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IDENTIFICATION OF IMPORTANT FACTORS OF FLOW FORMING OPERATION IN BRASS UTENSIL MANUFACTURING

KRISHNAMURTI L. MOTGHARE, CHANDRAHAS C. HANDA and RAKESH L. HIMTE

Department of Mechanical Engineering
Ph.D Research, KDK College of Engineering
Nagpur-440008, India
E-mail: klmotghare@gmail.com

Department of Mechanical Engineering
KDK College of Engineering
Nagpur-440008, India
E-mail: chandrahashanda@gmail.com

Department of Mechanical Engineering
Rungta College of Engineering
and Technology, Bhilai-490026, India
E-mail: rakeshhimte@gmail.com

Abstract

In brass utensil manufacturing, most of work is performed manually and repetitive in nature by unskilled workers with help of different tools and semi-automatic machine. The method adopted for flow forming operation is not scientific approach. Entire operations are falling under the class of man machine systems.

This paper investigates most influenced input variables like work piece parameter, tooling parameter, process parameter, machine parameter and extraneous factor are directly involved with response variables like accuracy, surface finishing and cycle time has measured which decides quality, performance of flow forming operation in brass utensil manufacturing. These identified factors are used to design the mathematical model for this operation by applying theories of experimentation. The same models are simulated for collected data by statistical tool.

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1. Introduction

Metal forming is one of the oldest methods of chip less forming [7]. In this process the diameter of the blank is reduced either over the whole length or in defined areas [1]. Here the metal is displaced axially along a mandrel externally by tool on blank. The blanks are clamped rigidly against the mandrel by means of a tailstock and the shape of the mandrel bears the final profile of the desired product. Research in metal forming has offers remarkable utilization of metal, high strength, excellent surface finish and close dimensional accuracy within the reasonable economics.

2. Methodology

In brass utensil manufacturing industry, most of work is performed manually and repetitive in nature by unskilled workers with help of various tools and semi-automatic machine. The method adopted for flow forming operation is not scientific approach and entire operations are falling under the class of man machine systems.

2.1 Identification of Input and Output Variables

For designing the predictive model, a number of influencing factors are identified based on detailed study of flow forming operation.

2.1.1 Independent Variables

(1) **Work piece parameters.** (i) Diameter of blank, (ii) Thickness of work piece, (iii) Material of blank, (iv) Diameter of finished product

(2) **Tooling parameters.** (i) Nose radius of tool (ii) Diameter of tool (iii) Length of tool

(3) **Process parameters.** (i) Feed rate, (ii) Mandrel speed, (iii) Attack angle

(4) Specification of workstation(m/c) parameters

(5) Anthropometric data of operator

(6) Environmental parameter: (i) Humidity

2.1.2 Dependent Variables

(1) Surface finish

(2) Accuracy

(3) Cycle time

2.2 Reduction of Variables using Dimensional Analysis

Deducing the dimensional equation for a phenomenon reduces the number of independent variables in the experiments. This is achieved by applying Buckingham's Π theorem when number of variables is more.

Table 1. List of Independent Π Terms of Flow Forming Operation.

SN.	Description of Π terms	Π terms
01	Π term related to anthropometric data of	Π_1
02	Π term related to specification of work piece	Π_2
03	Π term related to specification of tool	Π_3
04	Π term related to specification of work station	Π_4
05	Π term related to process	Π_5
06	Π term related to humidity	Π_6

Table 2. List of Dependent Π Terms of Flow Forming Operation.

SN.	Description of Π terms	Π terms
01	Π term related to response variable surface finish	Π_7
02	Π term related to response variable accuracy	Π_8
03	Π term related to response variable cycle time	Π_9

2.3 Development of Model for Flow Forming Operation in Brass Utensil Manufacturing

Data of independent and dependent parameters of the system has been collected to correlate various variables, mathematical models are form.

For the dependent Π term Π_7, we have

$$\Pi_7 = f(\Pi_1, \Pi_2, \Pi_3, \Pi_4, \Pi_5, \Pi_6)$$

$$\Pi_7 = K_1^*(\Pi_1)^{a1} * (\Pi_2)^{b1} * (\Pi_3)^{a1} * (\Pi_4)^{d1} * (\Pi_5)^{e1} * (\Pi_6)^{f1}$$

$$Log\Pi_7 = \log K_1 + a_1 * \log(\Pi_1) + b_1 * \log(\Pi_2) + c_1 * \log(\Pi_3) + d_1 * \log(\Pi_4) + e_1 * \log(\Pi_5) + f_1 * \log(\Pi_6).$$

We would determine a_1, b_1, c_1, d_1, e_1 and f_1 in equation by using MAT lab.

The model for Π_7 after substituting these values

$$\Pi_7 = 1.0000 * (\Pi_1)^{1.6412} * (\Pi_2)^{-0.0831} * (\Pi_3)^{14.7290} * (\Pi_4)^{-15.1816} * (\Pi_5)^{-0.0291} * (\Pi_6)^{-0.0780}.$$

Above same method is repeated to compute the model for Π_8, Π_9 term

$$\Pi_8 = 1.000 * (\Pi_1)^{-0.1386} * (\Pi_2)^{0.0023} * (\Pi_3)^{-1.6975} * (\Pi_4)^{2.8019} * (\Pi_5)^{0.0048} * (\Pi_6)^{0.0277}$$

$$\Pi_9 = 1.000 * (\Pi_1)^{0.4016} * (\Pi_2)^{0.0035} * (\Pi_3)^{1.4092} * (\Pi_4)^{-0.8729} * (\Pi_5)^{0.0207} * (\Pi_6)^{0.0378}.$$

3. Analyses of Indices for Mathematical Models

The indices of various independent p_i terms in the models are given below.

3.1 Mathematical Model for Π_7 (Surface Roughness)

$$\Pi_7 = 1.0000 * (\Pi_1)^{1.6412} * (\Pi_2)^{-0.0831} * (\Pi_3)^{14.7290} * (\Pi_4)^{-15.1816} * (\Pi_5)^{-0.0291} * (\Pi_6)^{-0.0780}$$

Table 3. Sequence of influence of independent Π terms on dependent Π_7 term of flow forming operation.

Dependent Π terms	Sequence of independent π terms according to intensity of influence					
Π_7 Surface roughness	Π_3 Sp. of tool	Π_1 operator	Π_5 Process parameter	Π_6 Humidity	Π_2 sp. of work piece	Π_4 Sp. of workstation
Indices	14.729	1.6412	-0.0291	-0.078	-0.0831	-15.1816

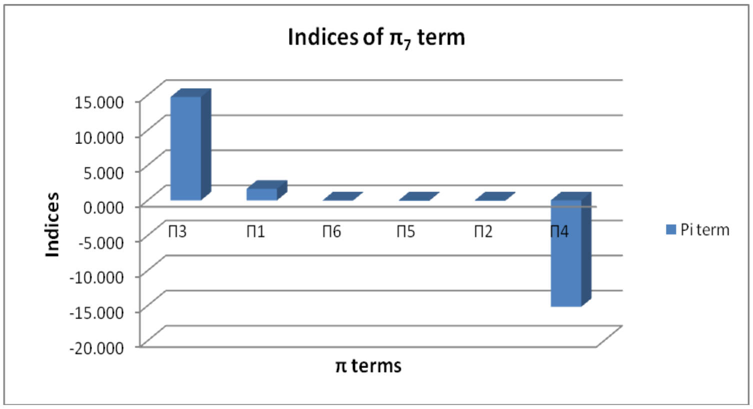

Figure 1. Indices of Mathematical Model for Π_7.

3.2 Mathematical Model for Π_8 (Accuracy)

$$\Pi_8 = 1.000 * (\Pi_1)^{-0.1386} * (\Pi_2)^{0.0023} * (\Pi_3)^{-1.6975} * (\Pi_4)^{2.8019} * (\Pi_5)^{0.0048} * (\Pi_6)^{0.0277}$$

Table 4. Sequence of influence of independent Π terms on dependent Π_8 term of flow forming operation.

Dependent Π terms	Sequence of independent Π terms according to intensity of influence

Π_8 Accuracy	Π_4 Sp. of workstation	Π_6 Humidity	Π_5 Process parameter	Π_2 sp. of work piece	Π_1 operator	Π_3 Sp. of tool
Indices	2.8019	0.0277	0.0048	0.0023	-0.1386	-1.6975

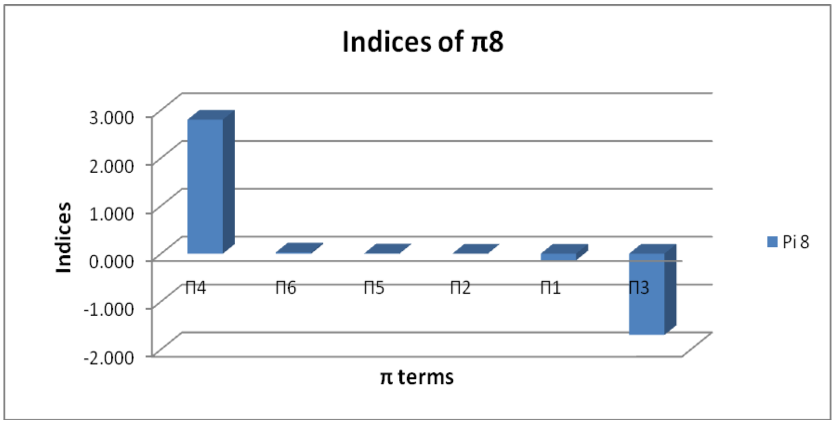

Figure 2. Indices of Mathematical Model for Π_8.

3.3 Mathematical Model for Π_9 (Cycle time)

$$\Pi_9 = 1.000 * (\Pi_1)^{0.4016} * (\Pi_2)^{0.0035} * (\Pi_3)^{1.4092} * (\Pi_4)^{-0.8729} *$$

$$(\Pi_5)^{0.0207} * (\Pi_6)^{0.0378}.$$

Table 5. Sequence of influence of independent Π terms on dependent Π_9 term of flow forming operation.

Dependent Π terms	Sequence of independent Π terms according to intensity of influence					
Π_9 Cycle time	Π_3 Sp. of tool	Π_1 operator	Π_6 Humidity	Π_5 Process parameter	Π_2 sp. of work piece	Π_4 Sp. of workstation
Indices	1.4092	0.4016	0.0378	0.0207	0.0035	-0.8729

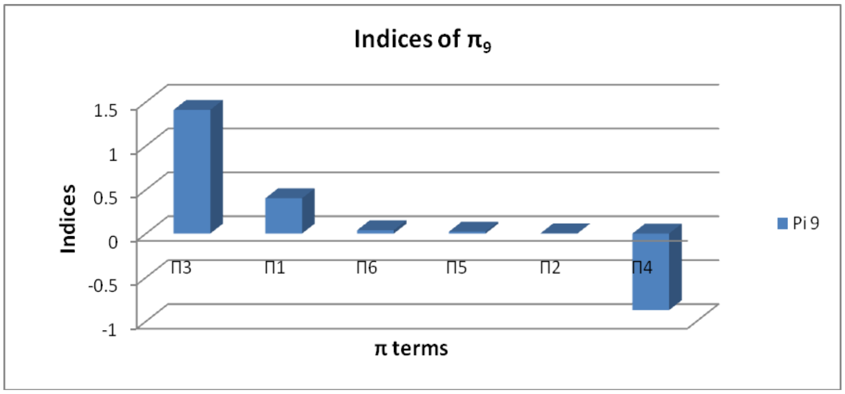

Figure 3. Indices of Mathematical Model for Π_9.

4. Discussions

After analysis of results, following discussions can be held.

Figure 1 gives comparative analysis of Π terms used in model for Π_7.

1. Π_3 and Π_1 term has positive index value and has direct effect on Π_7.

2. Π_4 term has negative index value followed by Π_2, Π_5, and Π_6. They have inverse effect on Π_7.

Figure 2 gives comparative analysis of Π terms used in model for Π_8.

1. Π_4, Π_6, Π_5 and Π_2 terms are above base line gives direct effect on Π_8.

2. Π_1 and Π_3 terms are below the base line gives inverse effect on Π_8.

Figure 3 gives comparative analysis of Π terms used in model for Π_9.

1. Π_3, Π_1, Π_6, Π_5, Π_2 terms are above base line gives direct effect on Π_9.

2. Π_4 term is below the base line and has inverse effect on Π_9.

Conclusions

The mathematical models developed for the phenomenon truly represents the degree of interaction of various independent variables. The indices of the model are the indicator of how the phenomenon is getting affected because of the interaction of various independent pi terms in the models. These models are very useful to measure quality of product.

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