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DESIGN AND ANALYSIS OF OD CHAMFERING MACHINEWHEEL ASSEMBLY FOR HELICAL SPRINGS

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ABSTRACT

The main objective of this paper is to deliver information about an automated & system integrated machine named as 'Spring OD Chamfering Machine' with the help of the data obtained by through research and development techniques. This paper mainly fuscous on the one of the main sub assembly of this machine named chamfering wheel assembly. This subsequent machine contributes to the precise delivery of sophisticated chamfering operation performed on a helical compression spring, which is primarily used in automotive industries. The accuracy and tolerance of this new machine has increased when compared to the old machine, the materials used for the manufacture has changed. The grinding wheel's length has increased, and the grinding wheel's material has also changed. This prescriptive paper offers genuine concepts & overview of the research and development done on the respective machine along with the basic introduction about the same. The machine has the huge scope for development as it is being an automated & system integrated machine and the same has been portrayed in the following paper.

Keywords: Automated & system integrated, Helical spring, Chamfering Machine, Chamfering wheel assembly, OD-outer diameter.

I. INTRODUCTION

For many machine manufacturers, automated chamfering is a reliable option. The automated machines still require operators, but there is a drastic reduction in the intensive labor and time required to do the job, thus reducing overhead and increasing efficiency. Skilled chamfering laborers can and will manually do an excellent job of chamfering. However, in the spring chamfering production, the automated chamfering machines provide greater consistency. This Chamfering machines can also provide more accurately a product that meets the specifications. These operations can be carried out in a variety of ways depending on the type of machine and set-up. It is possible to use a small face mill, a long edge cutter, an end mill or chamfer cutter. A grinding dresser or wheel dresser is a tool for dressing the surface of a grinding wheel (that is, slightly trimming).[8] Grinding dressers are used to restore a wheel to its original round shape (that is, to make it true), to expose fresh grains to renewed cutting action (including cleaning off clogged areas), or to make a different profile (cross-sectional shape) on the edge of the wheel.It can produce very fine finishes and very precise dimensions; however, it can rough out large volumes of metal quite quickly in mass production contexts. Usually it is better suited to machining very hard materials than "regular" machining (i.e. Cutting larger chips with cutting tools such as tool bits or milling cutters), and it was the only practical way to machine materials such as hardened steels until recent decades.[20] With the change of grinding depth, grinding area and positive pressure between spring and wheel change in the spring end chamfering process. In this way, if the pressure chamfering is adopted, the chamfering force will be inconstant and chamfering efficiency will be low. To improve chamfering efficiency and chamfering accuracy, the control force chamfering is applied with constant chamfering force. This chamfering method is good for the low-rigidity chamfering system. According to the spring end chamfering process, this paper deduces the chamfering force of spring end chamfering theoretically, and analyses the relationship of the chamfering force with the chamfering feed and depth.Types of springs: Helical compression springs, helical extension springs, conical springs, Torsion springs, Belleville springs

[21] Helical compression springs:Made from round wire and wrapped in cylindrical form with a fixed pitch. Plain end-least expensive, tends to bow sideways under load. Plain and ground end-Better mating conditions being flat,likely to get entangled in storage, Squared end, Squared and ground end.

Fig. 1: Un-chamfered and chamfered springs

II. OBJECTIVE

There are many ways to chamfer the outer diameter of the helical spring. But the main objective of this machine to provide chamfering operation on the helical spring **'simultaneously'** on it's both ends. The helical springs used in the automotive industries are not necessarily of same sizes i.e. they may have different diameters and lengths as per the required application. Imagine the exhaustive work if the operator were to perform the operation manually on all such varying size helical spring.To perform such simultaneous &effective chamfering on helical spring with all such variations, hence the need of automated & system integrated machine.[3]The purpose of spring end chamfering is to correct the verticality of spring and the parallelism of both spring ends, and to make spring ends and other components in close contact, and to improve the service life of compression spring by uniform pressure. [1] The requirements of the spring end chamfering describe as follows the chamfering angle is 45°; the thickness of the end needs to be not less than 1/8 of the spring wire diameter(1/4 is the best).[2] Spring end chamfering belongs to face grinding, and the characteristic of the spring determines unique grinding process.

III. NEED FOR SIMULTANEOUS OPERATION

- Enhancing chamfer quality.
- To reduce the operating time required.
- To reduce the operator's fatigue.
- To increase the industry's productivity.
- To reduce the labour.

IV. SPRING OD CHAMFERING MACHINE

Some of the main assemblies and parts are:

1. Chamfering wheel assembly.
2. Spring guiding assembly.
3. Spring pressure pad assembly.
4. Conveyor belt assembly.
5. Two base plates.
6. Base frame.
7. Two motors in grinding wheel assembly.
8. One motor in conveyor belt assembly with reduction gear box.

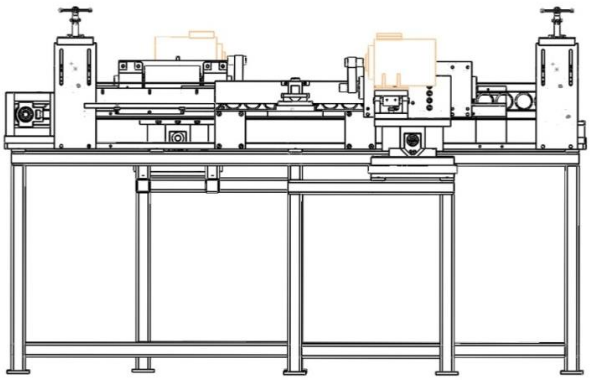


Fig. 2: Concept drawing of OD Chamfer machine

V. DESIGN OF CHAMFERING WHEEL ASSEMBLY

The chamfering wheel assembly is the main assembly in spring OD chamfering machine. This assembly performs the chamfering operation, as the shaft rotates at 3000rpm which in turn rotates the grinding wheel and as the spring comes in contact with wheel the material removal takes place.

Table 1: Chamfering wheel assembly parts

SL NO.	DESCRIPTION	QUANTITY
1	HOLDINGPLATE	1
2	WHEEL BACK PLATE	2
3	LOCK NUT-L	1
4	WHEEL SPACER	1
5	WHEEL SPACER	1
6	WHEEL SIDE SPACER	1
7	WHEEL SIDE SPACER-1	1
8	CHAMFERING WHEEL	1
9	MOTOR PULLEY	1
10	SPINDLE/SHAFT	1
11	PLUMBER BLOCK	2

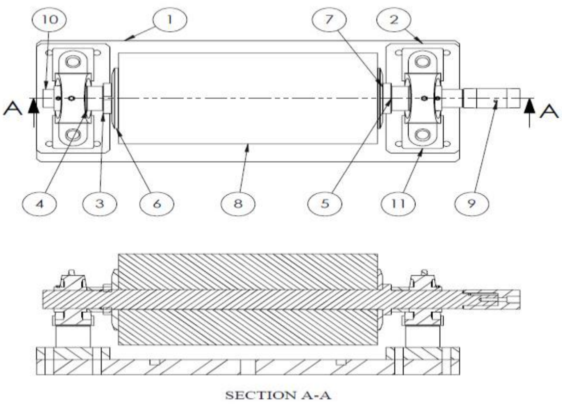


Fig. 3: Chamfering wheel assembly

Wheel assembly drawing.

1. **Wheel shaft**

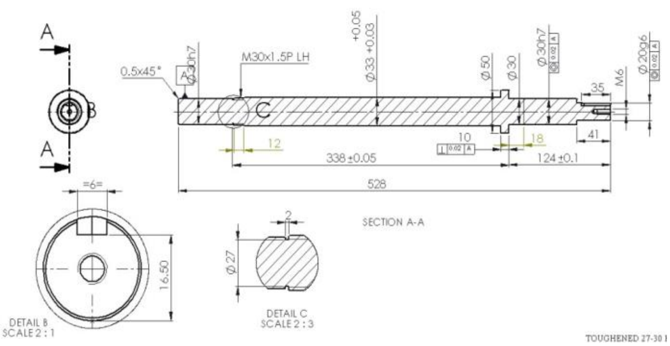


Fig. 4: Chamfering wheel shaft drawing

The chamfering wheel shaft is made up of 90MnCr material and it is hardened to 50-55 HRC, tolerance has to be maintained in ordered to get a good fit. The shaft must be zinc iron coating (trivalent yellow) and the burrs must be removed.

2. **Chamfering wheel**

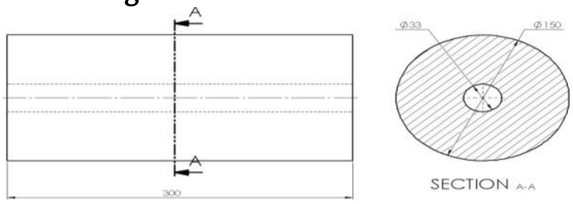


Fig. 5: Chamfering wheel drawing

The chamfering wheel is the important part in the chamfering wheel assembly, as the length of the chamfering wheel increases the chamfering quality increases but it results in more weight on shaft. Coarse grit size is used for more material removal at fast rate whereas fine grit size is used for less material removal but good surface finish at slow rate.

3. **Shaft support**

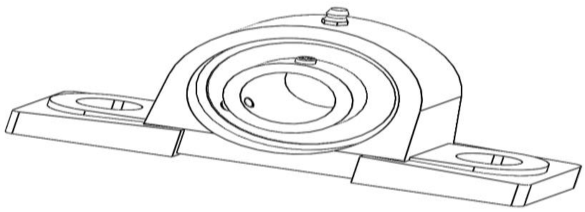


Fig. 6: Shaft support plumber block

In the older machines instead of the plumber block the manufactured support block were used, which used to get worn out quickly.[22] The life span of the plumber block is more compared than the manufactured support block and lubrication in the plumber block is easy.

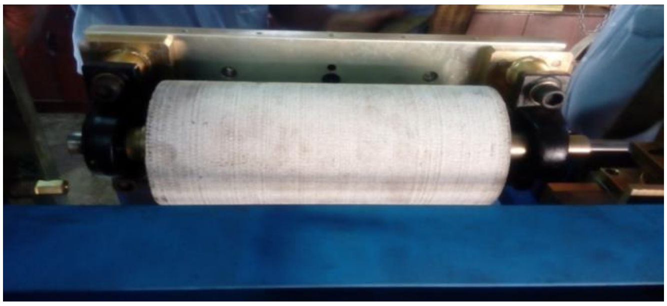


Fig. 7. Chamfering wheel assembly mounted on machine

VI. ANALYSIS OF CHAMFERING WHEEL ASSEMBLY

Mass properties of wheel assembly:

Mass = 25.31 kg

Volume = 9181043.72 mm^3

Surface area = 767046.39 mm^2

Table 2: Center of mass

Centre of mass (mm)	
X	= -1.19
Y	= 27.23
Z	= -0.52

Table 3:Principal axes of inertia and principal moments of inertia

Principal axes of inertia and principal moments of inertia: (kg*mm²)	
Taken at the center of mass.	
Ix = (0.00, 0.00, 1.00)	Px = 136516.98
Iy = (0.96, -0.30, 0.00)	Py = 531718.53
Iz = (0.30, 0.96, 0.00)	Pz = 541019.39

Table 4: Moments of inertia at the center of mass

Moments of inertia:(kg*mm²)		
Taken at the center of mass and aligned with the output coordinate system.		
Lxx = 532530.03	Lxy = -2624.87	Lxz = 50.68
Lyx = -2624.87	Lyy = 540204.85	Lyz = -1106.28
Lzx = 50.68	Lzy = -1106.28	Lzz = 136520.02

Table 5: Moments of inertia at the output coordinate system

Moments of inertia: (kilograms * square millimeters)		
Taken at the output coordinate system.		
Ixx = 551299.97	Ixy = -3447.80	Ixz = 66.36
Iyx = -3447.80	Iyy = 540247.75	Iyz = -1463.72
Izx = 66.36	Izy = -1463.72	Izz = 155319.25

B. Units maintained

Table 6: Units maintained for design of components

Unit system:	**SI (MKS)**
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

C. Material properties

Table 7: Material properties of chamfering wheel assembly

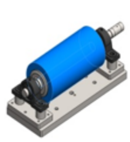
Model reference	**Properties**	
	Name: Model type: Default failure criterion: Yield strength: Tensile strength: Elastic modulus: Poisson'sratio: Mass density: Shear modulus: Thermal expansion coefficient:	**Plain Carbon Steel** **Linear Elastic Isotropic** **Unknown** **2.20594e+008N/m^2** **3.99826e+008N/m^2** **2.1e+011 N/m^2** **0.28** **7800 kg/m^3** **7.9e+010 N/m^2** **1.3e-005 /Kelvin**
	Name: Model type: Default failure criterion: Tensile strength: Elastic modulus: Poisson's ratio: Mass density: Shear modulus:	**PBT General Purpose** **Linear Elastic Isotropic** **Unknown** **5.65e+007 N/m^2** **1.93e+009 N/m^2** **0.3902** **1300 kg/m^3** **6.902e+008N/m^2**
	Name: Model type: Default failure criterion: Yield strength: Tensile strength: Elastic modulus: Poisson's ratio: Mass density: Shear modulus:	**1.2842 (90MnCrV8)** **Linear Elastic Isotropic** **Unknown** **1.75e+009 N/m^2** **1.93e+009 N/m^2** **2.1e+011 N/m^2** **0.28** **7610 kg/m^3** **7.9e+010 N/m^2**

Table 8: Loads applied

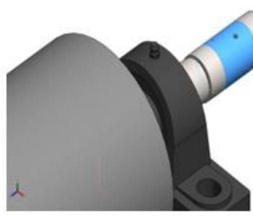
Load name	**Load Image**	**Load Details**
Force-1		Entities: **1 face(s)** Reference: **Edge< 1 >** Type: **Apply force** Values: **10 N**
Torque-1		Entities: **19 face(s)** Reference: **Face< 1 >** Type: **Apply torque** Value: **2.5 N.m**

Table 9: Fixtures

Fixture name	**Fixture Image**	**Fixture Details**
Fixed-1		Entities: **1 face(s)** Type: **Fixed Geometry**

E. Meshing details

Table 10: Meshing details

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off

Jacobian points	4 Points
Element Size	20.9427 mm
Tolerance	1.04713 mm
Mesh Quality	High
Remesh failed parts with incompatible mesh	Off
Total Nodes	141174
Total Elements	88131
Maximum Aspect Ratio	52.251
% of elements with Aspect Ratio < 3	93.7
% of elements with Aspect Ratio > 10	0.505
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:12

F. Resultant

Table 11: Resultant

Components	X	Y	Z	Resultant
Reaction force(N)	0.283819	0.903862	-0.00026321	0.947376
Reaction Moment(N.m)	0	0	0	0

G. Study results

Table 12: Stress results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/m^2 Node: 17814	302728 N/m^2 Node: 53677

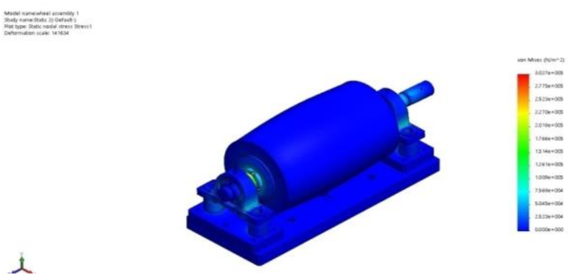


Fig. 8: Chamfering wheel assembly 1-Static 2-Stress-Stress1

Table 13: Displacement results

Name	Type	Min	Max
Displacement 1	URES: Resultant Displacement	0 N/m^2 Node: 17814	0.00039736 mm Node: 14997

Fig. 9: Chamfering wheel assembly 1-Static 2-Displacement-Diasplacement1

Table 14: Strain results

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0 Element: 10498	3.52513e-006 Element: 7830

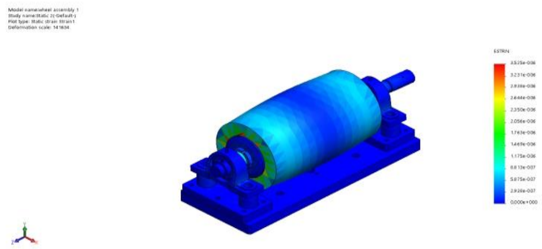


Fig. 10: Chamfering wheel assembly 1-Static 2-Strain-Strain1

VII. CONCLUSION

From all the research, development and their implementation, it can be concluded that the precise and simultaneous chamfering operation on the helical compression springs is achieved successfully by the automated & system integrated machine. The variations in the size of springs can easily be compensated but the key feature of such automated machine is that, the variations in the chamfer are also compensated without any hassle. These springs are used in very high quantity throughout all the various automotive industries. Hence, there is rapidly growing market for this machine in near future. This unique machine can also be used along with sensors and spring feeders to achieve complete automatic loading of jobs on the conveyor and hence, the objective of this project is thus fulfilled.

Summarizing the literature study, The process of chamfering the helical compression spring will be maximum if the length of the chamfering wheel is more and the abrasive bond must be good. Coarse grit size is used for more material removal at fast rate whereas fine grit size is used for less material removal but good surface finish. Hardening the rotating parts like shaft increases the life by reducing the wear and the material selection must be made based on the parts operation in the machine, using plumber block instead of the manufactured support block which results in high efficiency and less wear.

Most machine-related injuries can be prevented completely. To keep your workplace safe and avoid expensive injuries and lawsuits, providing proper training to all employees before operating any machinery or guards and maintain regular maintenance and repairs. Instruct employees never to remove machine guards during machine operation.

VIII. FUTURE SCOPE

This completely automated & system integrated machine once developed has a lot of scope for the future development when it comes to automating the entire manufacturing line in the industry. With the help of job feeding mechanisms, job carryout mechanisms & different sensors, the machine can be effectively used in any kind of chamfering operation on all different sized jobs. By providing some external & internal Poka-Yoke, machine may not need any operator to provide attention and hence, ultimately the productivity & quality of manufacturing will be drastically improved.

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