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PERFORMANCE TEST ANALYSIS OF GEARLESS POWER TRANSMISSION SYSTEM FOR FOUR NUMBER OF ELBOW PINS

Md. Abu Hasan Al Askary, **Bably Das**, **Sumaiya Maheen Binte Hoque**

Department of Mechanical Engineering, Chittagong University of Engineering and Technology, Bangladesh
as.hasan45@gmail.com*, bably@cuet.ac.bd, mahinsumaiya@gmail.com

Abstract- *An efficient means to transmit power is important for the present socio-economic world. Usually power transmission is associated with belt, chain, gear, rope, shaft etc. from the mechanical point of view. Uses of gear for transmitting power is a popular way but noise, friction, wearing, breaking of components etc. results in power loss and lower efficiency. A real-time study of the gearless transmission mechanism which is efficient and an economical way to transmit power is presented in this paper. The system has interchangeability and low cost for manufacturing. The response of four number of elbow pins has been analyzed by SOLIDWORKS software's simulation feature for various speed between 50 to 400 rpm and the efficiency has been calculated from input and output speeds. The efficiency has been obtained nearly about 85 percent.*

Keywords: Power transfer, Gearless transmission, Simulation and Efficiency,

1. INTRODUCTION

An important requirement of the world is more speed for rapid and fast working. For this reason, different types of components and machines are manufactured by many persons day by day. Engineers are also facing to the challenge of achieving new ideas and new designs. If someone wants to transfer power efficiently from its source of generation to the required place to obtain required task, then power transmission is vital concern [1]. For transmitting power and motion, different types of medium are used between two shafts. Using for transmitting power within a short distance like gears or couplings, belt pulley or chain-sprocket is another type of transmitting mechanism where the power can be transmitted to a long distance. A belt which consists of flexible material and is used to mechanically link between two or more spinning shafts. Belt drives are used to efficient transmission motion. Friction drive is also transmitting drive. It can transmit power by using two wheels one to another. But this type of system is not very efficient and cost effective [2]. Generally, gear is used to transfer power in short distances. To transmit power between two shafts, different types of gear are used for base on different conditions. These are used for transmitting power in various purpose of depending on shaft. Helical gear, herringbone gear and spur gear are used for parallel shaft. Worm gear, bevel gear is used for non-parallel shaft for transmitting power. But those have some disadvantage during manufacturing, lubricating, cooling and cost. Those have also limitation to power transfer in short distance, interchangeability, compellability of design calculation [3]. But in gearless power transmission system, it has many scopes. It is a backlash-free torque transmission and time saving installation. At even high speeds, it can be safe torque transmission. This mechanism can be also estimated radial vibration. For this reason, it is widely used for the movement of submarine's periscope, drill machining for different angular positions, lubrication in the C.N.C lathe machines, air blower in the computer and electric machine etc.

2. LITERATURE REVIEW

A briefing for gearless power transmission system between the co-axial shaft of various diameter were presented by Prof. A. Kumar and S. Das in the paper. They showed that motion could be transmitted up to 8 number of pins for smoother operation [4]. M. Lokash et al. had been expressed that the gearless power transmission mechanism with 6 L-type of pins to twisted at 90-degree angle could transmit power with 92 percent of efficiency. The pump and compressor were introduced to that paper. When the link rotates and reciprocates inside the drilled hole, it gave compression and pumping effect [5]. Prof Pavan Nikam et al. were comprising three pins bent into a 90-degree angle could be used for the woodcutter mounted on the shaft. When the number of pins increased then the transmission would smoother. The pins should be proper surface finish. The woodcutter could cut about 250mm width wood sheets [6]. Ashish Kumar et al. was designed the gearless power transmission system and the examination of the component was done on ANSYS. The investigation of the component was conveyed with 0.63 Moment of Inertia. Conduct of framework was plotted on various outlines for example speed versus time, acceleration versus time, angular acceleration versus time, separation distance versus time [7]. Prof. B. Naveen Baradiya et al.

had analyzed gearless transmission mechanism on SOLIDWORKS software. The reaction of elbow pin and hub had been plotted with time by varying motor rpm. They were simulated elbow pin for 5 second to find out von mises stress. It was observed that the system was capable of running 120rpm for normal conditions [8]. Solanki Nehal et al. used elbow mechanism instead of bevel gear with 4 number of L-type pins. They analyzed the mechanism for 50 to 200 rpm speed and concluded that it was run smoothly about 150rpm. Another, the number of pins increased, the operation would be smoother in that system [9]. Mahantesh Tanodi et al. analyzed about Z-links. When the size of Z-link decreased, off-set to shaft ratio increased. But it was concluded to maintain small off-set to shaft ratio to get more strong and rigid Z-link connector [10]. S.B Yapalaparvi et al. checked for smother operation, the minimum required three number of pins [11]. Shiv Pratap Yadav et al. researched about gearless power transmission system for real time study. They used three number of elbow pins at right angle orientation. It was working between eighty to hundred rpm speed. They proposed to replace that mechanism instead of cumbersome usage gears [12].

3. WORKING PRINCIPLE

The gearless power transmission mechanism is a device which transmits motion at any fixed angle from driving shaft to drive shaft. The elbow pins slide inside the cylindrical hole of the hub and forming a sliding pair. They are the free to slide in and out as the driving hub revolves. The motor drives the pully by the belt. The pully is connected to the hub through a shaft. So, the motion can transmit from the driving hub to the driven hub through elbow rods. The motion transmission can be apparent when one rods during one revolution.

4. METHODOLOGY

The aims of this project are to do response of four number of pins by SOLIDWORS simulation feature for different speeds and performance test of this system.

4.1 Flow Chart

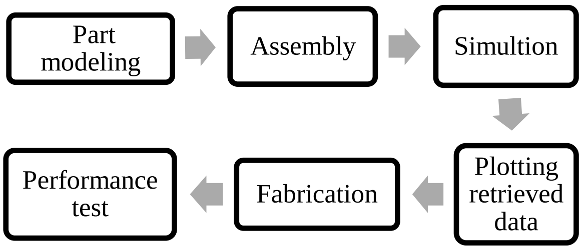

Figure 1: Flowchart of the project.

4.2 Assumptions

According to the research paper [13], some parameters are assumed for this project. For the design of shaft diameter is 20mm, length is 230mm. For the design of hub, the outer diameter (D_o) is 92mm, internal diameter (D_i) is 32mm, length(L) is 82mm. For elbow rod, diameter is 8mm, length is 300mm.

Equation (1) shows the torque calculation.

Power of motor, $P = \frac{1}{4}$hp =186.5 Watt.

The speed of the motor, N =1450 rpm.

Torque equation,

$$T = \frac{60P}{2\pi N} \tag{1}$$

Where, P is power, T is torque, N is speed,

So, $T = \frac{60\times186.5}{2\pi\times1440}$ =1238N-mm.

Equation (2) shows the bending stress of hub calculation.

The mass(m) of the system is 20kg

Force, F=mg=20×9.81=196.2N.

Bending stress of hub,

$$\sigma = \frac{FDi^2}{Do^2 - Di^2} \tag{2}$$

So, the calculated value of bending stress is 27 N/mm².

Equation (3) shows the bending stress of elbow pin calculation.

The section of modulus of elbow pin,

$Z=0.012R^3=0.768$ kg/mm²,

Where, R is radius of elbow pin.

Bending stress of elbow pin,

$$\sigma = \frac{PL}{4Z} \tag{3}$$

Where, P is power, L is length, Z is section modulus. So, the calculated value of bending stress of elbow pin is 18212.89 N/mm².

4.3 Simulation for Four Number of Pins

In SOLIDWORKS-2017 version software, all of the parts of the model are drafted under part and assembly workbench. Every parts of the model are rigid and concentric mate is used for relative motion. The feature of lock mate is used for shaft and hub. The simulation is performed on the mechanism to watch the response of elbow pin by von mises stress distribution. It is also performed by motion loads which is acted as dynamic loads. Mild steel is used for simulation and fabricate the model. Figure 2 shows the von mises stress distribution for speed 50rpm and figure 3 shows the maximum value of von mises stress vs speep graph for speed 50,100, 150, 200, 250, 300, 350 and 400 rpm respectively.

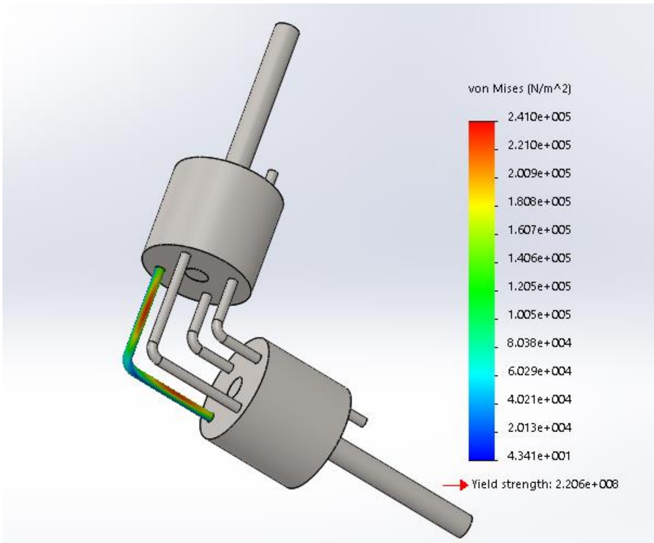

Figure 2: Von mises stress distribution of speed 50 rpm.

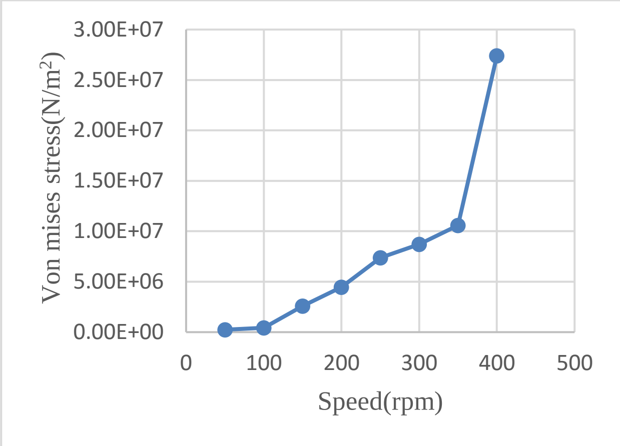

Figure 3: Maximum value of von mises stress vs. speed.

From this graph, it is clear that when speed is increased then von mises stress is also increased.

5. FABRICATION OF THE PROJECT

The gearless power transmission system is a system which can drive without using any gear. It can transmit power or motion from one shaft to another shaft at any fixed angle. In this project, it consists of four number of elbow pins, motor, cylindrical hub, flexible belt, bearing and frame. The pins can transfer power through hub from one shaft to another shaft. At first, an electric motor is supplied power to input shaft through a flexible belt. The input shaft is connected to the hub. Elbow pins are bent at right angle between two hubs for transmitting motion. These pins are slide and rotate freely around cylindrical holes which locates in the hub. The holes are located equally in the hub. One voltage regulator is also connected for controlling speed of the system. This system is suitable for low torque operations. Figure 4 shows the gearless power transmission system.

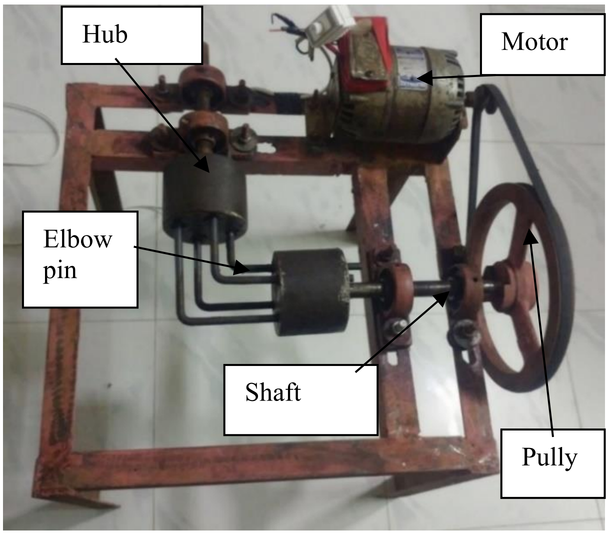

Figure 4: Gearless power transmission system.

5.1 Performance Test

The gearless power transmission system consists of four number of pins. Performance test of this gearless power transmission system depends on input motor speed, input shaft speed and output shaft speed. Efficiency is calculated from this input shaft speed and output shaft speed. Table 1 shows the data collection for this system.

Motor speed(rpm)	Input speed(rpm)	Output speed(rpm)	Efficiency (%)
602	129	105	81.3
688	154	123	79.8
657	173	146	84.4
701	178	156	87.6
705	186	136	73.1
753	217	179	82.5
801	229	162	70.7
815	237	216	91.1
856	246	192	78.0
946	302	275	91.0
922	308	253	82.1
958	314	281	89.5
962	328	296	90.2
958	335	287	85.7
978	342	308	90.1
984	346	305	88.1
986	348	322	92.5
987	356	302	84.8
997	360	318	88.3
998	363	308	84.8

Table 1: Performance test data

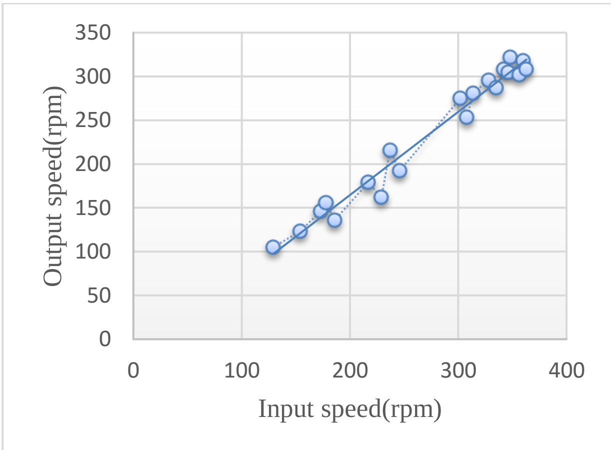

Figure 5: Output speed vs. input speed.

Figure 5 shows the performance test graph. From performance test graph, it is clear that when input shaft speed is increased then the output shaft speed is also increased gradually.

6. RESULT AND DISCUSSION

It is concluded from this analysis that when speed increases, the maximum value of von mises stress is increased. The system runs smoothly when it is run at low speeds. The efficiency is obtained nearly 85%. The gearless power transmission system works very well but some vibration is found for hub and elbow pin clearance in the system.

7. CONCLUSION

The system has a bright future in industries because of low cost. It can be used for machining operation, such as boring, drilling, grinding operations. This system may break for sudden applying load, because elbow pins and hub alignment are very sensitive. The effect of corrosion in this system is less than geared drive. Some speed loss is found in this system due to frictions and clearance between hub and elbow pin. It can be reduced by proper surface finish and using lubrication. Lubrication can be applied to the drill hole in the hub. But, the main advantage of this system is full of interchangeability and low cost.

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9. NOMENCLATURE

Symbol	Meaning	Unit
T	Torque	(N-mm)
N	Speed	(rpm)
F	Force	(N)
L	Length	(mm)
Z	Section Modulus	(kg/mm²)
σ	Bending Stress	(N/mm²)
D	Diameter	(mm)