# Designing Energy Efficient & High-Speed Mechanical Presses for Improved Ram Motions using Advanced Algebraic Techniques


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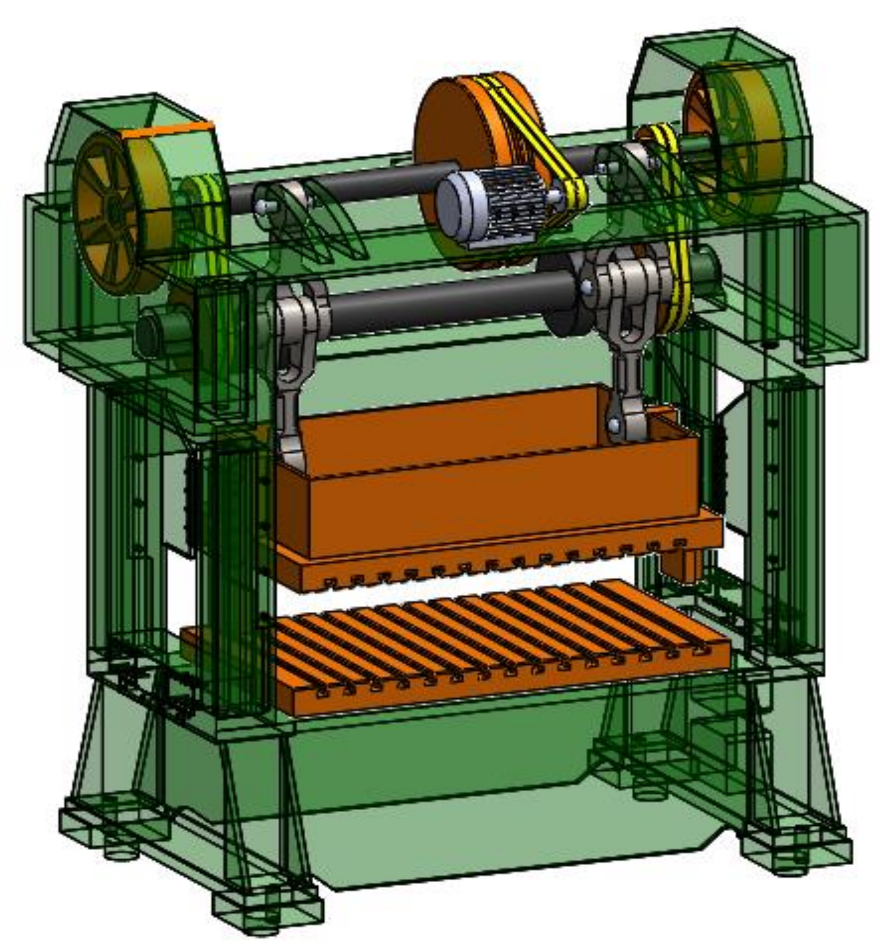
**Objective: To determine a mechanical press design with either constant velocity or maximized dwell.**

## Introduction

A mechanical press is a machine that shapes parts by driving a ram into metal and deforming the material into a desirable shape. As this is an incredibly common process for forming metal parts, from pop cans to car fenders, presses see significant use in industry on a global level. The objective of the proposed research is to generate alternative drivetrain designs for mechanical presses that produce specialized ram motions, which is appealing to industry. The focus of this work is on mechanical presses due to their faster speeds, lower cost, greater accuracy, higher precision and energy efficient operation as compared to other pressing options. Due to their ubiquity, even small improvements yield huge savings in terms of processing time and energy consumed. This research work is formulated to generate designs with practical dimensions and encountering forces in line with industry expectations. Moreover, these new designs will either improve dwell or improve the range of constant forming velocity, both strongly desired in industry.

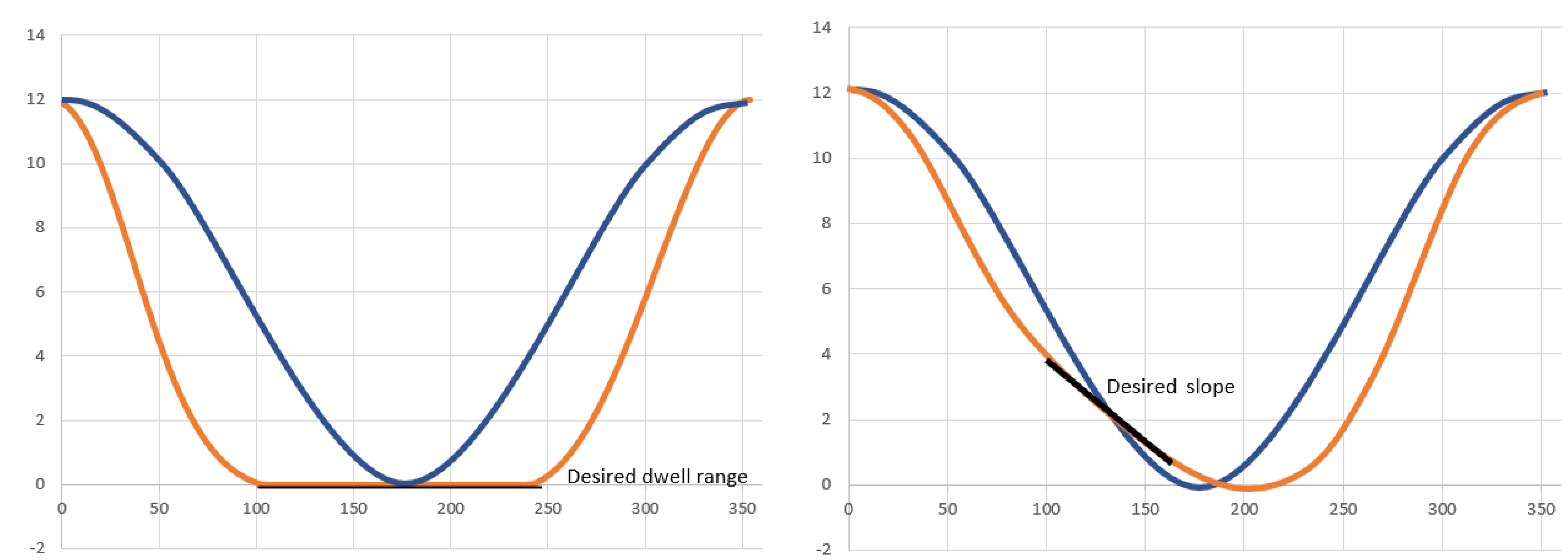
## Knuckle Joint Driven Press



## Stroke Curve Comparison

As shown in the figure on the right, the blue curve represents the motion before altering the design, and the orange curve represents the desired motion for improving the design. Industry use specifies the desirable situations as a longer, flatter dwell or a closer-to-constant press velocity near the bottom of the stroke.

## Desirable Designs




(a) Extended dwell (b) Constant forming velocity

**Knuckle Press Position Equations**

$$\begin{cases} a * c(\phi_i + \delta) + b * c(\theta_{bi}) - c * c(\theta_{ci}) - d * c(\theta_d) = 0 \\ a * s(\phi_i + \delta) + b * s(\theta_{bi}) - c * s(\theta_{ci}) - d * s(\theta_d) = 0 \end{cases}$$

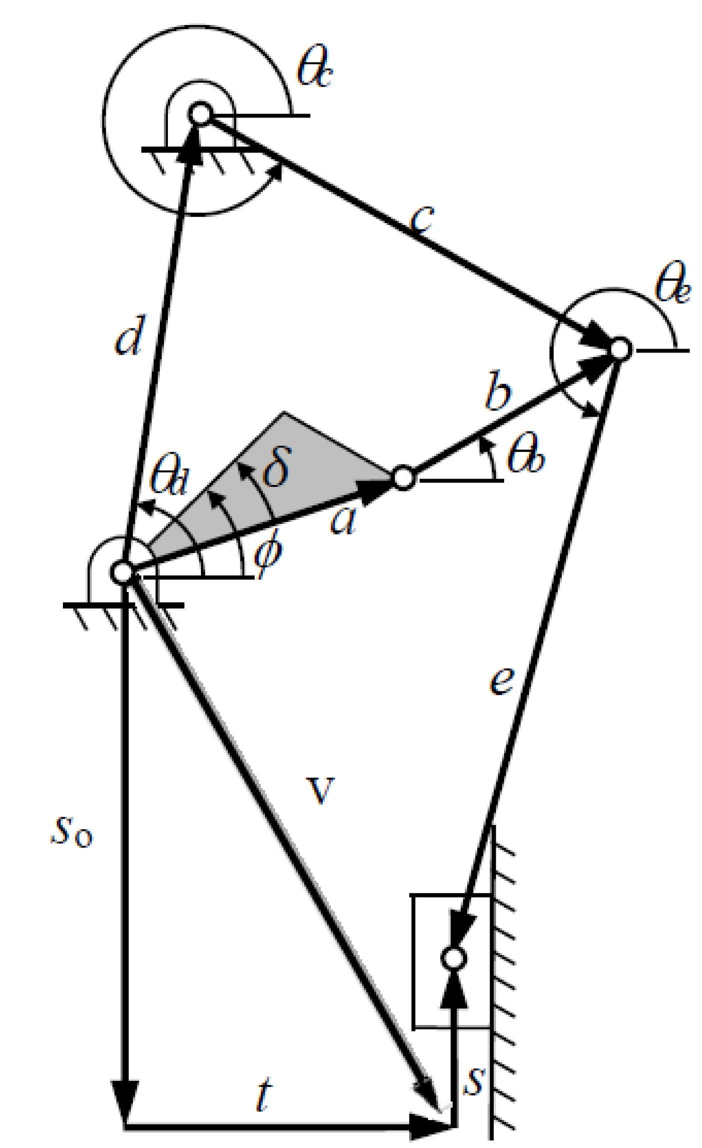
$$\begin{cases} a * c(\phi_i + \delta) + b * c(\theta_{bi}) + e * c(\theta_{ei}) - v * c(\theta_v) = 0 \\ a * s(\phi_i + \delta) + b * s(\theta_{bi}) + e * s(\theta_{ei}) - v * s(\theta_v) - s = 0 \end{cases}$$

**In Isotropic Form**

$$\begin{cases} aT_{\phi i}T_\delta + bT_{bi} - cT_{ci} - dT_d = 0 \\ a\bar{T}_{\phi i}\bar{T}_\delta + b\bar{T}_{bi} - c\bar{T}_{ci} - d\bar{T}_d = 0 \end{cases}$$

$$\begin{cases} aT_{\phi i}T_\delta + bT_{bi} + eT_{ei} - vT_v - si * I = 0 \\ a\bar{T}_{\phi i}\bar{T}_\delta + b\bar{T}_{bi} + e\bar{T}_{ei} - v\bar{T}_v + si * I = 0 \end{cases}$$

## Vector Diagrams




The vector diagram above is the mathematical abstraction of the press shown on the left. These vector diagrams are used to generate the equations shown. Isotropic coordinates are a little used formalism being promoted by mathematicians in the mechanical engineering sector because they are well suited to numerical algebraic techniques.