Identifying problematic rotors from cardboard and steel quality data

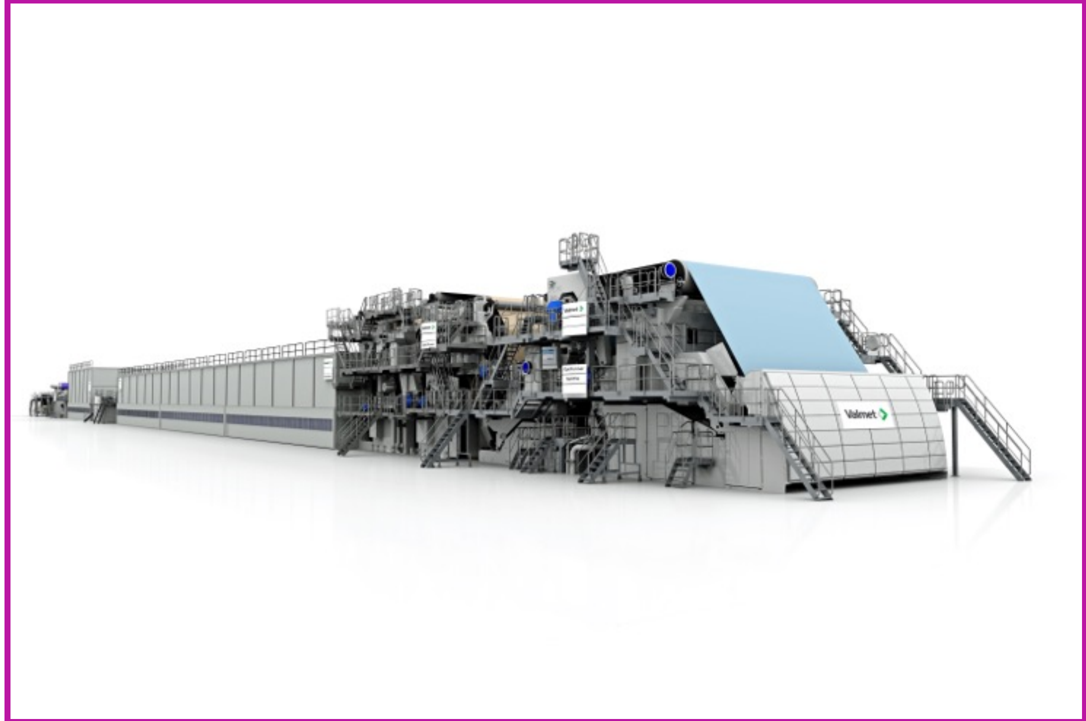

Image: Valmet

Image: Jonas Ginter

Aalto University
School of Engineering

Motivation

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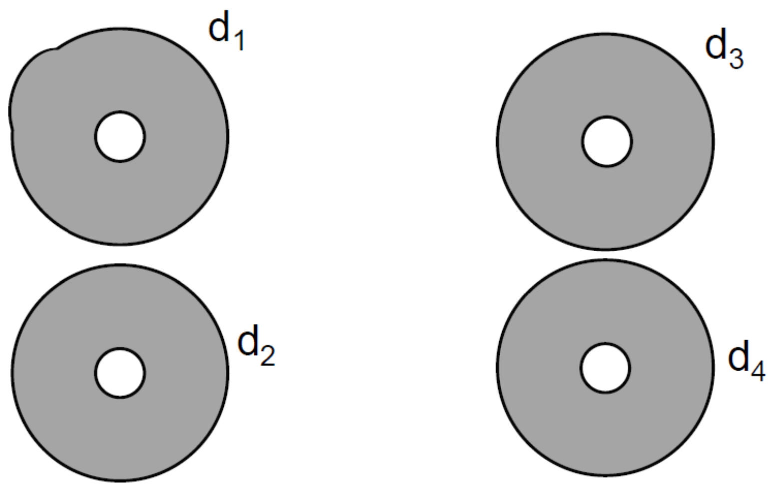
- E-commerce → demand for cardboard is skyrocketing
- Steel industry → carbon emissions
- So even little improvement = Good!

Motivation

Up to dozens of rolls in one cardboard machine or steel rolling line.



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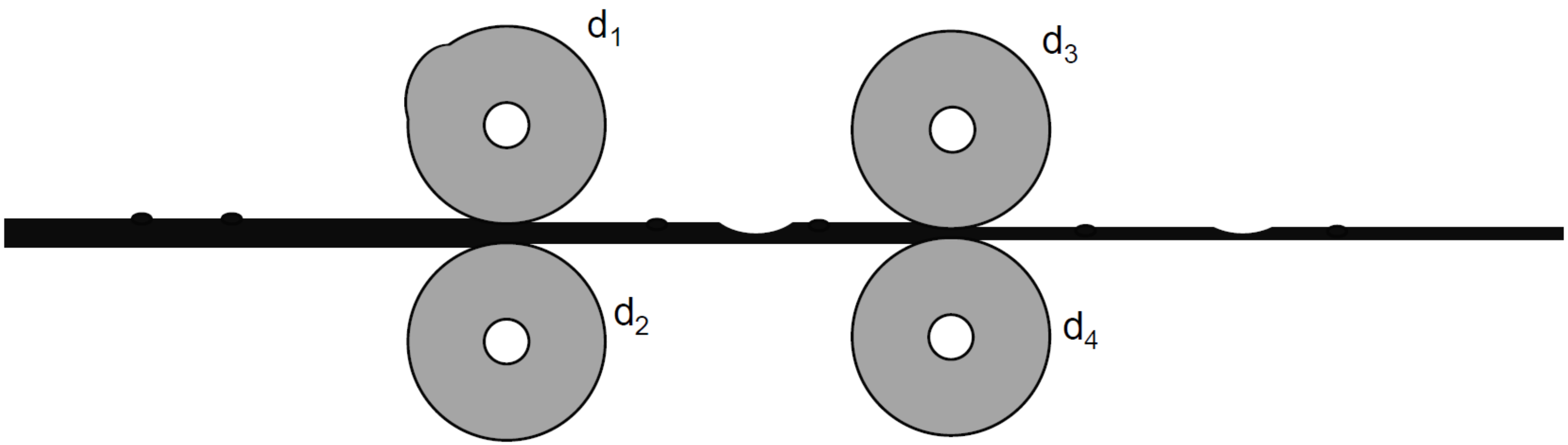
Each roll has defects that cause imperfections to the end product.



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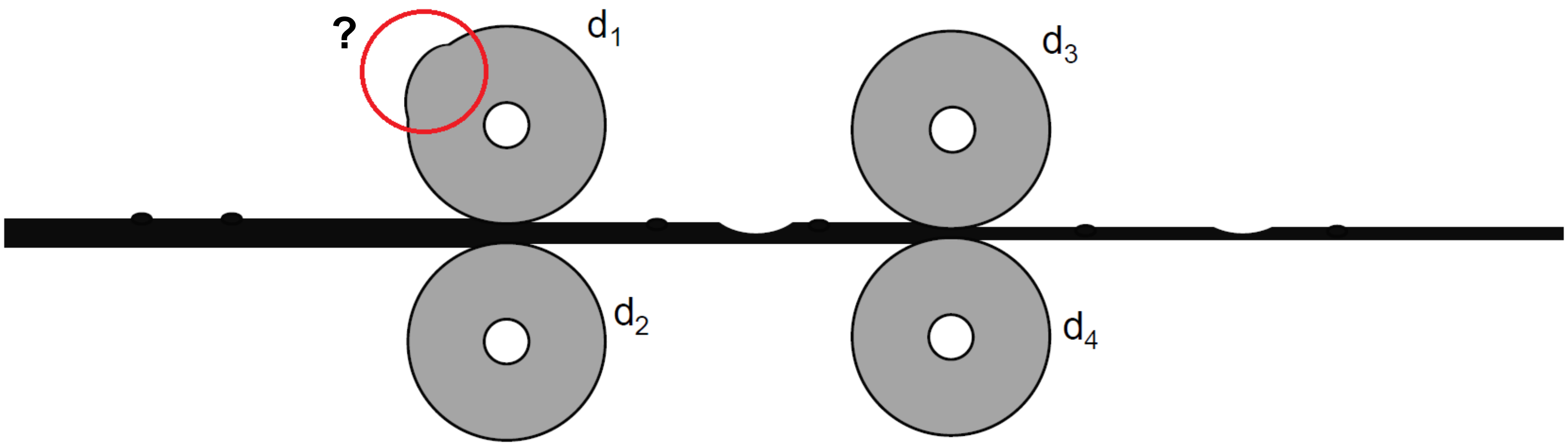
Which roll causes the most imperfections?



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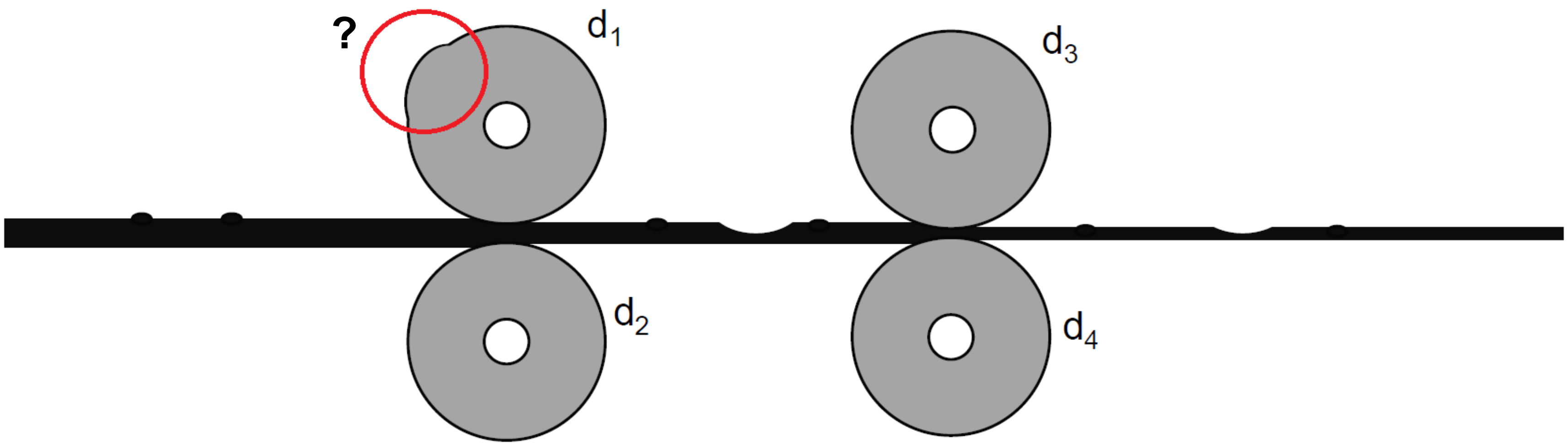

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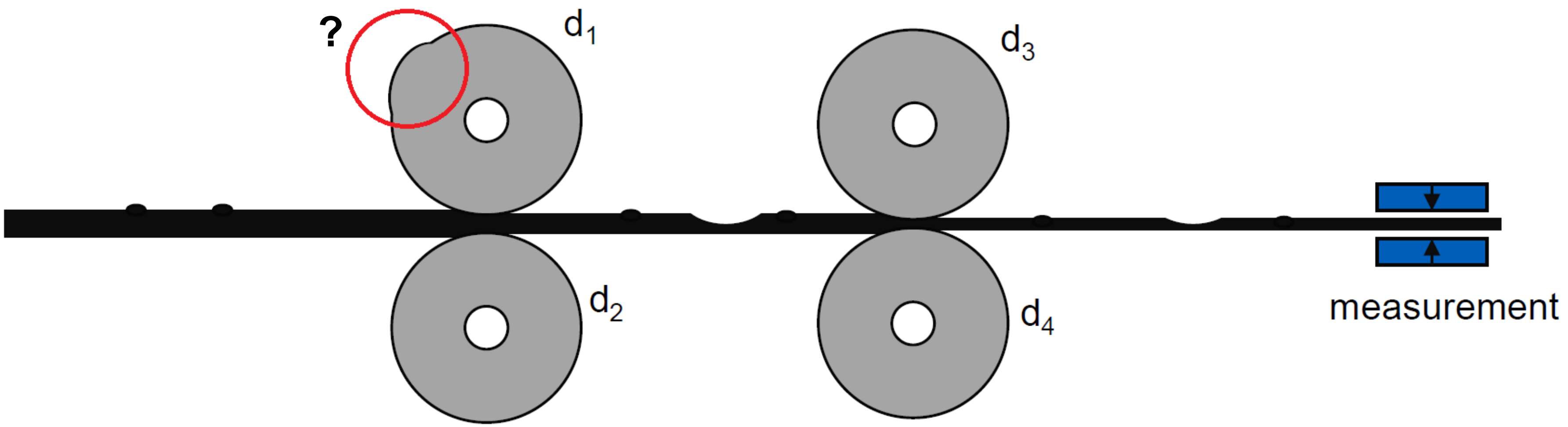
Can this be deduced from only the measured thickness variation of the end product?



Proposed method

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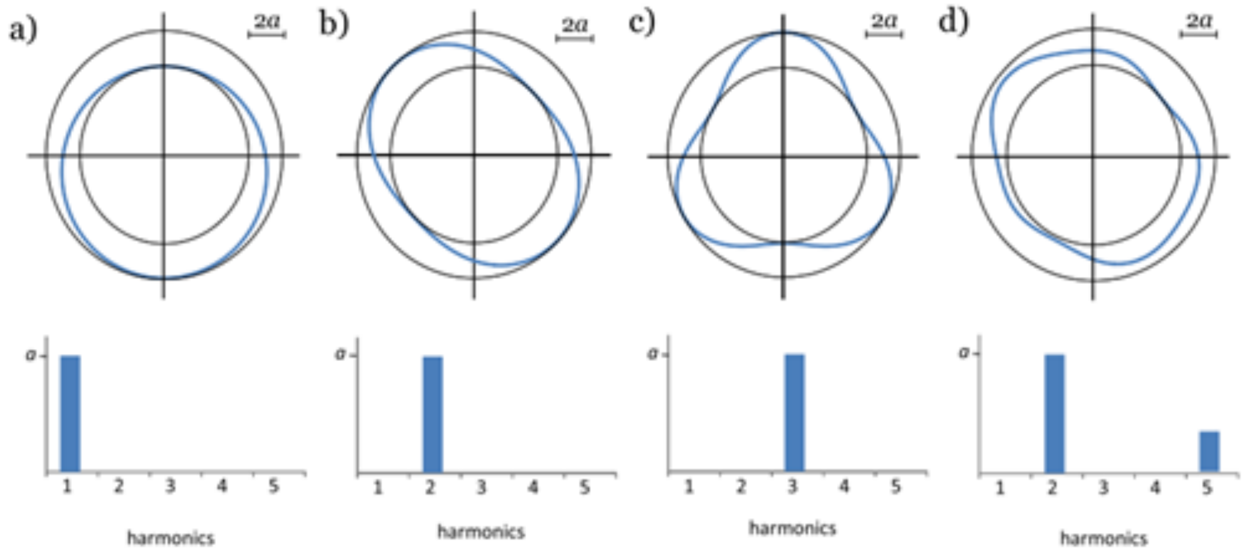
Rotors have roundness errors that are repeated 1, 2, 3, … times per revolution (eccentricity, ellipticity, triangularity…) → sum of sinusoids.

Eccentricity Ellipticity Triangularity Ellipticity + 5-lobed



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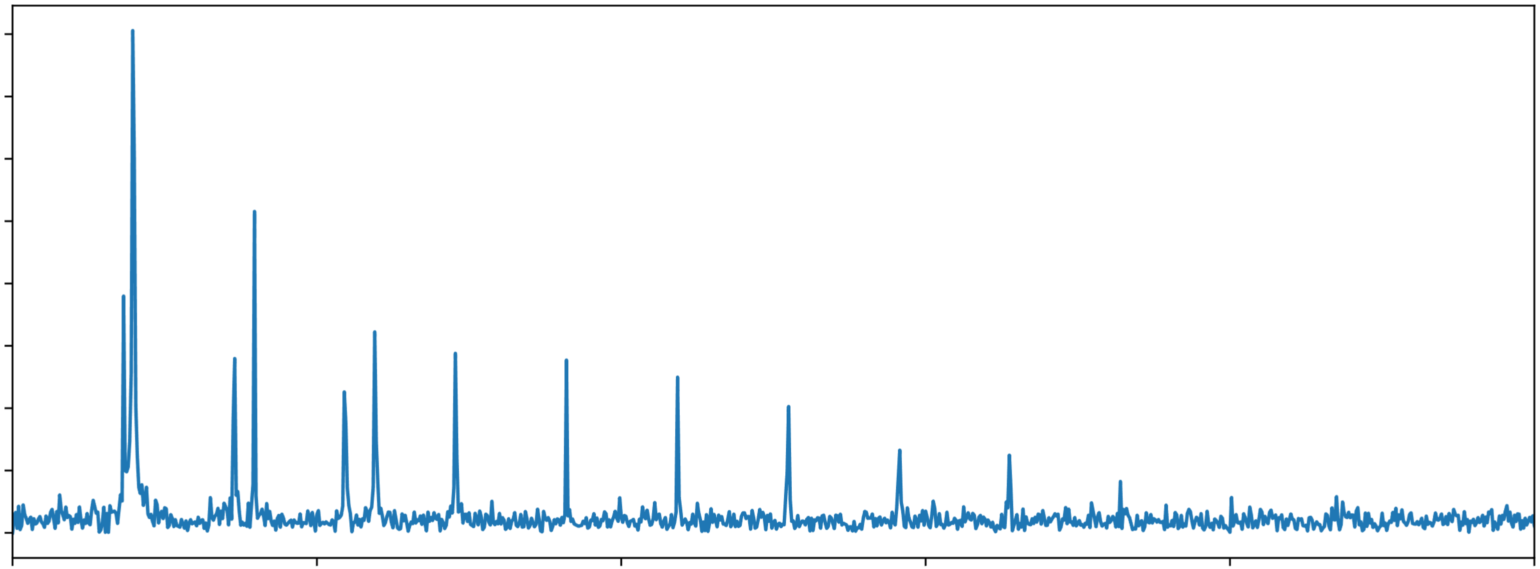
Rotors have roundness errors that are repeated 1, 2, 3, … times per revolution (eccentricity (a), ellipticity (b), triangularity (c) ….) → sum of sinusoids (d).

→ Obtain the spectrum of the thickness measurement data, identify harmonic series.



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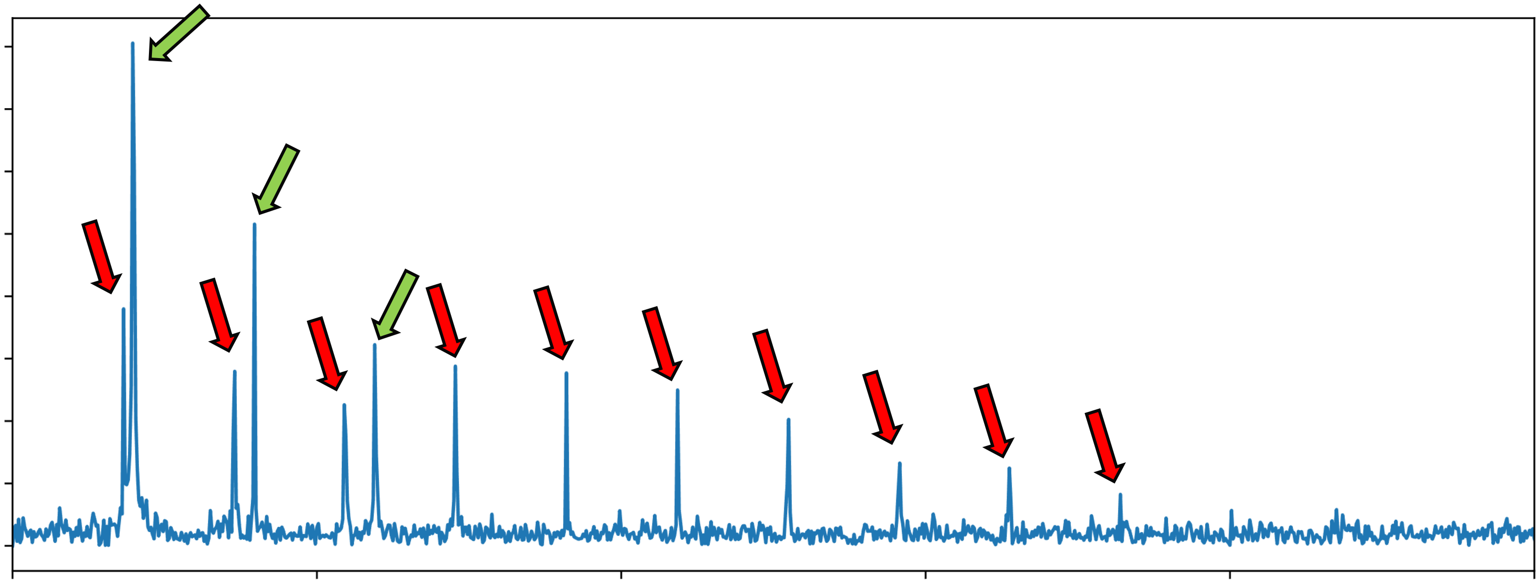

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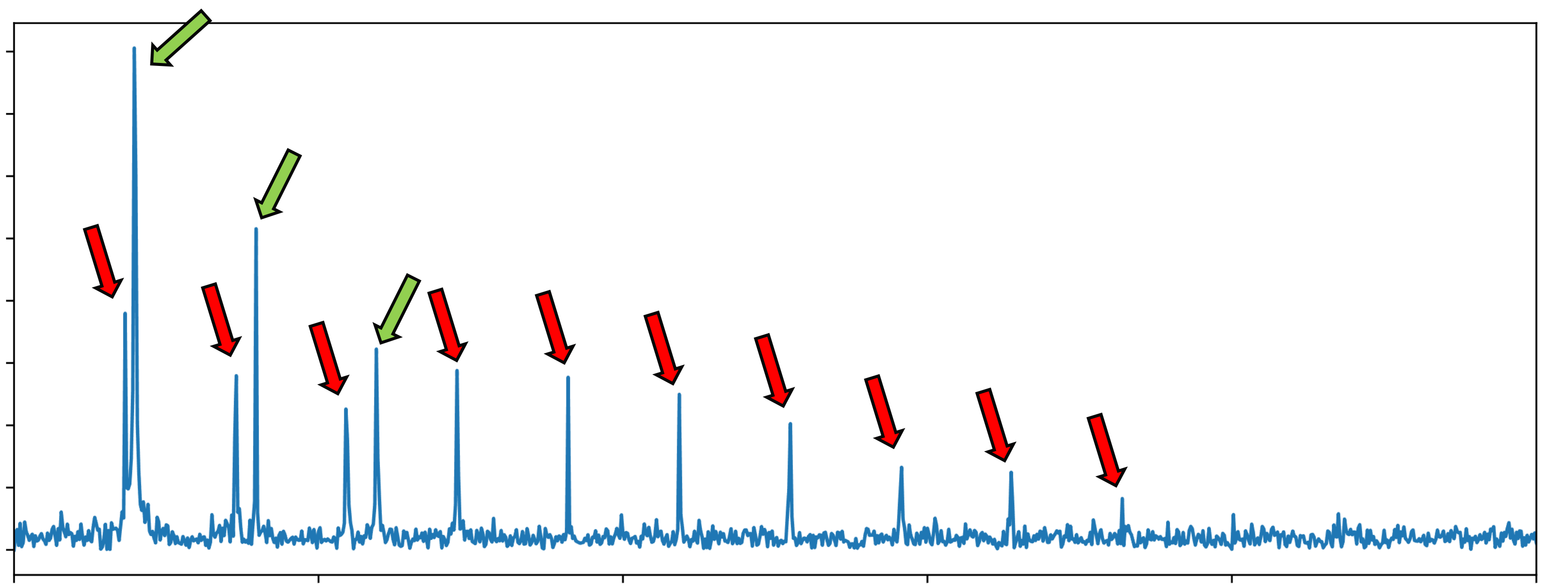

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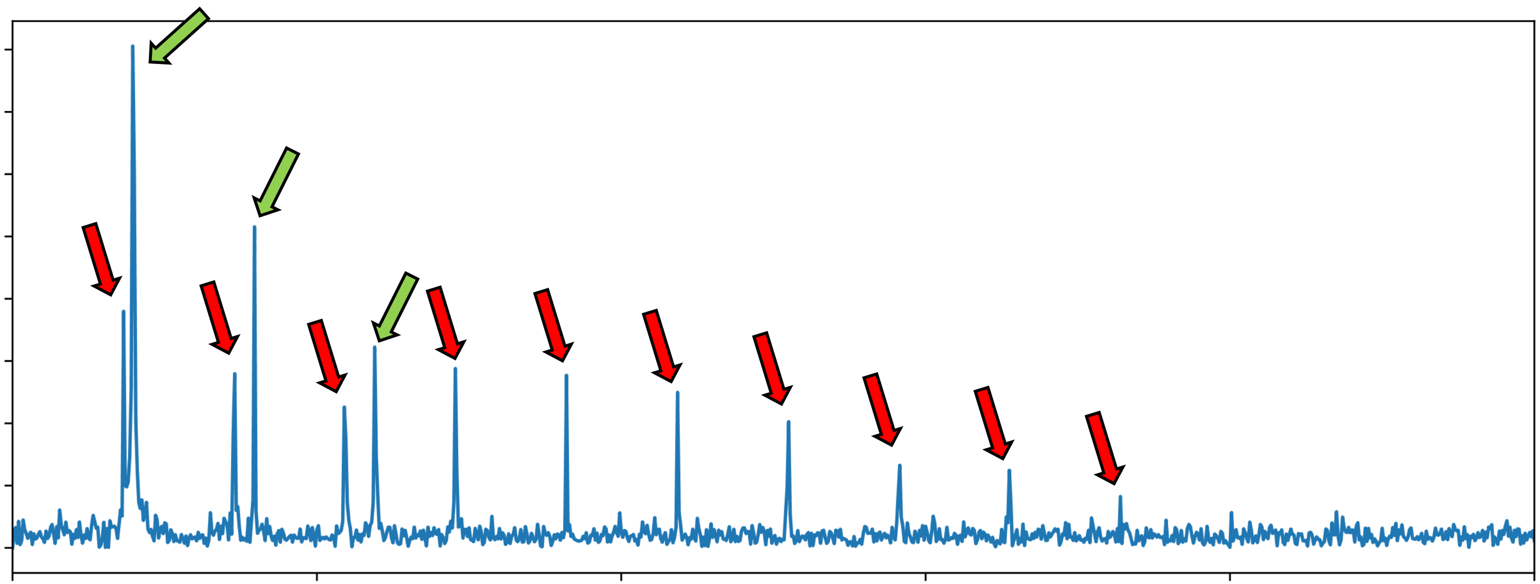
→ Use Fourier transform and periodogram?



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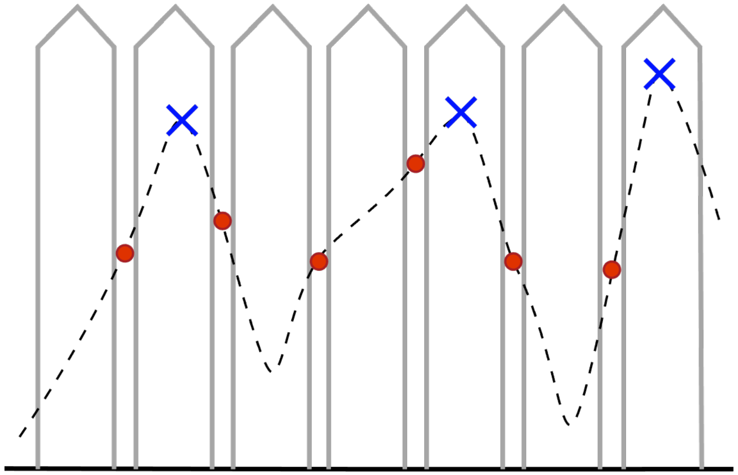

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- Limited frequency resolution → very similar sized rolls not separable.
- Picket-fence effect → very thin, sharp peaks may not be visible at all.
- No averaging (without windowing) → variance not improved with more samples.
  - Windowing → information is lost.

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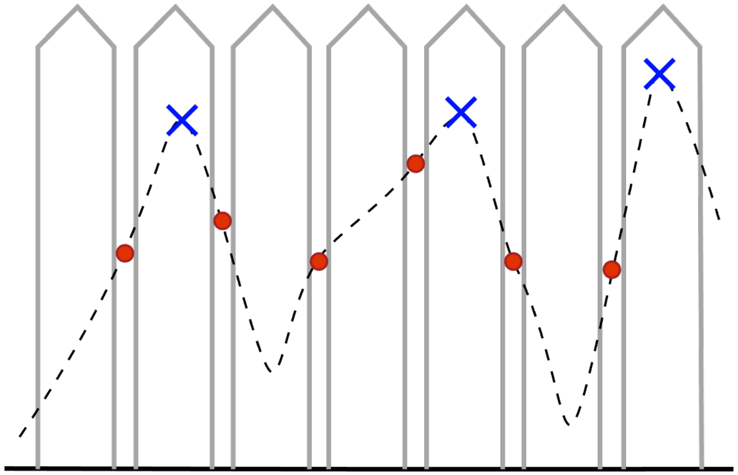

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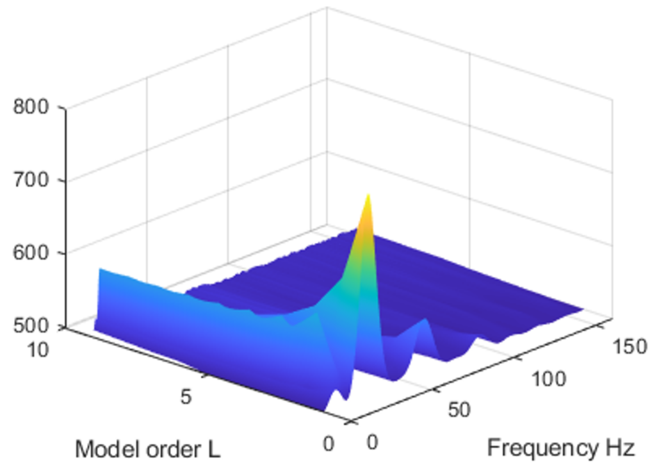

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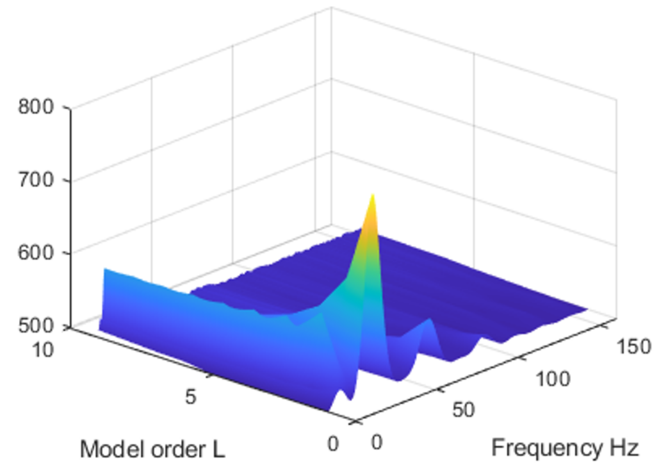

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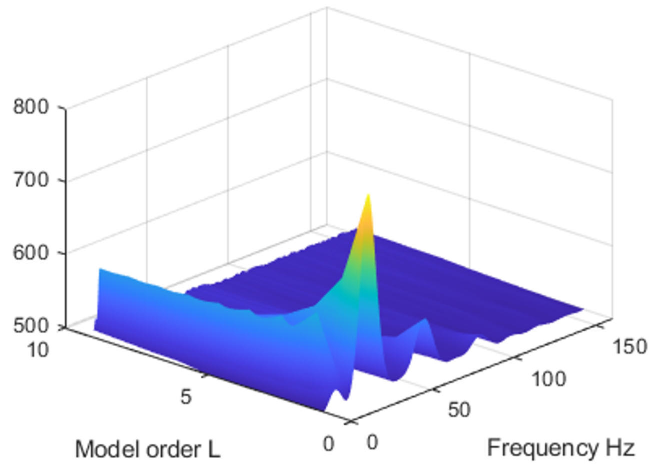

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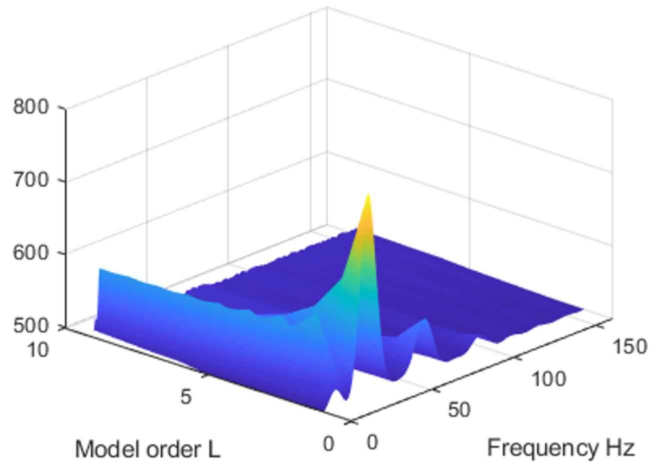

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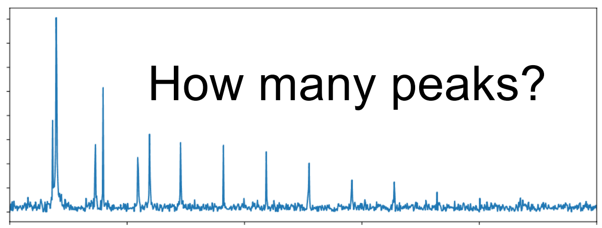

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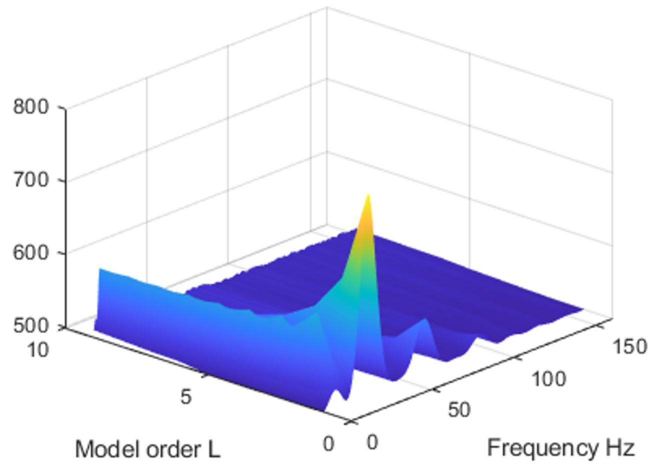

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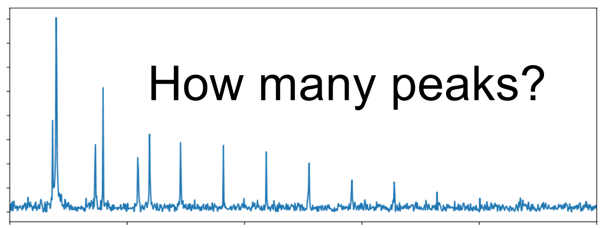
- Number of sinusoids in the signal has to be known *a priori*.
  - Methods exist to estimate this number
  - The big question: can these methods be applied in our context?



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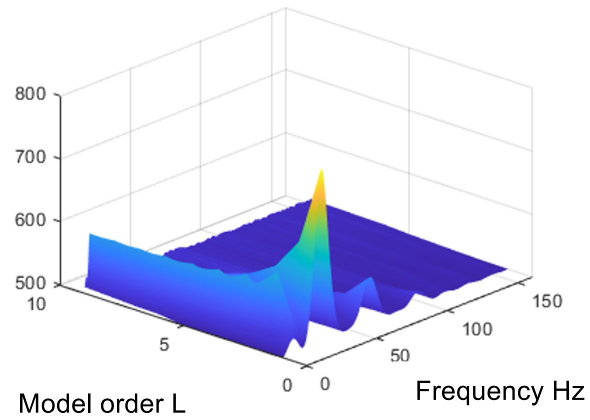
The punchline



$$F = 20\ Hz$$
$$= \cdots$$
$$d = 1033{,}1\ mm$$

Roll	Diameter mm
Former	1350,0
1.Press.up	971,1
1.Press.low	1033,1
2.Press.up	891,8
2.Press.low	882,2
1.Dry	1495,0
1.Caland	701,3
1.Caland.therm	1503,1
2.Caland	721,9
2.Caland.therm	1432,1
3.Caland	680,4
3.Caland.therm	1242,6
Spreader	265,5
Rollcylinder	1707,3
1.Util	1210,3
1.Mid.Util	1900,0
Therm	1358,8