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New Approach For Assessing Whirling Process Parameters By Computing Equations

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Abstract-*There is greater demand for sheet metal spinning, because of cost impact on the parts with very high strength-to-weight ratios available at low cost. Presently there is no adequately guideline available for industry to set process parameters for Whirling Process. Industries are setting such process parameters by hit and trails. Therefore it delays in meeting product delivery time and establishing desired quality of output. Looking at business demand there is great requirement further research on providing setting parameter for Whirling process. Whirling processes are efficient in producing certain characteristics; and there is great flexibility in the process, with a relatively low tool cost. The objectives of this investigation are to establish critical working parameters in spinning, by computing equation on product quality characteristics; and to optimize the working parameters.*

The example used is the stainless steel covers which are used in king pin application in four wheeler industry. This research will help metal formulating Industries to establish whirling process with quality and quantity [2Q].

Keywords: *Whirling; Process; Formula; Optimization; Machine*

INTRODUCTION

Research covers the conventional whirling process, in particular the production of open-ended cup products, in which it is important to maintain a uniform, defect-free wall and closing. *Göbel, R., Henkenjohann, N. (2005)* suggest, these processes used on pressed sheet metal circular part hold on to the rotating mandrel and are clamped between a rotating mandrel and supporting holder. The end of round cover sheet is gradually shaped over the mandrel through the action of a roller that produces a localized pressure as it moves axially over the outer surface of the sheet to produce a symmetrical product. Since the sheet deformation is imparted incrementally through a localized contact region between the deforming sheet and forming tools, it is important to determine the optimum process conditions, in order to provide effective process control to produce high-quality and defined quantity products as stated by *Göbel, R., Kleiner, M. (2010).*

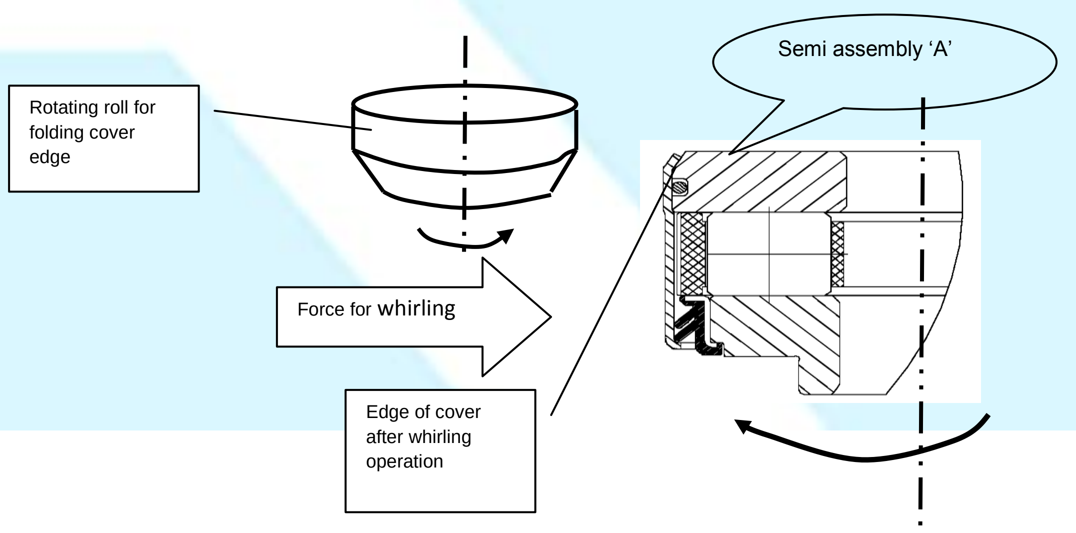
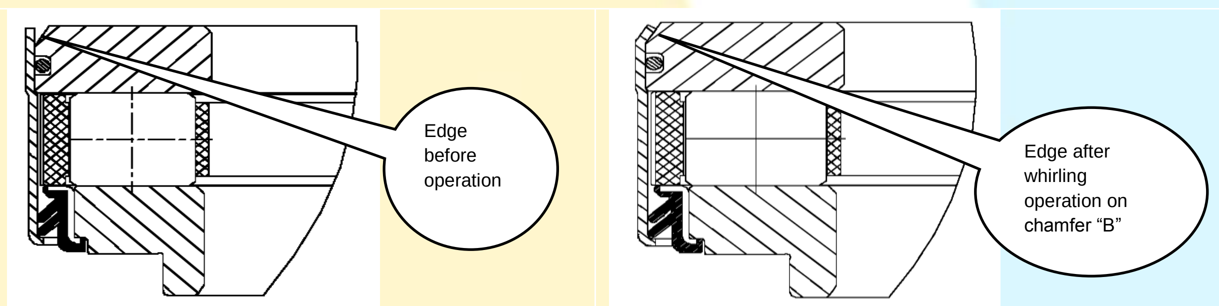


Figure-1 Whirling concept

There are a large number of parameters that influence the conventional whirling process, which maybe described either as machine or work piece parameters.
The machine parameters include rotational mandrel speed, and pressure on roller feed rate. The work piece parameters include sheet thickness, initial blank diameter, and material properties.
In this paper a combination of DOE and numerical simulation approaches is used to determine the most important working parameters in conventional whirling; and to show how these parameters affect the average closing and spring back, and a force applied during the manufacture of a cylindrical cup. Additionally, using a min–max optimization method, the optimum working parameter settings that allow the best quality characteristics to be obtained for this product are determined*(Kleiner, M., Göbel, R., Klimmek. , Ch. , Heller, B., Reitmann, V., Kantz, H.(2003)*.
Basic whirling process
The semi-assembly 'A' rotates because it is driven by electric motors. Rotating mandrel rotates around its own axis, when it comes in contact with cover edge because of the friction taking place between steel cover and conical shape of roll, as shown in Figure-2 (*Kunert, J. (2004)*).
The appearance of components before and after whirling process is shown in Figure-2.Basically steel cover edge got folded on chamfer of washer "B".



Before whirling After whirling

Figure -2

PROBLEM STATEMENT

Presently there is no specific guideline available to set the machine parameter to get required quality and quantity .Industries are losing resources like machine and man hours in setting whirling parameters for steel component profile generation.

Computing Force for whirling process

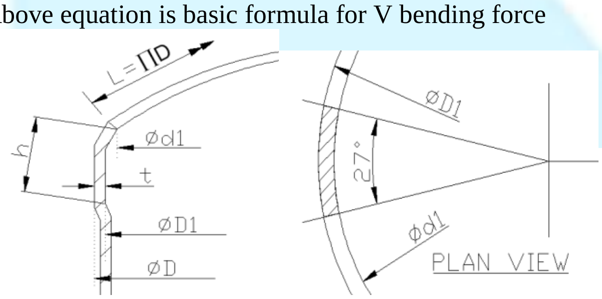
As derived by *Smith (1990,pg.-7)*, SME Die design force calculation can derived based on basic V bending for calculation.

Whirling Force (F) = $(K*L*Ts*t^2/w)*(\alpha/360^o)$ ……{1}

Where;

K – Coefficient, K=1.33
L – Bending line length in mm, in this case for JCT528222 bearing L = Πd
Ts – Tensile strength, Kg/mm^2 for steel 40 Kg/mm^2
t - Plate thickness (mm)

Above equation is basic formula for V bending force



Cross section of steel cover which is going to whirling on angular chamfer

DOE results

For product KP528222 [ID=52, OD=82, Width=22];

L = Π*82 = 257.6 mm i.e. length of periphery
d is the diameter of the cover in mm
w- Bend length, for steel cover is 6.7mm
α - Angle of intersect = 27º as per sketch shown above

For product KP528222 spinning force will be,

$F= (K*L*Ts*t^2/w)*(\alpha/360^o)$
$F= (1.33*257.6*40*0.7^2/6.7)*(27/360)=F= 75.1$ Kg

So Spinning Force required is Minimum 60 Kg

Deriving Rotational speed for whirling RPM

As per *ASM Handbook, Volume 14B, metal working: Sheet Forming (#05120) deformation*, "The rotational speeds that are best suited to manual metal spinning, depend mainly on work metal composition and thickness. For example, a given blank of stainless steel can be spun at a surface speed of 60 m/min (200 surface feet per minute, or sfm). Under otherwise identical conditions, changing to aluminum blank will permit speeds of 120 to 180 m/min (400 to 600 sfm). Selection of optimal speed depends largely on operator skill. In many metal-spinning operations, speed is changed (usually increased) during the operation by means of a variable speed drive on the headstock".

Spinning RPM calculation:

N= V*1000 / (Π*D) ……………{2}
Where;
V= Speed of the roller in m/min

D= Diameter of component, D=82 in case of JCT528222 bearing
N= RPM (Revolutions per minute)

DOE results

So for product KP528222 [ID=52, OD= 82, Width=22];
As per ASM handbook minimum speed can be 60 m/min

So for V= 60m/min
N=60*1000/ (Π*82) = 232.90 rpm
& For V= 180 m/min
N=180*1000/ (Π*82) = 698.73 rpm

So spinning rpm should be in the range of 230 to 1000.

PREDICTION OF EACH QC

It is useful to develop an empirical model that allows the description and prediction of each of the selected QCs under any combination of process parameters.

As a result of using numerical factors in this study, it is possible to predict the equivalent QCs at any value of each process parameter even if it was not one of the preselected levels. Using a general second-order polynomial equation, an empirical model is constructed based on the critical parameters, i.e. force and RPM. Each process parameter and interaction is multiplied by a coefficient as shown in equation (2). The value of each coefficient under each quality characteristic is displayed in Table 1. R-square for all models did not go below 95 per cent.

Quality characteristic = X + x1A + x2B + x3C + x4AB + x5AC + x6BC + x7A2 + x8B2 + x9C2………{3}

Where A is the feed rate, B is the relative clearance between the roller and mandrel, C is the roller nose radius and x1–x9 are the model coefficients indicated in Table 1.

Table-1 Coefficient values corresponding to each QC

	Average bending in mm	Bend variation in mm	Spring back	Roller pressure
Const.	$2.68X10^{0}$	$-1.336X10^{-1}$	$1.027X10^{0}$	$1.98X10^{0}$
X1	$6.333X10^{0-2}$	$1.359X10^{-1}$	$2.303X10^{-1}$	$4.406X10^{2}$
X2	$1.333X10^{0-2}$	$6.729X10^{-1}$	$4.306X10^{-1}$	$8.011X10^{2}$

CONCLUSIONS

a) It was observed that, the roller force, relative RPM and sheet material parameters were the most critical variables affecting the process formability, i.e. ability of forming without wrinkling or severe thinning. The initial sheet diameter, edge length whilst important, had less effect. The rotational mandrel speed and friction coefficient had effect upon the process formability.

b) Using the DOE approach, an experimental plan was generated and conducted through numerical simulation of the whirling process. The results were assessed using the mathematical calculation technique to identify the most critical working parameters.

c) As feed rate increased, the average spring back, and maximum axial force increased. Process does not require coolant.

d) For each of the responses, i.e. thickness variation, spring back, and maximum axial force, significant parameter interactions were identified and a mathematical model was fitted which described the influence of the machine factors reasonably well.

e) Producing a cylindrical cup with this parameter setting resulted in an optimal component. An additional advantage of this optimization approach is the flexibility with respect to product requirements.

f) The statistical methods described in this paper are easy to use and to implement. The proposed DOEs, formulas and min–max optimization procedure are applicable to any forming process.

LIMITATION

This study is conducted on stainless steel material and research can be extended to other metal and see the result. Also formula is established for specific shape and further research is possible to derive formula or equation based on different shapes of components.

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