Popular science summary of the PhD thesis

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Title of the PhD thesis	Adaptive tooling technology for high-volume metal forming: From concept to industrial readiness
PhD school/Department	DTU Construct

Science summary

Modern manufacturing relies on high-volume stroke-based metal forming processes to produce billions of everyday components, from beverage cans to battery housings. These processes are fast and efficient, but they face two persistent challenges: severe tool wear and variation of part dimensions during production. Both issues increase costs, waste, and environmental impact. This PhD project addresses these challenges by introducing a technology for tool diameter adjustment that allows forming tools to change their dimensions during production, thereby adapting to process variations.

The research focuses on ironing – a process used to thin and straighten the walls of deep-drawn metal cups. Conventional ironing punches have a fixed diameter, which means that micrometre-scale variations in material thickness or tool dimensions due to thermal expansion can cause parts to fall out of tolerance. Moreover, severe friction during punch retraction from the ironed cup leads to galling – a damaging wear phenomenon – forcing manufacturers to use environmentally harmful lubricants and frequent tool maintenance.

To solve these challenges, this project developed an adjustable-diameter ironing punch that acts as an actuator within the forming tool. By expanding before ironing and contracting before retraction, the punch could both control part height and mitigate the redundant wear. Laboratory and industrial trials demonstrated that this adaptive tool can maintain consistent part height over thousands of strokes, while reducing or even eliminating wear during punch retraction. These improvements enable stable production with non-chlorinated lubricants and extend tool longevity by at least an order of magnitude.

Beyond ironing, the concept has potential for other processes where high contact pressures and dimensional variation occur, such as extrusion or powder compaction. By combining mechanical design, advanced materials, and closed-loop control, this technology paves the way for smarter, more sustainable manufacturing, reducing scrap, chemical use, and downtime – key steps toward greener high-volume production.

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