Transmission Drive for Rotary Union Test Rig

L. Chindarkar[1], S. Kharabe[2], S. Barhatte[3], D. Dhurve[4], V. Kulkarni[5]

[1,2,3,4]*Dept. of Mechanical Engineering, D.Y. Patil College of Engineering , Akurdi, Pune, Maharashtra, India*
[5]*Prof. of Mechanical Engineering, D.Y. Patil College of Engineering, Akurdi, Pune, Maharashtra, India*

Abstract – *The rotary union test rig is designed to check the dynamic performance of rotary union component which is widely used in machine tool spindle industry. The design challenge for this particular system is the range of over 115 types of rotary unions to be tested and maximum Rpm up to 15000 to be covered with static hydraulic pressure. In order to overcome this, a belt transmission drive is designed consisting of V-belts for lower rpm range and synchronous timing belts for higher rpm range. For Power transmission, single HP motor is used along with Variable Frequency Drive to vary the speed of input shaft and to achieve the lower rpm range. Motor shaft on input side and spindle on output side are also designed for power transmission over a fixed distance. To maintain the belt tension for proper power transmission, movable motor base is used which eliminated the design of tension pulleys and their packaging complexities.*

***Key Words*: Rotary unions, transmission drive, test rig, synchronous timing belts.**

1. INTRODUCTION

A rotary union is a union that allows for rotation of the united parts. It is thus a device that provides a seal between a stationary supply passage (such as pipe or tubing) and a rotating part (such as a drum, cylinder, or spindle) to permit the flow of a fluid into and/or out of the rotating part. While rotary unions come in many shapes, sizes, and configurations, they always have the same four basic components: a housing unit, a shaft, a bearing, and a seal. Rotary unions typically are constructed from stainless steel to resist rust and corrosion, but many other metals can be involved like aluminum. As rotary union is subjected to high rpm application such as machine tool spindle, its dynamic performance needs to be checked along with its dimensional testing.

Figure 1: Rotary union

This application requires high precision power transmission with minimum amount of slippage and maximum amount of alignment accuracy. Different rpm ranges are covered with different types of belt drives. Belt pulley drive is selected instead of gearbox drive for following reasons:

1) Design of multi-speed gearbox is very complex.

2) Only specific rpm ranges can be achieved which limits its use in wide rpm range applications.

3) The process of design and manufacturing of gearbox is very tedious and time consuming process.

4) Since gearbox for wide range of rpm is not easily available in the market it makes it more expensive.

Whereas Belt Drive is selected due following advantages:

1) Belt drives can be used in applications where distance between shafts is more.

2) Belt drives are highly efficient drives. (For Timing belts it is 98% and for v-belts it is 95%)

3) They are lubrication free and require less maintenance cost.

4) Noise and vibration are damped out which will cause less fatigue to operator.

5) Machinery life is increase because load fluctuations are shock absorbed.

2. OBJECTIVES

1) To keep the spindle run out only up to 5 micrometre to maintain high degree of alignment of rotary union with spindle.

2) To run rotary unions under static hydraulic pressure, this will check rotary union's performance on extreme pressure.

3) Wide variety of over 110 types of rotary unions of different diameters and lengths to be checked only on single working platform.

4) To ensure the fool-proofing and safety of operator since he will be subjected to high rpm and high pressure working.

3. PROCESS METHODOLOGY

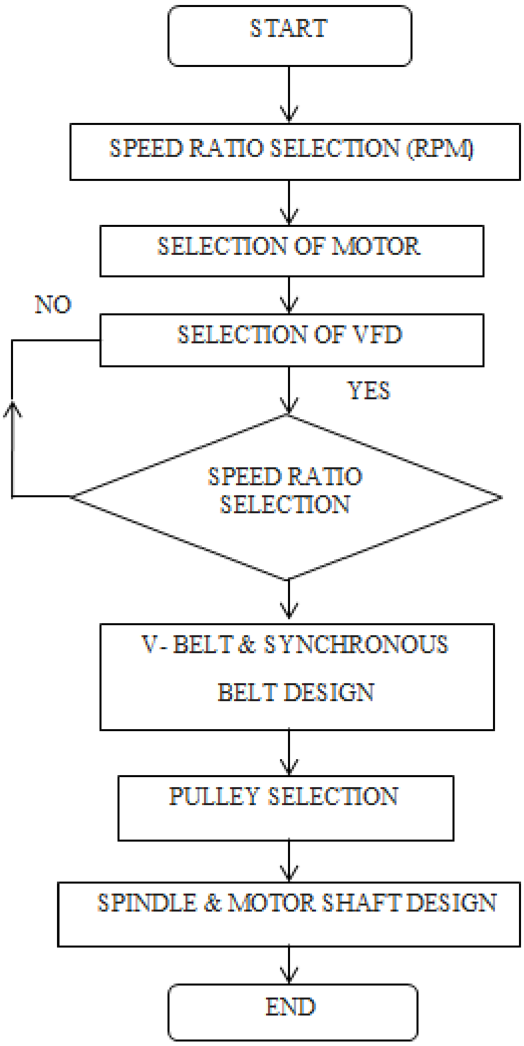

Figure 2: Process Methodology Flowchart

3.1 Speed Ratio Selection

The torque requirement for the operation is not significant since overall weight of assembly to be rotated consist of motor shaft, spindle, taper locking system, rotary union which is comparatively very less. The only prime concern is rpm of the drive. And to achieve this, belt and pulley drive is selected.

To cover the rpm range, four set of pulleys are used. Along with that for lower rpm range is achieved by using V-belt drives. To serve this purpose three V-pulley sets are used whereas higher rpm range is achieved by the use of synchronous belt drives with single set of timing belt pulley.

3.2 Motor Selection

To achieve maximum 15000 rpm DC Servo motors are available but they are very costly and their maintenance is also expensive. Whereas AC induction motors are cheaper with simple construction and easy maintenance. Also it comes from fractional horse power up to thousands of horse power. So, motor with single Horse power 3 phase induction AC supply, 2.12 N.m torque is selected which will serve the purpose of rotating all rotary unions with different weights up to 3000 rpm.

Specifications of AC Motor are:

i.Three Phase Induction motor

ii.1 HP, 2880 rpm

iii.Torque= 2.12 Nm at 2880 rpm

iv.Double shaft motor

v.Variable Frequency Drive is used to achieve

Double shaft motor is selected for the compactness of assembly as well as to reduce the chances of overhang failure of motor shaft because all four pulley sets would be mounted on only one side of the shaft.

3.3 VFD Selection

Variable speed drive is a type of adjustable-speed drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage. It is used in order to achieve lower rpm. . By using the variable frequency drive, motor rpm can be reduced and low rpm range up to 2880 rpm is achieved.

3.4 Synchronous Drive

Synchronous belt drives operate on the tooth grip principle. The belt resembles a flat belt with evenly spaced teeth on the inside surface. Molded belt teeth are designed to make positive engagement with mating grooves on a pulley or sprocket. Because synchronous belts have positive engagement between belt teeth and sprocket grooves, there is relatively little motion between the belt and sprocket and no slip. The no-slip characteristic provides exact synchronization between a power source and a driven unit.

Specific advantages of the Synchronous drive system can be summarized as follows:

• Longer belt life: The strong fiberglass tensile cords wrapped in a durable neoprene body provide the flexibility needed for increased service life.

• Precision registration: Synchronous drive belts provide timing and synchronization accuracy that make for flawless registration, with no loss of torque carrying capacity.

• Increased load-carrying capacity: Load capacities far exceed HTD and trapezoidal belt capabilities making Synchronous drive belts the choice for accurate registration, heavy loads and small pulleys.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

• Quieter operation: The Synchronous drive belt's specially engineered teeth mesh cleanly with pulley grooves to reduce noise and vibration. Clean meshing and reduced belt width result in significant noise reduction when compared to Trapezoidal and HTD belts.

• Precise positioning: Synchronous drive belts are specifically designed for applications where precision is critical, such as computer printers and plotters, laboratory equipment and machine tools.

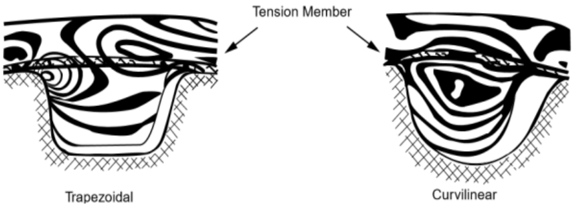

Figure 3: Belt tooth profiles

The trapezoidal shape timing belt was superseded by a curvilinear tooth profile which exhibited some desirable and superior qualities. Advantages of this type of drive are as follows:

1. Proportionally deeper tooth; hence tooth jumping or loss of relative position is less probable.
2. Lighter construction with correspondingly smaller centrifugal loss.
3. Smaller unit pressure on the tooth since area of contact is larger
4. Greater shear strength due to larger tooth cross section.
5. Lower cost since a narrower belt will handle larger load.
6. Energy efficient, particularly if replacing a "V" belt drive which incurs energy losses due to slippage.
7. Installation tension is small, therefore, light bearing loads.

As Chances of slippage of belt increases when spindle speed increases, so for higher rpm range timing belt drive is used. This provides drive efficiency of 98%, which is the highest in all belt drives available. Synchronous belt drive is also called as positive drive.

3.5 V-Belt Drive

Since high precision component performance checking of rotary union is to be done, it is required to have minimum amount of slippage and alignment problems. Also combination of traction, speed of movement, load of the bearings, and long service life is desirable. All of these purposes are meeting by V-belts. Hence to achieve the lower rpm range between 50 rpm to 3000 rpm V- belts are selected.

General Procedure followed to design V-belt:

Step 1: Determine the correction factor according to service (F_a) from which depends upon the type of driving unit, driven machine and the operational hours per day.

Step 2: Calculate the design.

Step 3: Decide the type of cross section of the belt.

Step 4: Calculate the diameter of smaller and bigger pulley which will depend on the cross section of belt.

Step 5: Determine the pitch length of belt.

Step 6: Compare the above value of L with preferred pitch length L in the standard table. In case of non-standard value, nearest value of pitch length from table should be taken.

Step 7: Find out the correct centre distance C by substituting the above value of L.

Step 8: Calculate the arc of contact for smaller pulley. It is not advisable to use an arc of contact less than 120° for V-belt drive. Therefore, minimum arc of contact should be 120°

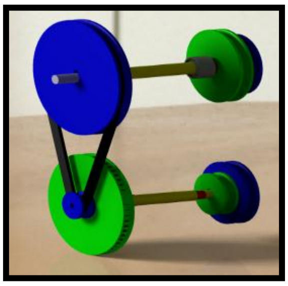

Figure 4: Drive Train

3.6 Movable Motor Base for Belt Tensions

Instead of designing tension pulleys which can create problems for packaging, we have used movable motor base. This simple component will vary the distance between input and output shafts due to which belt tensions will be adjusted and set up to required amount. These feature a one-piece formed base with single or double bolt adjustment for push-pull action. It has also simplified the overall assembly and made the mounting of motor horizontally possible.

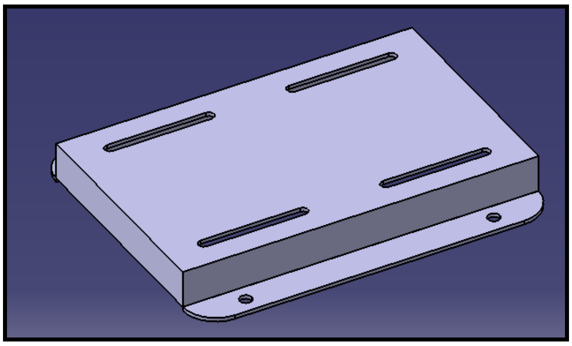

Figure 5: Movable Motor Base

3.7 Pulley Selection

To reduce the overall weight of assembly, aluminum 7075-T6 material is selected. Even if it is three times lighter than steel it has strength equal to steel.

PROPERTIES	Al 7075-T6
Young's Modulus (MPa)	7.20E+04
Poisson's Ratio	0.33
Density (tonne/mm^3)	2.80E-09
UTS (MPa)	5.72E+02
Yield Strength (MPa)	5.03E+02

Figure 6: Aluminum 7075-T6 properties

Again to reduce the motor shaft and spindle length and to make assembly more compact adjust cent pulleys are integrated also they are optimized with weight reduction slots but by ensuring its strength at the same time.

3.8 Spindle and motor shaft design

Spindle and motor shaft are designed by considering them as overhang beam. Then maximum torsion moment was calculated and shaft was checked considering combined torsion and bending moment. Material selected for both spindle and motor shaft is EN8.

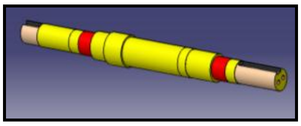

Figure 7: Motor Shaft

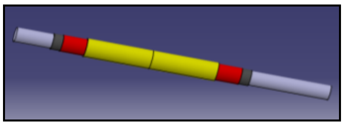

Figure 8: Spindle Shaft

4. Conclusion

Wide range of rpm ratios are covered with the help belt drive transmission which consists of combination of V- belts and synchronous belts for lower and higher rpm ratios respectively. This transmission drive is designed to serve the purpose of dynamic testing of rotary unions. The entire assembly is simplified and optimized with the help of movable motor base. And the objective of designing compact and light weight assembly is achieved.

REFERENCES

[1] RU143 US Engineering catalogue by Deublin.

[2] Handbook of timing belts and pulleys by GATES POWERGRIP.

[3] Material website: http://asm.matweb.com

[4] Design Manual Timing Belt V832-E by MITSUBOSHI.

[5] Design of Machine Elements by V. B. Bhandari. Tata McGraw-Hill Education -2010.