

Priority Topic Area: **Responsible Production, Innovation and Industry**

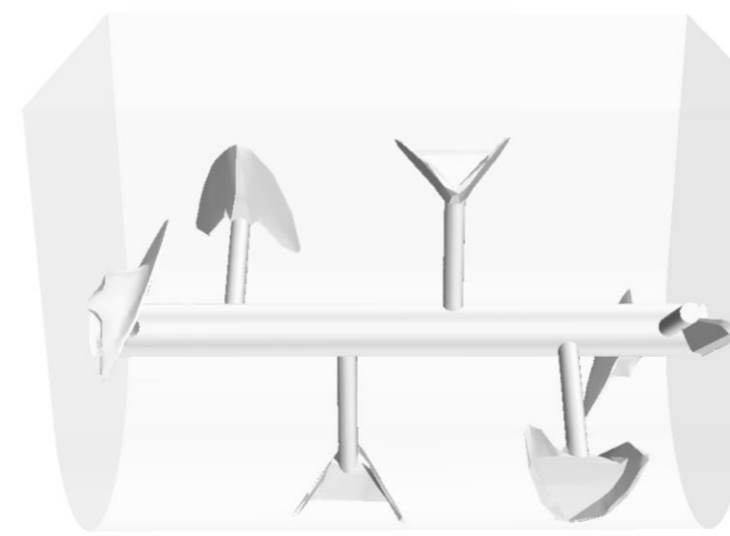
1. Problems Faced by Industry

- Climate-related legislation and United Nations SDG-12 are forcing companies to optimise their processes.
- **Must reduce energy use, carbon emissions and waste.**
- Largest savings possible by process design optimisation.

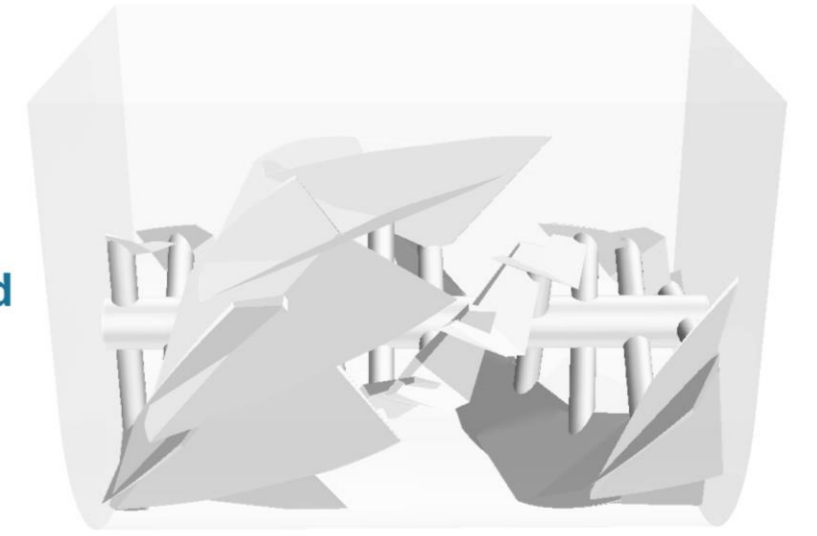
2. Current Technologies

- Optimising industrial geometric designs is:
 - **Costly:** £100,000 per new design.
 - **Slow and labour-intensive:** it takes years to create a single new design.
 - **High risk:** trial-and-error, as likely to get worse as better.
 - **Out of reach for SMEs:** requires human experts which are expensive and hard.
- E.g. £349,685 for single new design over 2 years¹

Base design



Evolved design



500x improved mixing

↑ Calibrated *in-silico* model



↓ Validated 500x improved mixing



Fig 1. Geometry optimisation of a ploughshare mixer used in industry to mix pastes and powders. CFD simulations validated using Positron Emission Particle Tracking/Projection Imaging. CAD optimised for mixing efficiency using HARPPP.

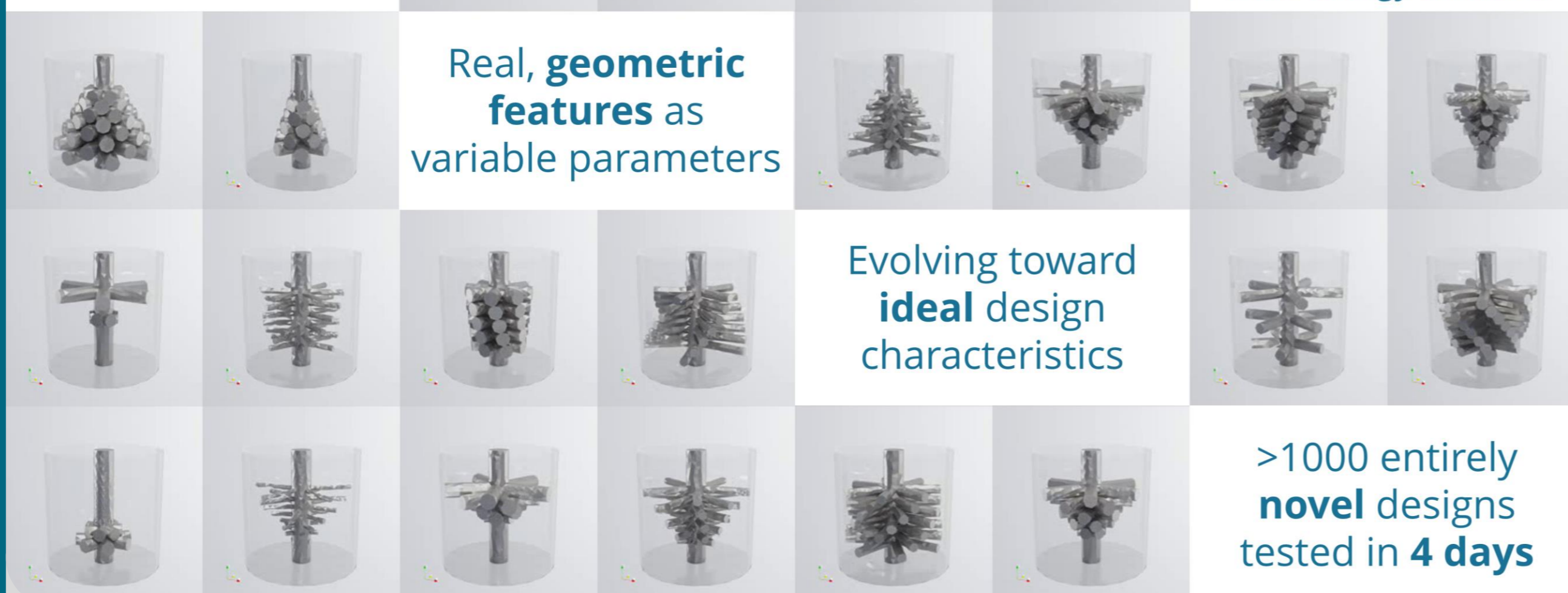
3. Our Biology-Inspired AI Technology

- World-first autonomous geometric design optimisation engine
- Discovers **orders-of-magnitude performance gains**, beyond what a human designer may envision – patentable designs
- Can be **accessible to SMEs** without dedicated R&D teams: fully automated, can be set up by a single engineer
- Discovers novel, patentable designs / redesigns existing processes
- Optimises processing conditions of existing equipment
- Scales up unit operations without building suboptimal prototypes
- All of the above, simultaneously.

Cost function: **minimise power draw**

Milling accounts for 4% global energy use.

HARPPP design is **47% more energy efficient.**



Real, **geometric features** as variable parameters

Evolving toward **ideal design characteristics**

>1000 entirely **novel designs** tested in **4 days**

Fig 2. Geometry optimisation of a vertical mill; Milling accounts for 4% of global energy usage. DEM simulations optimised for reduced power draw using HARPPP.

4. Benefit to society

- Upon implementation, Mondelez sustainability team calculated single site savings of:
 - **4000 tonnes CO2 per year**
 - **£200,000 per year**
- In 2022, UK industry's energy consumption was approximately 256,000,000,000 kWh²
 - If results similar to those with Mondelez were reproduced across 1% of the manufacturing sector, we **could save 300,000 tonnes of CO2 per year.**
- Improved throughput enables reduced operational cost and allows lower consumer price point.
- Allow industry to align with UK's Net Zero Strategy, the Strategic Technologies for Europe Platform and US/EU Green Deals.

5. Next steps

- **Patent application** for core technology drafted
- **Spinning out EvoPhase** start-up to maximise real-world impact
- General technique for particles and/or fluids; **continue active projects** on: ribbon mixers, static mixers, catalyst pellet shapes, pharmaceutical powder blending

References/Acknowledgements

1. UK Research and Innovation. (2022). *THERMIX, novel adaptable heat exchange inserts*. (UKRI: 57083)
 2. UK Department for Business, Energy & Industrial Strategy. (2023). *UK energy in brief 2023*.
- All simulations were executed on the BEAR Cloud service at the University of Birmingham, <http://www.birmingham.ac.uk/bear>.