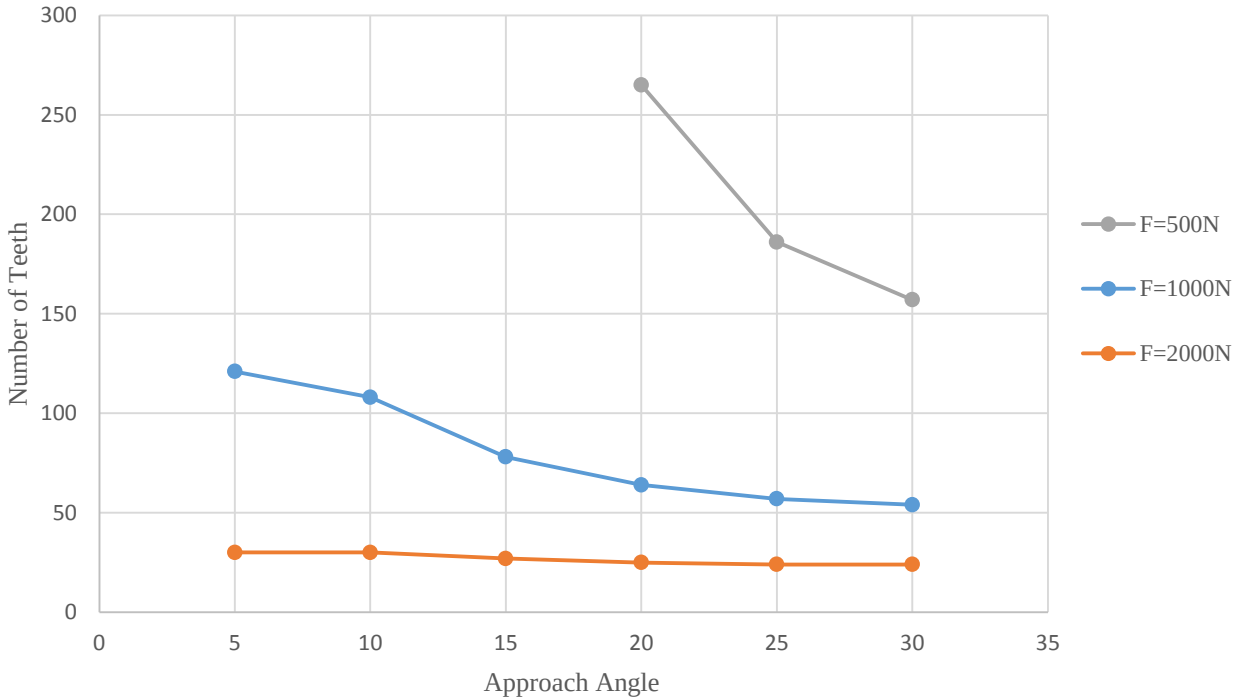
- Limiting forces in two Roughing region is 2000(N) and Semi-Finishing region is 1000 (N)
- Number of teeth : 167





Simulation Results

- Variation of the teeth number vs approach angle with different limiting forces



Conclusion

- An approach for automatic teeth generation
- Generated intermediate teeth with the given limiting forces in Roughing and Semi-Finishing region
- Increasing tool life by preventing chipped or broken teeth & Better surface quality
- The edge forces plays an important role at lower limiting forces

Thanks For your Consideration

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