

# بسم الله الرحمن الرحيم





# شبكة المعلومات الجامعية التوثيق الالكتروني والميكرو فيلم





# جامعة عين شمس

التوثيق الإلكتروني والميكرو فيلم

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Cairo University

# **OPTIMIZATION OF SYNCHRONIZATION PARAMETERS FOR HYDROFORMING T-TUBE PROCESS**

By

**Moataz AbdelGawad Mohammed AbdelGawad**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
in Partial Fulfillment of the  
Requirements for the Degree of  
**DOCTOR OF PHILOSOPHY**  
in  
**MECHANICAL DESIGN AND PRODUCTION ENGINEERING**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
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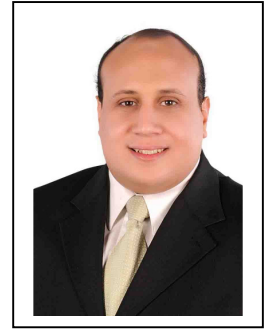
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**Title of Thesis:**  
**OPTIMIZATION OF SYNCHRONIZATION PARAMETERS FOR  
HYDROFORMING T-TUBE PROCESS**

**Key Words:** Tube hydroforming; Machine learning; Multiple ridge regression;  
Loading path; Wrinkling

**Summary:**  
An adaptive, heuristic, nonlinear mathematical model (AHNM) was proposed to optimize the loading path of a hydroforming process as a result of adaptive minimization of the internal pressure and axial load of the process. FEA was used to analyse the process, also this research examined several Machine Learning algorithms such as; Multiple Ridge Regression and Random Forest to learn the relations between the features. The linearity between the features was assumed to create simple AHNM model, where the Multiple Ridge Regression was found to give the highest accuracy. AHNM model was implemented, solved, and optimized using several steps of tee protrusion height. A new Test Rig was developed to experiment the validity of the obtained loading paths for different thicknesses of tube. This research applied the machine learning in this process for the first time, and confirmed that creation of the (AHNM) modelling was successful application.

## **Disclaimer**

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

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# Nomenclature

Symbol	Description
$AL_t$	Axial load at time $t$
$AS_t$	Maximum axial stress within the area of the non-circular protrusion at time $t$
DT	Decision Tree algorithm
FEA	Finite Element Analysis
FEM	Finite Element Modeling
$HS_t$	Maximum hoop stress within the area of the non-circular protrusion at time $t$
$IE_t$	Average internal energy of the whole deformed part at time $t$
$IP_t$	Internal pressure inside the tube at time $t$
$KE_t$	Average kinetic energy of the whole deformed part at time $t$
$MAS$	The maximum allowable deformation stress
$MAT$	The maximum allowable thickness
$MaxT_t$	Maximum thickness at the area of the non-circular protrusion at time $t$
$MD_t$	Maximum vertical displacement within the area of the non-circular protrusion at time $t$
$MIAS$	The minimum allowable deformation stress, and the
$MIAT$	The minimum allowable thickness
$ML$	Machine Learning
$MinT_t$	Minimum thickness at the area of the non-circular protrusion at time $t$
$MS_t$	Maximum principal strain within the area of the non-circular protrusion at time $t$
$MT_t$	Minimum thickness at the area of the non-circular protrusion at time $t$
$N$	Total number of periods
$n$	Material hardening exponent
$PP_t$	Punch pressure at time $t$
RF	Random Forest algorithm
T-Tube	Tube with lateral protrusion
T- protrusion	Lateral protrusion of Tube
$t$	Time period
$\varepsilon_{critical}$	The critical strain at which instability occurs
$\sigma_{axial}$	The axial stress within the tube
$\sigma_{hoop}$	The circumferential stress within the tube