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"DESIGN & FABRICATION OF MECHANICAL TYPE BELLOW MAKING MACHINE"

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ABSTRACT

The un-reinforced of U-shaped bellows are defined as the flexible element of an expansion joints consisting of one or more convolutions and the end tangent with the ratio of length of the bellows to the diameter of the bellows must be ≤ 3with no more than five plies. The bellows is the flexible element of the expansion joint. It must be strong enough circumferentially to withstand the pressure and flexible enough longitudinally to accept the deflections for which it was designed, and as repetitively as necessary with a minimum resistance. This strength with flexibility is a unique design problem that is not often found in other components in industrial equipment. Bellows are frequently used in the pressure vessels or piping system, aerospace, micro electromechanical and industrial system etc. it has the function to absorb regular or irregular expansion and contraction in the system. Since bellows require high strength as well as good flexibility.

When you think of the word "bellows" you probably have a picture in your mind of the leather bellow historically used to blow air into their fireplace. However, there is another kind of bellow, a metal bellows, which is a high technology product used in machinery, medical and industrial applications. Metal bellows are manufactured and sold by companies specializing in metal expansion joints and other piping systems. Some bellows are microscopically small while others are very large. Simply stated, metal bellows are thin walled flexible elements which allow for expansion in a system of pipes, while at the same time containing gasses and liquids in a pressure filled environment.

A metal bellow is also commonly referred to by the names: flexible metal element, element, corrugations, and compensator. Each metal bellow is made by taking into account its pitch, convolution height, thickness, number of plies, convoluted length, skirt length, and inside diameter.

As you can see there are many metal bellows available to fit many needs. Bellows are available from companies who fabricate metal expansion joints.

Here in this our target is to build a machine which can mechanically manufacture bellow

KEYWORDS

Bellow, Bellow making machine, Design of bellow, Bellow machine structure, Bellow design and calculation

INTRODUCTION

When you think of the word "bellows" you probably have a picture in your mind of the leather bellow historically used to blow air into their fireplace. However, there is another kind of bellow, a metal bellows, which is a high technology product used in machinery, medical and industrial applications. Metal bellows are manufactured and sold by companies specializing in metal expansion joints and other piping systems. Simply stated, metal bellows are thin walled flexible elements which allow for expansion in a system of pipes, while at the same time containing gasses and liquids in a pressure filled environment. The bellows most sensitive effective parameters which affect the final shape of the convolution**.** Few researchers have studied on bellows effective parameters. In this state, precise control of the parameters is very important in order to form high-quality metal bellows with good thickness distribution and desirable dimensions and resilience. this paper, a new method has been proposed for manufacturing of the metal bellows and important parameters such as initial length of tube, internal pressure, axial feeding and velocity, mechanical properties and the type of materials The results of the present work could be used as a basis of designing a new type of the metal bellows. It was observed that mechanical properties of material have considerable effect on final dimensions of bellows. it can be seen that when Young modulus is increased, spring back of the manufactured bellows is decreased. These results showed that mechanical behaviour of the material used, conformed to spring back value.

Said by: V.A. Patel
Assistant professor, S.P.C.E. Visnagar, India

A metal bellow is also commonly referred to by the names: flexible metal element, element, corrugations, and compensator. Each metal bellow is made by taking into account its pitch, convolution height, thickness, number of plies, convoluted length, skirt length, and inside diameter. Every metal bellows has a unique working pressure, life cycle, and spring rate which are entirely dependent on their shape and the material in which they are made of. These considerations, and some specific mathematical formulas, insure that a metal bellow meets the standards set by the Expansion Joint Manufacturers Association. The EJMA specifications exist to make sure that a metal bellow is able to perform under the specifications it Claims to. This is for both productivity and safety.

Said By: Witzemann GmbH

DATA COLLECTION THROUGH LITERATURE SURVEY

Table Given from:
Metraflex for pipes in motion

Material	Manufacturing feasibility and availability
Monel 400	This nickel copper alloy finds limited use for bellows manufacture in some specialized application such as chlorine service. However, the manufacture of small diameter bellows would be uneconomic and we advise that an alternative material should be used where the service condition permit
Nimonic 75	This high nickel alloy is a standard material for the manufacture of bellows for high temperature service, it is virtually immune to chloride stress corrosion and was extensively used where resistance to this form of failure was required before incoloy 825 became available.
Nimonic 80A Nimonic C263	Bellows has been manufactured in these material since 1960 and can be supplied where the service condition warrant their use. Bellows can also be supplied in other nimonic alloys which are available in sheet form.
Hastelloy B	This nickel molybdenum alloy possesses outstanding resistance to hydrochloric acid and is also resistance to hydrogen chloride gas as well as sulphuric and phosphoric acid. Bellows can be supplied when required, subject to the availability of the sheet material.
Hastelloy C 276	A nickel chrome molybdenum alloy having outstanding resistance to a wide variety of severely corrosive chemical process environments including: wet chlorine, hypo chlorides, chlorine dioxide solution, hot contaminant mineral acids and acetic acid, sea water and brine. Bellows can be supplied when required, subject to the same limitation as for hastelloy B.

Material	Manufacturing feasibility and availability
Gr. 304	Standard material for convolution manufacture. Bellows supplied in this grade are usually used on water or steam application. for temperature to 850^{o}F.
Gr.304L	Bellows can be supplied in this material when required, subjected to availability of sheet of the require gauge. For nitric acid service, the use of 321 supplied to special compositional limit is an alternative frequently employed.
Gr. 316	Improved corrosion resistance as compared to 321, especially with regard to pitting corrosion. Specified where 321 is inadequate but where condition are not sufficiently sever to require the use of more expensive material, such as high nickel alloys. Typical uses include high sulphur crude oil, brackish water, flue gases food processing and numerous application in chemical and petrochemical processing.
Gr. 321	Adequate corrosion resistance and mechanical properties at ambient and elevated temperature, 800^{0}F to 1500^{0}F
Gr. 347	This grade is occasionally specified and bellows can be manufacture subject to the availability of suitable material in most application, 321is equal in service to 347, and it is our normal practice to offer this grade when 347 is requested.
Gr.310	This grade is sometimes requested for special purpose. Because of difficulty in obtaining material, suitable for bellows manufacture, it is our practice to offer incoloy 800 as a superior alternative material where necessary.
Incoloy 800	Bellows can be supplied in this material when its goods corrosion resistance and high temperature properties are require to meet service condition. Incoloy 800 is preferred to type 310 stainless steel for bellows manufacture.
Incoloy 825	A very useful high nickel alloy having good corrosion resistance towards and variety of media, and excellent resistance to chloride and caustic stress corrosion. Application include steam service when the highest degree of reliability is required and cases where type 316 stainless steel may be inadequate for example, dew point condition in flue gas service, static and contaminated sea water, and sulphuric and phosphoric acids.
Incoloy 600	Bellows can be manufacture by this material when required. The alloy combines goods general corrosion resistance with virtual immunity to chloride stress corrosion resistance and also has good high temperature strength and oxidation resistance. For high temperature service where corrosion

	resistance is not a requirement, Nimonic 75 is often preferable because of its superior mechanical properties.
Incoloy 625	One of the more recent nickel- chrome molybdenum alloys combining good high temperature
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Component used in bellows making machine

1) Bearing
2) Electric motor
3) Belt& Pulley
4) Bellows shape disk roller

Bellows shaped disk roller:

The bellows disk is a main part of the machine. Due to bellows disk the bellows are formed. The bellows shaped disk is used for form a bellows. The disk is mounted on a shaft. The edge of the bellows tooth is curve form.

Construction of the bellows making machine:

Construction of the bellows making machine is simple the equipments required for the machine is less. It mainly consist of electric motor, belts and pulley, Bellows disk, bellows shaped shaft, Bearing. Using these equipments in machine the bellows are formed. These bellows are used in more purpose. The main purpose of the bellows is to absorb shock and uncertain rise of pressure. Bellows are mainly constructed for absorb uncertain pressure.

In our bellows making machine are used electric motor for rotate the pulley. An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse of this would be the conversion of mechanical energy into electrical energy and is done by an electric generator. The electric motor produces a1440 rpm. The voltage required for the electric motor is 230 volts and frequency is 50 Hz.

There are two pulley are used. The sizes of the pulleys are different. The larger diameter pulley is connected to electric motor shaft and small diameter of pulley is connected to main bellows disk shaft. The two pulleys are transmitting power by using trapezoidal (V-shaped) belt. The arrangement of the belts and pulley is such a way that, the speed of the bellows disk shaft is less than electric motor shaft.

The bellows disk is a main part of the machine. Due to bellows disk the bellows are formed, otherwise the whole system is waste. A bellows disk is drive by an electric motor therefore; electric motor is a heard of the machine. The bellows disk is mounted on a shaft. The both end or the shaft is joined by bearing to the fixed angle.

The main shaft of the bellows disk roller is couple with the hydrostatic bearing. Here the hydrostatic bellows are used. The main function of bearing is that constrains relative motion and reduces friction between moving parts to only the desired motion. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. There are four bearing are used. two hydrostatic bearing are used and two ball bearing are used the ball bearing are used for couple with bellows shaped roller shaft which used for support the main bellows disk.

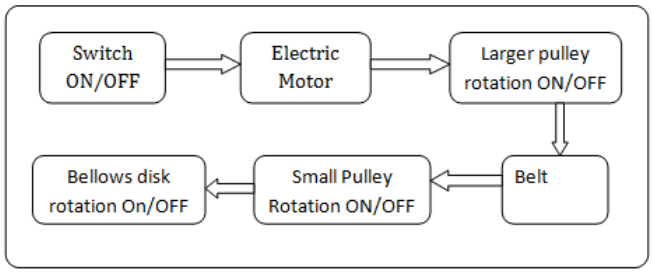
Bellows disk fabrication

The bellows disk is formed according to following data.The dimensions of the bellows disk are as follows:

1) The diameter of the rotor = 114 mm
2) Length of the rotor = 180mm
3) Pitch distance between two tooth = 12 mm
4) Radius of the groove = 2mm (radius)
5) Degree of the groove = 18.6^0
6) Total length of the shaft = 750mm
7) Weight of the bellows disk = 5 kg

Working

The bellows making machine is machine which form a bellow. The formed bellows are used in more place like industrial application, automobile purpose, power plant, piping joint, and valve shaft. The machine consist of four bearing are used. Bearing are classified into number of type here we have used hydrostatic bearing for main roller and ball bearing are used for bellows formed roller shaft. The driving bellows disk shaft is fixed with hydrostatic bearing and the bellows formed roller shaft is fixed in ball bearing. The cost of ball bearing is less than the hydrostatic bearing.



The 2 mm distance clearance is remaining between the two rollers for forma bellows. There is1440 rpm electric motor is used to give power to the machine. Here two pulley are used which is which is drive by using belt. The big pulley is attached to electric motor and the small pulley is attached to main bellows disk shaft. The two pulleys are connected by using V- belt. Due to that pulley the rpm of the bellows disk roller are very low.

When the motor is start then the big pulley of the machine is run because the shaft of the electric motor and the big pulley are same. With the help of v- belt drive the small pulley of the machine will also rotate. The shaft of the main shaft bellows disk are attach to small pulley therefore the main shaft will also rotate which exert force on a sheet metal and bellows are formed from sheet metal.

Design and Calculation

General procedure in machine design

1) Recognition of need
2) Synthesis (mechanism)
3) Analysis of forces
4) Material selection
5) Design of machine element (size and stresses)
6) Modification
7) Detail drawing
8) Production

Design of shaft:

Speed of the shaft(N) = 40 rpm
Force acting on the shaft
At point C (F) = 50 N
At point D (F) = 40 N
Weight of bellow disk roller = 5kg
Length of shaft= 750mm

We know, that torque ,

T =force*perpendicular distance
T =50*750
$=37.5*10^3$ N.mm
T = 37.5 N.m

Power transmitted

$P = 2\pi NT/60$
$= 2\pi*40*37.5/60$
P =117.80 Watt

To find the Bending moment

For vertical load diagram

$-40+R_A-8829+R_B=0$
$R_A+R_B = 40 + 8829$
$R_A+R_B = 8869$..... (1)

Taking moment about point "A"
$\sum M_A = -40 * 30 + 8829 * 360 - R_B * 720$

$R_B * 720 = 3.17 \times 10^6$
$R_B = \frac{3.17\times10^6}{720}$
$R_B = 4412.83$ N

Substitute the value of the R_B in Equation (1)

$R_A + R_B = 8869$
$R_A + 4412.83 = 8869$
$R_A = 4456.17$ N

For vertical bending moment diagram

V.B.M. At "D" = - 4456.17*30+8829*390 – 4412.83*750
$= 2.4$ N.mm

V.B.M. At "A" = 8829*360*-4412.83*720
= 1202.4 N.mm

V.B. M. At "C"= -4412.83*360
$= -1.58 \times 10^6$ N.mm
V.B.M. At "B"= 0

Total Vertical Bending moment

$M^2 = 2.4^2+1202.4^2-(1.58 \times 10^6)^2$

$M^2 = 2.49 \times 10^{12}$ N.mm

$M = 1.58 \times 10^6$

Equivalent Torque

$Te^2 = M^2 + T^2$

$Te^2 = (1.58 \times 10^6)^2 + (37.5*10^3)^2$

$Te = 1.58 \times 10^6$ N.mm

By using torsional shear stress equation

$Te = \frac{\pi}{4} * d^2 * f_s$

Where,

D = diameter of shaft = 25 mm

$1.58 \times 10^6 = \frac{\pi}{4} * (25)^3 * f_s$

$f_s = 128.78$ N.mm^2

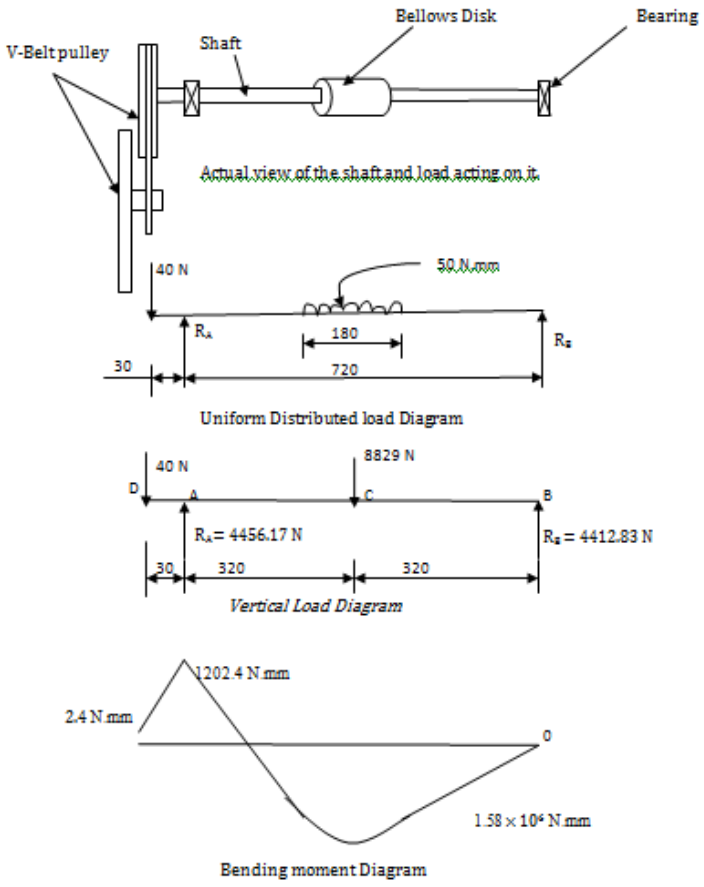
Shaft Subjected to twisting moment

$$\frac{T}{J} = \frac{\tau}{r}$$

T = Twisting moment (or torque) acting upon the shaft

J = Polar moment of the inertia of the shaft about axis of rotation

$= \frac{\pi}{32} * d^4$



τ = Torsional Shear Stress

r = Distance from neutral axis to the outer most fibre $= \frac{d}{2}$

where d = Diameter of the shaft

$$\frac{T}{\frac{\pi}{32} \times d^4} = \frac{\tau}{\frac{d}{2}} \quad \text{or} \quad T = \frac{\pi}{16} \times \tau \times d^3$$

$$\tau = \frac{T \times 16}{\pi \times d^3}$$

$$\tau = \frac{37.5 \times 10^3 \times 16}{\pi \times 25^3}$$

$$\tau = 12.22\ N.mm$$

Design of the pulley

1) Diameter of big pulley (D) = 450 mm

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The diameter of the (D) may be obtained either from velocity ratio consideration or centrifugal stress consideration. We Know that the centrifugal stress induced in the rim of the pulley,

$$\sigma_t = \rho . v^2$$

ρ = Density of the rim material

ρ = 7200 kg/m^3 for cast iron

V = velocity of the rim

$$= \frac{\pi DN}{60}$$

$$= \frac{\pi \times 450 \times 100}{60 \times 60} = 39.26 \text{mm/sec}^2$$

$$\sigma_t = \rho . v^2$$

$$\sigma_t = 7200 \times 39.26 \qquad = 11.097 \times 10^3 \text{N/mm}^2$$

D being the diameter of the pulley and N is the speed the pulley

2) If the width of the belt is known, then width of the pulley or face of the pulley (B) is taken 25% greater than the width of the belt

B = 1.25 b; where b = width of the belt

B = 1.25 * 12 = 15 mm

3) The thickness of the pulley rim (t) is $\frac{D}{200} + 3$ mm for single belt. The diameter of the pulley (D) is in mm.

$$t = \frac{450}{200} + 3$$

t = 5.25mm

Dimension of hub

1) The diameter of the hub (d_1) in terms of the shaft diameter (d) may be fixed by the following relation:

$$d_1 = 1.5\,d + 25$$
$$= (1.5 \times 25) + 25$$
$$= 62.5 \text{ mm}$$

2) The length of the hub

$$L = \frac{\pi}{2} \times d$$

$$L = \frac{\pi}{2} \times 25$$

L = 39.26 mm

Dimension of small pulley

1) Diameter of small pulley (D_1) = 300 mm

The diameter of the (D_1) may be obtained either from velocity ratio consideration or centrifugal stress consideration. We know that the centrifugal stress induced in the rim of the pulley,

$$\sigma_t = \rho . v^2$$

ρ = Density of the rim material

ρ = 7200 kg/m^3 for cast iron

v = velocity of the rim

$$= \frac{\pi D_1 N}{60}$$

$$v = \frac{\pi \times 300 \times 30}{60 \times 60} = 7.85 \text{ m/sec}$$

$$\sigma_t = \rho . v^2$$

$$\sigma_t = 7200 \times 7.85^2 = 443.682 \times 10^3 \text{N/mm}^2$$

D being the diameter of the pulley and N is the speed the pulley

2) If the width of the belt is known, then width of the pulley or face of the pulley (B) is taken 25% greater than the width of the belt

B = 1.25 b; where b = width of the belt

B = 1.25 * 12 = 15 mm

3) The thickness of the pulley rim (t) is $\frac{D_1}{200} + 3$ mm for single belt. The diameter of the pulley (D_1) is in mm.

$$t = \frac{300}{200} + 3$$

t = 4.5 mm

Dimension of hub

1) The diameter of the hub (d_2) in terms of the shaft diameter (d) may be fixed by the following relation:

$$d_2 = 1.5\,d + 25$$
$$= (1.5 \times 25) + 25$$
$$= 62.5 \text{ mm}$$

2) The length of the hub

$$L = \frac{\pi}{2} \times d$$

$$L = \frac{\pi}{2} \times 25$$

L = 39.26 mm

Advantages

- Simple and rugged in construction.
- Good for low to moderate pressures.
- Moderate cost.
- Need less installation space.
- The material can flow from both side
- Manufacturing process is simple.

Limitations

- Difficult to processed harder material.
- Accuracy less compare to fully automatic machines
- Ambient temperature compensation needed.

Future Scope

1. By using the lead screw in the assembly of the system, the bellows roller shaft can be lifted above and below the from the surface by applying manual force on

the handle so that the external force is applied on the bellow sheet metal.

2. Due to day to day more use of Renewable Energy Sources , this system can be made efficient and eco-friendly by using solar collectors to run the motor. This leads to increase the efficiency of the machine and does not harm the environment as well as there is optimum use of electricity through this.

Conclusion:

Thus in this way the Design and Fabrication of metal bellow making machine is successfully done. This kind of model can be useful in small scale industries, Power Plants, etc. Difference of effort required between the conventional bellow making machine and metal below making machine.

There are many aspects of the Design which needs further modification like we need to increase the depth form 15mm to above 20mm. Also the space required is considerably less than the conventional bellow making machine.

Therefore the search for higher efficiency bellow making machine continues. Though this machine is innovative in its own respect, still it has scope to elaborate the mechanism and can be studied further for obtaining better results.

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