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DESIGN AND FABRICATION OF SLIDING RAM BY USING QUICK RETURN MECHANISM

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Abstract: This work aims to propose a novel design for quick return mechanisms, and the new mechanism is composed by a generalized Oldham coupling and a slider-crank mechanism. First, the kinematic dimensions that affect the time ratio are found by investigating the geometry of the proposed design. By transforming into its kinematically equivalent mechanism, and then the design equations of time ratio are derived. Furthermore, a design example is given for illustration. Moreover, the design is validated by kinematic simulation using ADAMS software. Finally, a prototype and an experimental setup are established, and the experiment is conducted. The results show that proposed new mechanism is feasible and with reasonable accuracy. In addition, it is more compact and easier to be balanced dynamically than a conventional quick return linkage.
Quick-return (QR) mechanisms feature different input durations for their working and return strokes. The time ratio (TR) of a QR mechanism is the ratio of the change in input displacement during the working stroke to its change during the return stroke. Several basic types of mechanism have a QR action. These types include slider-crank and four-bar mechanisms. A project on QR mechanism design, within a first course on the theory of mechanisms, has been found to be effective for exposing students to concepts of mechanism design and analysis. This paper reviews basic QR mechanisms, presents a project problem and solution examples, and discusses the value of inclusion of such project problems within theory-of-mechanism courses.

1. Introduction

A quick return mechanism is a mechanism that converts rotary motion into reciprocating motion at different rate for its two strokes. When the time required for the working stroke is greater than that of the return stroke, it is a quick return mechanism. It yields a significant improvement in machining productivity. Currently, it is widely used in machine tools, for instance, shaping machines, power-driven saws, and other applications requiring a working stroke with intensive[1-5] loading, and a return stroke with non-intensive loading. Several quick return mechanisms can be found in the literatures, including the offset crank-slider mechanism, the crank-shaper mechanisms, the double crank mechanisms, and the Whitworth mechanism.

All of them are linkages. A linkage has its strengths and weaknesses. It is inexpensive to make and easy to lubricate; however, it is bulky and difficult to balance. In situations, if compact space is essential to the design, then a linkage may not be a good choice. Therefore, how to find a new alternative of quick return mechanisms is an open topic that deserves to be examined. There are many scholars devoted to the studies of quick return mechanisms, and many valuable contributions have been made. [6-10]

Alkesh used the Whitworth mechanism to constructing a high velocity impacting press. Akash&Ashutosh performing the design of the spatial RSSR quick return mechanism. Beale employed Galerkin's method to investigate the dynamic and stability[1-5] of a flexible link used in a quick return mechanism. Fung and Lin utilized different control approaches to investigate the response of a quick return mechanism with or without a flexible link. Hat et al. proposed a finite difference method with fixed and variable grids to approximate the numerical solutions of a flexible quick-return mechanism. Chang investigated the coupling effect of the geared rotor on the quick-return mechanism undergoing three-dimensional vibration. A quick return mechanism is an apparatus that converts circular motion (rotating motion following a circular path) into reciprocating motion (repetitive back-and-forth linear motion) in presses and shaping machines, which are utilized to shape stocks of metal into flat surfaces, throughout mechanical engineering. The quick return mechanism is the foundation behind the energy of these machines. The mechanism consists of an arm attached to a rotating disc that moves at a controlled uniform speed. Unlike the crank, the arm of the mechanism runs at a different rate than the disc. By having the disc run at a different rate than the attached arm, productivity increases because the amount of time needed for a cut is reduced. The design of this mechanism specializes in vector calculus and the physical aspects of kinematics (study of motion without the effects of forces) and dynamics (study of forces that affect motion).

A. Quick Return Mechanics:

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The mechanism consists of an arm attached to a rotating disc that moves at a controlled uniform speed. Unlike the crank, the arm of the mechanism runs at a different rate than the disc. By having the disc run at a different rate than the attached arm, productivity increases because the amount of time needed for a cut is reduced. The design of this mechanism specializes in vector calculus and the physical aspects of kinematics (study of motion without the effects of forces) and dynamics (study of forces that affect motion).

B. Abbreviations and Acronyms:

ADAMS-Automated Dynamic Analysis of Mechanical System
QR -Quick Return
TR -Time Ratio

C. Units:

All Dimensions are in mm.
Rotation of gear in rpm

D. Equations:

- The position of the arm can be found at different times using the substitution of Euler's formula:

$$e^{i\theta} = \cos\theta + i\sin\theta$$

- angular velocity of the disc:

$$\omega = \frac{v}{r}$$

- The angle between crank and fixed link (θ): Tan θ = OP/NP

- Time of cutting stroke / Time of return stroke = θ / Φ=(360- Φ)/ Φ

2. Literature view

Sir Joseph Whitworth is best known in connection with his development of a rationalised system of screw threads and for the screw threads that bear his name; British Standard Whitworth (BSW). He proposed this thread system in 1841 and the relevant British Standard is BS 84: 1956. However, the principal contribution of this exceptionally talented engineer was his introduction of new standards of accuracy in manufacturing to a degree previously unknown.[6]

By 1830 a skilled mechanic could be expected to work to an accuracy of only one sixteenth of an inch but by 1840, thanks to Joseph Whitworth, an accuracy of one ten-thousandth of an inch was a practical proposition. Subsequently,[7] Whitworth devised an instrument (a bench micrometer) that could measure to one millionth of an inch. He also introduced a standard for the flatness of plane surfaces, which was essential for fine engineering work and for the manufacture of surface plates used for marking out purposes.[8]

Joseph Whitworth was born in Stockport, Cheshire, [9]on the 21 December 1803 and he was the son of Charles Whitworth, a schoolmaster (another source says that he was a Congregational minister), and Sarah. He was christened on the 8 February 1804 at Church gate Independent on Orchard Street, Stockport. It is possible that the maiden name of Charles Whitworth's wife was Sarah Pullan, the couple marrying at Pateley Bridge, Yorkshire, on the 2 August 1795.[16]
Joseph Whitworth married twice. [11]His first wife was Frances Anker and they were married on the 25 February 1825 at Ilkeston, Derbyshire. His second wife, 25 years his younger, was Mary Louisa Orrell and they were married in 1871 at Westminster, London.[17-20]
Joseph Whitworth only received an elementary education and during this period of his life he did not distinguish himself. On leaving school he became an indentured apprentice to an uncle who was a cotton spinner in Derbyshire. This was only a four-year apprenticeship and on completion of this he worked for another four years as a mechanic in [15]a factory in Manchester. He then found employment working for Henry Maudsley (1771-1831), inventor of the screw-cutting lathe.[21-25] Maudsley's factory was on Westminster Bridge Road in[13] London and here he

worked alongside other men who were also destined to become famous engineers, such as James Nasmyth (1808-1890), inventor of the steam hammer, and Richard Roberts (1789-1864), inventor of a self-acting spinning mule.[26]

3. History

The earliest evidence, anywhere in the world, for the crank combined with a connecting rod in a machine appears in the late Roman[19] Hierapolis sawmill from the 3rd century AD and two Roman stone sawmills at gerasa, Roman Syria, and Ephesus,[20] Asia Minor (both 6th century AD).[27] On the pediment of the Hierapolis mill, a waterwheel fed by a mill race is shown powering via a gear train two frame saws which cut rectangular blocks by the way of some kind of connecting rods and, through mechanical necessity, cranks. The accompanying inscription is in Greek[28].

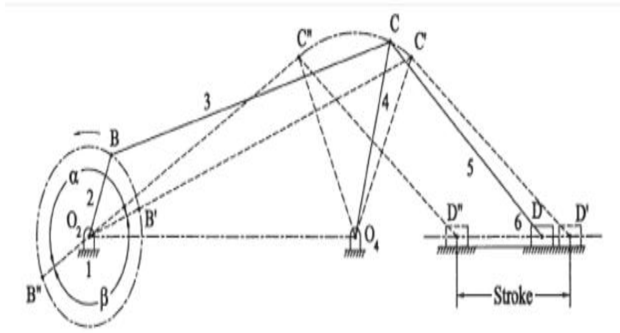
The crank and connecting rod mechanisms of the other two archaeologically attested sawmills worked without a gear train. In ancient literature, there is a reference to the workings of water-powered marble saws close to Trier, now Germany, by the late 4th century poet Ausonius; about the same time, these mill types seem also to be indicated by the[29] Christian saint Gregory of Nyssa from Anatolia, demonstrating a diversified use of water-power in many parts of the Roman Empire The three finds push back the date of the invention of the crank and connecting rod mechanism by a full millennium; for the first time, all essential components of the much later steam engine were assembled by one technological culture.[23]

A. Renaissance Europe:

The crank became common in Europe by the early 15th century, often seen in the works of those such as the German military engineer Konrad Kyeser. Devices depicted in Kyeser'sBellifortis include cranked windlasses (instead of spoke-wheels) for spanning siege crossbows, cranked chain of buckets for water-lifting and cranks fitted to a wheel of bells.Kyeser also equipped the Archimedes' screws for water-raising with [24]a crank handle, an innovation which subsequently replaced the ancient practice of working the pipe by treading. The earliest evidence for the fitting of a well-hoist with cranks is found in a miniature of c. 1425 in the German Hausbuch of the Mendel Foundation In Renaissance Italy, the earliest evidence of a compound crank and connecting-rod is found in the sketch books of Taccola, but the device is still mechanically misunderstood. A sound grasp of the crank motion involved demonstrates a little later Pisanello who painted a piston-pump driven by a water-wheel and operated by two simple cranks and two connecting-rods.[25-28]The 15th century also saw the introduction of cranked rack-and-pinion devices, called cranequins, which were fitted to the crossbow's stock as a means of exerting even more force while spanning the missile weapon (see right). In the textile industry, cranked reels for winding skeins of yarn were introduced.[30]

B. Figures

[*Quick Return Mechanism]*



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