© April 2022 | IJIRT | Volume 8 Issue 11 | ISSN: 2349-6002

Use of Push Pull Toggle Clamp Instead of Conventional Fixture Method in VMC Machine

BHAVESH KUMBHARE[1], ACHAL ADBAILE[2], PRAJWAL RASEKAR[3], SAURABH RAUT[4], SHREYASH KAPSE[5], TANMAY TEMBHURNE[6], RAHUL WAGHMARE[7]

[1, 2, 3, 4, 5, 6] Student, Dept of Mechanical Engineering, Jhulelal Institute of Technology, Nagpur, Maharashtra, India

[7] Assistant Professor, Dept of Mechanical Engineering, Jhulelal Institute of Technology, Nagpur, Maharashtra, India

Abstract— Cycle time is one of the key parameters that must be improved to the greatest extent possible when the manufacturing business is attempting to improve efficiency, cost of capital, and customer experience. Among production industries, reducing production cycle times can offer a competitive advantage. A company's production cycle is an indicator of how well it can convert assets into profits, inventory into products, and supply chains into cash flow. When companies want to please their distributors, a shorter production cycle is a powerful selling point. Because of reduced production cycle times, companies enjoy increased productivity, high customer satisfaction, and high profits. This paper is concerned with identifying a problem relating to production cycle time in VMC machines which lead us to implement a toggle clamp in place of the conventional fixture. In addition, we constructed a bed to operate the toggle clamp. The main objective of using a toggle clamp is to reduce the cycle time thus, achieving improved productivity and higher customer satisfaction.

Indexed Terms-- VMC machines, Production cycle, Production cycle time, Toggle clamp, Productivity.

I. INTRODUCTION

Productivity is an important determinant of the performance of companies and nations in terms of production. Increasing industrial productivity can enhance standards because greater real income improves the industry's ability to purchase quality goods and services.

In a production system, productivity is the ratio of output to the input. Productivity can be improved by following ways;

a) Reducing input required for getting desirable output
b) Increasing output with provided fixed input
c) Achieving higher output with small increase in input. [2]

Cycle time reduction is one of the factors that can enhance manufacturing industry productivity. A good machine tool system concentrates on cycle time by eliminating the non-value-added activities.

Cycle Time = $\frac{\sum (Setup\ time + Machining\ time)}{number\ of\ components\ produced}$ [2]

In this paper, our objective is to focus on reducing the cycle time for increased productivity in a manufacturing business. The use of a Push-Pull Toggle Clamp is implemented instead of the previously used Conventional fixture in a VMC machine to reduce the cycle time of workpiece operation. The toggle clamp takes comparatively very less time for loading & unloading the workpiece than the usual conventional fixture.

II. OVERVIEW OF CONCEPT

The overall time necessary to turn raw materials into final goods is referred to as Production cycle time. It is comprised of operation time, loading & unloading time, setup time, and idle time. Only during operation time is value-added, and loading and unloading, setup, and idle times are categorized as 'Downtime.' Reduced downtime per job unit can be achieved by reducing set up time, machine idle time, or loading &

unloading time. Downtime, and thus cycle time reduction, is regarded as one of the finest possibilities as the industry strives to improve production, reduce costs, and improve customer response time.

In this paper, we concentrated on one of the three components of cycle time reduction: the reduction in workpiece loading and unloading time as shown in "Fig. 1".

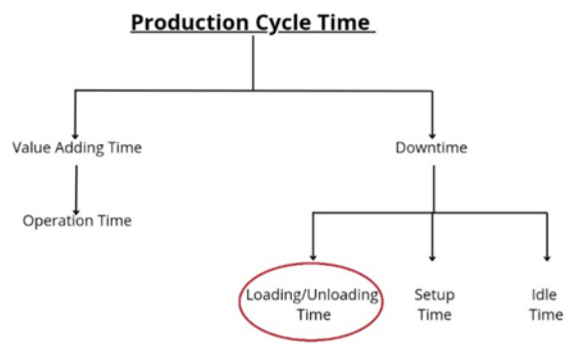

Fig. 1: Production Cycle Time

III. BACKGROUND

A Vertical Machining Center (VMC) is a machining center with a vertically oriented revolving spindle (z-axis). A VMC is a machine that is controlled by a CNC (Computer Numerical Control) system. As the spindle operates in a vertical orientation (as shown in "Fig. 2"), clamping at the top surface of the job is not possible. In this scenario, straight line clamping is required, which Straight Line Action (Push Pull) Toggle Clamps can supply. The Push Pull Toggle Clamps are intended for use in a straight line. The handle is simple to use and slides the clamp's plungers in and out along their axis, gripping a workpiece by holding its side surface rather than its top surface.

Fig. 2: VMC with vertically oriented spindle

IV. METHODOLOGY

This section describes the methodology of actual tool implementation and components of the tool. Toggle clamps are quick-action clamps. These have a natural ability to move completely free of the work, allowing for faster part insertion/removal. When compared to the application force, the holding force of toggle clamps is extremely high. Through a combination of levers and pivot points, a Toggle Clamp is used to secure stationary workpieces and other components in place. This adaptable and quick-acting work holding tool comes in a range of action types, each with its own set of uses and designs based on the needs of the operator.

The force, in a Push Pull Toggle Clamp, is applied in a straight line by these Toggle Clamps. The clamp toggles between forward and backward positions, which is very handy in instances when you may need to pull forward and apply force rather than pushing forward and applying force. Components of a Push Pull Toggle Clamp include clamping plate, base plate, screw (for adjusting the clamping pressure), handle, pivot point, linkages, clamping arm and bolt holes which are shown in "Fig. 3".

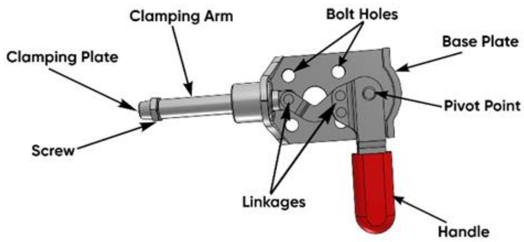

Fig. 3: Components of a Push Pull Toggle Clamp

V. WORKING MECHANISM

The toggle clamp is a clamp product for fixing workpieces through a connecting rod mechanism, a quick clamping and quick opening mechanism that adopts the dead point principle of the mechanical four-bar linkage mechanism, and has the functions of "accurate positioning, quick loading and unloading, locking and clamping". [4]

The slider-crank mechanism is a particular four-bar linkage configuration that converts linear motion to rotational, or vice versa. Internal combustion engines are a common example of this mechanism, where combustion in a cylinder creates pressure which drives a piston. The piston's linear motion is converted into rotational motion at the crank through a mutual link, referred to as the connecting rod. [5]

Slider-Crank Mechanism:

A slider crank mechanism is a variation on the traditional four bar linkage. It is made up of one sliding and three turning pairs. This mechanism is used to convert rotational motion into reciprocating motion and vice versa. Links 1 and 2, links 2 and 3, and links 3 and 4 make three turning pairs in a slider crank chain, whereas links 4 and 1 form a sliding pair. Link 1 relates to the fixed frame. Link 2 represents the crank and has rotary motion. Link 3, combined rotary and reciprocating motion, represents the connecting rod. Link 4 represents a slider with reciprocating motion. A simple slider-crank mechanism is represented in "Fig. 4".

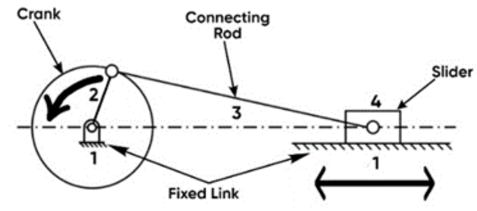

Fig. 4: Slider-Crank Mechanism

A Push Pull Toggle Clamp follows Slider-Crank Mechanism as:

Sr. no.	Components of Toggle Clamp	Function as a slider crank
1	Handle	Crank
2	Clamping Arm	Slider
3	Pivot Point & Linkages	Connecting Rod
4	Base Plate	Fixed Link

Table 1

Clamps having a toggle action are usually controlled by a pivot and lever linkage arrangement. The pivot pin is attached to the fixed-length levers or linkages. In a Push Pull Toggle Clamp, the clamping arm is held to slide back and forth. The handle pivots around a point on the base plate. The clamping arm is connected to the handle by a connection of linkages. The pin in the handle, the link, and the clamp arm align horizontally in the clamped position of a crank-slider mechanism as shown in "Fig. 5". The clamp's force is directed along the links. In toggle action, there is an over Center lock point, which was formerly a fixed stop and linkage. The clamp cannot unlock or move while in the over Centre lock position unless the linkage is changed.

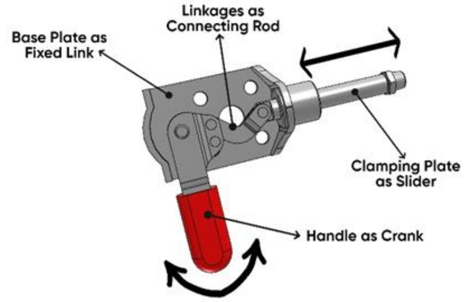

Fig. 5: Push Pull Toggle Clamp as a Slider-Crank

VI. FABRICATION OF FIXTURE BED

Push Pull Toggle Clamp requires a dedicated arrangement for clamping a workpiece inside a VMC machine. We termed this arrangement as "Fixture Bed". Fabrication of this fixture bed followed industry standards for operations to be performed on a specific workpiece.

Dimensions of Fixture Bed –

	Base	*Block above the base*	*Metal Strip in front of the block*
Length	240 mm	140 mm	45 mm
Height	40 mm	90 mm	90 mm
Width/Thickness	150 mm	45 mm	25 mm

Table 2

Fig. 6. Fixture Bed

VII. CALCULATION OF PRODUCTION CYCLE TIME DIFFERNCE

A comparative evaluation of the productivity of a VMC machine was conducted, first using a conventional fixture arrangement and then using a Toggle Clamp, to examine the production difference between both tools.

Let, Cycle time required for 1 component in VMC machine = 150 sec & Ideal no. of hours per shift = 8 hours.

Using Conventional Fixture –
Total Cycle time for 1 component = Cycle Time + (Clamping - declamping time) = 150 sec + 50 sec = 200 sec

∴ One job requires 200 sec to be finished.

Now, Production per hour = 3600 ÷ 200 = 18 components per hour are produced

Production per shift = 18 components × hours per batch = 18 × 8 = 144 components

Using Push Pull Toggle Clamp –
Total Cycle time for 1 component = Cycle Time + (Clamping - declamping time) = 150 sec + 05 sec = 155 sec

∴ One job requires 155 sec to be finished.

Now, Production per hour = 3600 ÷ 155 = 23 components per hour are produced
Production per shift = 23 components × hours per batch = 23 × 8 = 184 components

Thus, 40 more components per batch can be produced if we use clamping through a toggle clamp instead of a conventional fixture.

Percentage increase in production = [(184 - 144) ÷ 144] × 100 = 28 %
Thus, if we calculate in terms of percentage, we may find a 28 percent increase in production per batch.

CONCLUSION

The toggle clamp implemented for the project is a standard or light action toggle clamp which cannot be used where require high levels of production, high clamping forces and robustness is required. Heavy Duty Toggle Clamps are more robust in construction than normal Toggle Clamps. Heavy Duty Toggle Clamps are more durable and are typically utilized in locations with harsh environment, increased production, perhaps more weld waste, or where the tool needs to last longer. Heavy Duty Toggle Clamps were originally designed for the automotive sector, where high levels of output and clamping forces were necessary.

The use of a toggle clamp instead of a conventional fixture assembly reduces the overall necessary production cycle time of a VMC machine. The primary advantage of Toggle Clamps is their increased efficiency. Depending on what you have been utilizing in the past, efficiency will provide a cost benefit by speeding up production and improving outputs when you are able to enhance the speed at which components are loaded and unloaded. As a result, industries can see this instrument as a value-added device that they should employ in their workplaces.

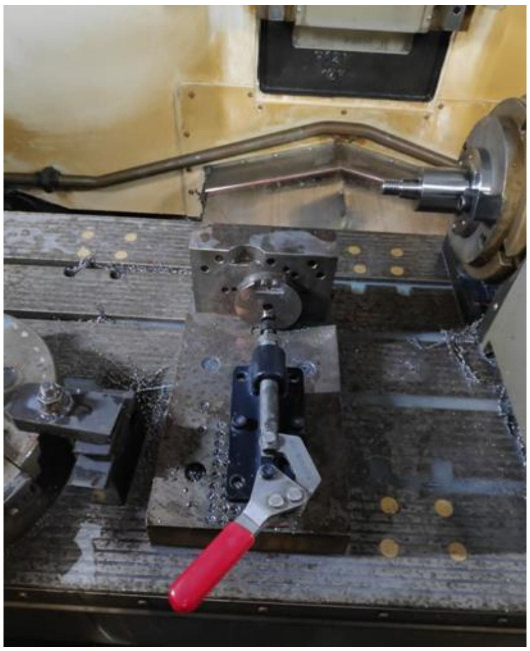

Fig. 7. Complete Assembly of Toggle Clamp with Fixture Bed

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