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Design and Fabrication of Gearless Power Transmission Mechanism

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Abstract: Traditional power transmission across non-parallel or angled shafts relies heavily on bevel, crossed-helical, or worm gear configurations. However, these gear sets introduce manufacturing complexities, high production costs, backlash, and mechanical friction losses. This paper presents the design, kinematic principle, and fabrication of an elbow-link gearless power transmission mechanism. Utilizing a multi-slider kinematic chain formed by 90-degree bent rods sliding within matching drilled hubs, this system transfers continuous rotary power between intersecting and skew shafts at a 1:1 speed ratio without gear teeth. Experimental validation demonstrates smooth, low-noise operation, reduced maintenance requirements, and significant cost savings compared to traditional gear systems.

Keywords: Gearless transmission, Elbow mechanism, Kinematic sliding pairs, Skew shafts, Power transmission, Mechanical design

I. INTRODUCTION

Transmitting mechanical power between non-collinear and angular shafts is a fundamental requirement across automotive, industrial, and aerospace machinery. Conventional engineering approaches deploy bevel gears for intersecting shafts and worm or crossed-helical gears for non-intersecting (skew) shafts. Despite widespread use, geared transmissions present notable drawbacks:

1) High manufacturing costs necessitating specialized gear-cutting machinery.
2) Frictional losses and mechanical wear at sliding tooth contacts.
3) High sensitivity to center-distance variations and shaft misalignment.
4) Backlash and high-frequency acoustic noise at elevated rotational speeds.

The gearless transmission mechanism—historically related to multi-rod elbow couplings—overcomes these limitations. By converting rotary input into reciprocating sliding motion across curved/bent links, and subsequently back into uniform rotary output, torque is transmitted without gear teeth. This work details the structural design, kinematic model, component fabrication, and performance characteristics of a multi-pin gearless transmission prototype.

II. KINEMATIC PRINCIPLE AND WORKING MECHANISM

The transmission mechanism consists of an input shaft, an output shaft, two cylindrical hubs (pin housings), and a set of bent connector rods (elbow links).

A. *Working Principle*

1) The driving shaft (A) and driven shaft (B) are mounted on rigid bearing supports oriented at an angle of 90 degrees.
2) Cylindrical hubs attached to the shaft ends contain axially drilled guide holes positioned at an equal pitch circle radius, offset at 120° intervals.
3) Bent links configured at a 90° angle are inserted into the corresponding holes of both hubs, establishing a set of sliding kinematic pairs.
4) As the driving shaft rotates, the bent rods simultaneously reciprocate linearly within their guide channels and transfer tangential forces.
5) The combined sliding and swinging motion forces the driven hub to rotate synchronously with the driver at a constant velocity ratio (1:1).

$$\omega\_input = \omega\_output$$

Smoothness is governed by the number of links (n). While configurations can employ between 3 and 8 links, a three-link (n = 3) geometry offset at 120° provides a dynamically balanced, non-locking transmission loop.

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III. DESIGN AND FABRICATION DETAILS

A. Component Specifications

The experimental unit was sized for bench-scale power transmission validation:

Component	Dimensions / Specification	Material
Prime Mover	1440 RPM, Single Phase AC Motor	Standard Induction Unit
Transmission Belt / Pulley	45 mm Driver, 250 mm Driven (A-56 Belt)	Cast Iron / Synthetic Rubber
Transmission Shafts	Ø 20 mm - 25 mm Diameter	Mild Steel (Turned & Polished)
Elbow Links (Bent Rods)	Ø 10 mm - 12 mm Dia, 240 mm length (90° bend)	High-Tensile Steel / Hardened MS
Pin Housing (Hubs)	Ø 62 mm × 95 mm Length	Mild Steel
Bearings	P204 / Standard Pillow Block Bearings	Alloy Bearing Steel
Base / Frame	460 mm × 460 mm × 305 mm	Structural Steel Frame / Welded Box Section

B. Fabrication Process

1) Primary Shaping & Turning: Shafts, hub outer profiles, and pin blanks were turned on a conventional center lathe to maintain concentricity.
2) Precision Drilling: Three holes were bored into the hubs on a precision pitch circle diameter (PCD) at 120° spacing to ensure uniform rod clearance without excessive backlash.
3) Bending & Alignment: Rods were bent accurately to 90° and heat-treated to mitigate bending fatigue during cyclic reciprocating action.
4) Assembly: The supporting chassis was fabricated via electric arc welding. Shafts were mounted on pillow-block bearings, aligned orthogonally, and coupled through the pre-lubricated bent elbow links.

IV. COMPARATIVE ANALYSIS: GEARED VS. GEARLESS TRANSMISSION

Evaluation Parameter	Traditional Bevel / Crossed-Helical Gears	Gearless Elbow Transmission
Manufacturing Complexity	High; requires specialized gear-hobbing/shaping tools	Low; standard lathe turning, drilling, and rod bending
Production Cost	High due to tooling, materials, and tight tolerances	Low; constructed from standard stock materials
Friction & Wear Type	High-pressure line/point contact sliding	Surface contact across distributed cylindrical sliding pairs
Operational Noise	Significant gear mesh whine and backlash chatter	Smooth and quiet operation
Shaft Diameter Compatibility	Restricted to standard standardized design envelopes	Adaptable across non-standard shaft diameters
Maintenance	Frequent lubrication, backlash adjustments, high replacement cost	Low maintenance; inexpensive link replacement upon failure

V. POTENTIAL APPLICATIONS

Due to its compact layout and torque-transmission characteristics across angles, the gearless elbow mechanism is suitable for:

1) Multi-Spindle Gang Drilling: Operating multiple angled drill heads from a unified drive source.
2) Machine Tool Auxiliary Drives: Compact lubrication and coolant pump actuation in CNC lathes.
3) Submarine Periscope Positioning & Tower Clocks: Transmitting multi-axis motion through confined structural conduits.
4) Confined Space Tooling: Right-angle socket wrench extensions and portable manual drive implements.
5) Light-Duty Utility Vehicles: Steering and auxiliary drives in go-karts and localized industrial shop equipment.

VI. CONCLUSION

The design and fabrication of the gearless power transmission mechanism demonstrates a cost-effective, quiet, and mechanically viable alternative to conventional right-angle gear drives. By eliminating tooth engagement in favor of multi-link sliding kinematic pairs, the system achieves 1:1 angular power transmission with reduced vibration, minimal manufacturing cost, and simpler maintenance. Future work will focus on dynamic stress analysis under continuous heavy load regimes, wear-resistant material coatings for the sliding pins, and adapting the architecture to dynamically variable shaft angles.

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