Enhancing Productivity by Using Adjustable Multi-Spindle Attachment

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Abstract

Productivity improvement has become an important almost in all mass manufacturing industries, who really implement various methods in the manufacturing process. Productivity improvement techniques can be applied effectively in enterprises of any size, from one-person companies to corporations with thousands of staff. The majority of the techniques were first seen in mass – production operations but the benefits they can yield in SME are not to be underestimated. Indeed, the absence in SME of many of the rigidities commonly found in large companies make it easier for them to reap the benefits of productivity improvement techniques. Lean thinking and enterprise resource planning systems, it zooms in on productivity improvement techniques. Productivity also applies to service sector and many organizations of these sectors are also implementing various methods to improve their productivity.

Manufacturing is becoming the provision of complete service over the whole product life cycle. This new service provision requires manufacturers to get closer to their customer and to operate far more responsively than past. Many mass manufacturing industries like machine building, automobile and electronics industries are serious about their productivity improvements.

The time study, method study engineers of production engineering in collaboration with process planning engineering staff trying to reduce the time of manufacturing process, by clubbing more operations at a time or going for an accessories which can reduce the cycle time of operation. This paper is related to one of time reducing operation process by using the adjustable multi spindle attachment, for machining the three T-slots at a time to increase the output rate. By using this attachment three T- slots can be machined at a time reducing the operation time of the component to1/3 of original time. That means the time saving is 2/3 of total machining time. The output of component from the operation is three instead of one by conventional machining process. Hence it enhances the productivity time saving of the operation and the quality remains the same.

Key Words*: Machining time, Side and Face Cutter carbide inserted type, T-slot cutter, Table, Bolster and Accessory*

I. INTRODUCTION

Manufacturing is becoming the provision of complete service over the whole product lifecycle. This new service provision requires manufacturers to get much closer to their customers and to operate far more responsively than they have in the past.'[9] The second report, Emerging Global Manufacturing Trends - Output from the working sessions at Inform an 2000, prepared by the Institute for Manufacturing at the University of Cambridge, contains the following list of issues that organisations should consider in response to the main trends in global manufacturing:

- Human resources issues
- Using regulations as a positive force
- Intellectual capital/knowledge management
- Agility and dynamic supply chain network

• Innovation
• Migration to higher/value-added service
• Clear core competencies that will create a barrier to new entrants

One of the primary responsibilities of the operations manager is to achieve productive use of an organization's resources (labor, equipment, facilities, money, etc.) In very general terms productivity is a measure of output based on input. This is usually calculated as a productivity ratio.[10]

Productivity = Output/Input

A single factor productivity measure is Machine Productivity, Labor Productivity, capital Productivity and Energy Productivity. In this paper Machining Productivity is considered and units of output per machine hour, dollar value of output per machine hour are considered as the main criteria. [1]

To improve Productivity

- Develop Productivity measures for each operational development.
- Determine critical operations by looking at the systems as whole to see how interrelationships or bottlenecks affect productivity.
- Develop methods for soliciting improvement ideas.
- Establish reasonable goals for improvement.
- Make it clear that management supports improvement ideas and consider incentives for contributors. [3]

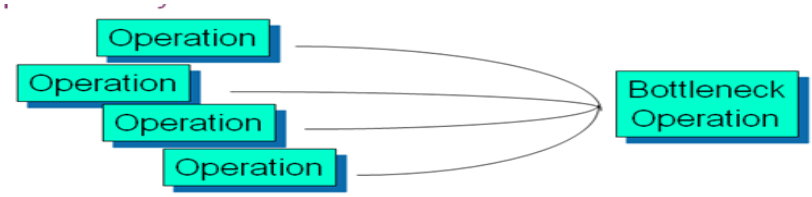


Fig. 1. Productivity development

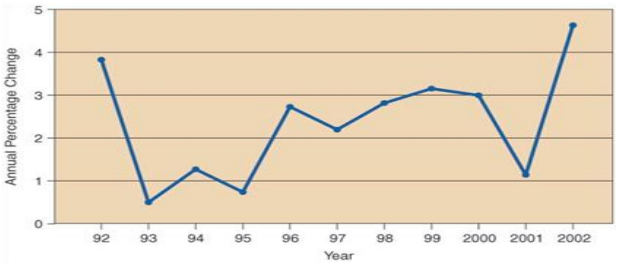


Fig. 2. Productivity development [2]

Fig. 3. Productivity improvement[3]

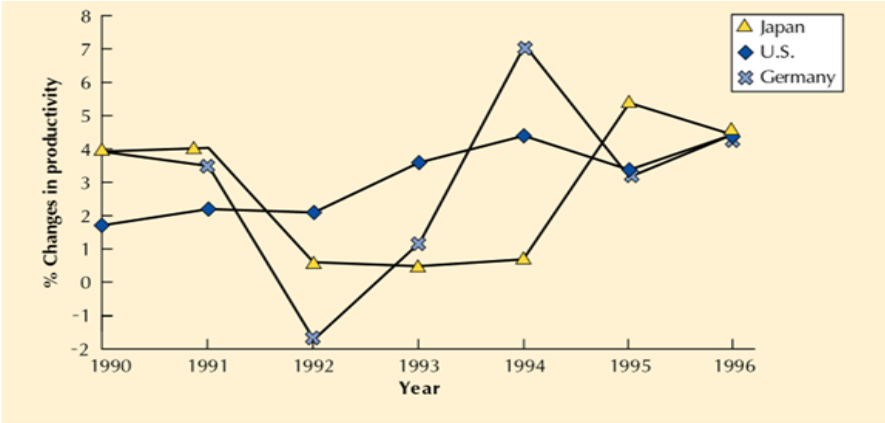


Fig. 4. Change in Productivity [3]

Productivity is scorecard on effective resource use

- A nations productivity effects its standard of living
- US productivity growth averaged 2.8% from 1948-1973
- Productivity growth slowed for the next 25 years to 1.1%
- Productivity growth in service industries has been less than in manufacturing.

1.1. The Role of SME in supporting large Manufacturing Firms

Of the entire 1999 business population of 3.7 million enterprises, only 24,000 were medium sized (having 50-249 employees and fewer than 7,000 were large(having 250 or more employees) Small business, including those without employees, accounted for over 99% of business, 45% of non – governmental employment and (excluding the finance sector) 38% turnover. [3]In contrast, the 7,000 largest businesses accounted for 45% of non-government employment and 49% of non-government and 49% of turn over as shown in Fig.5

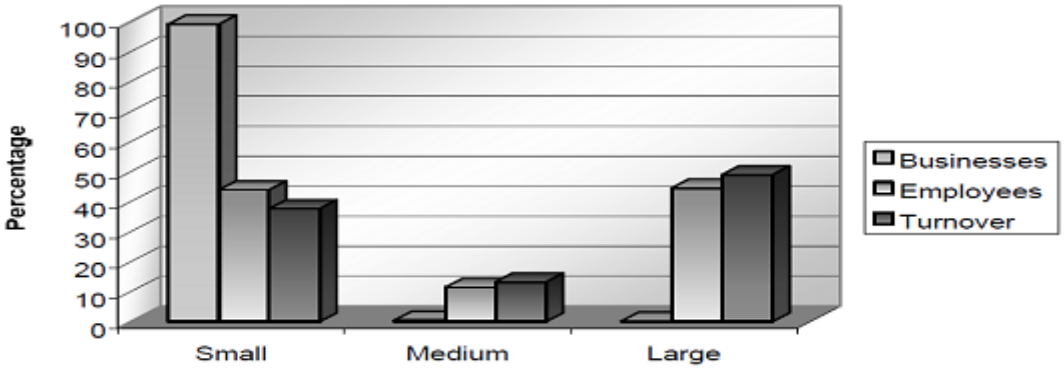
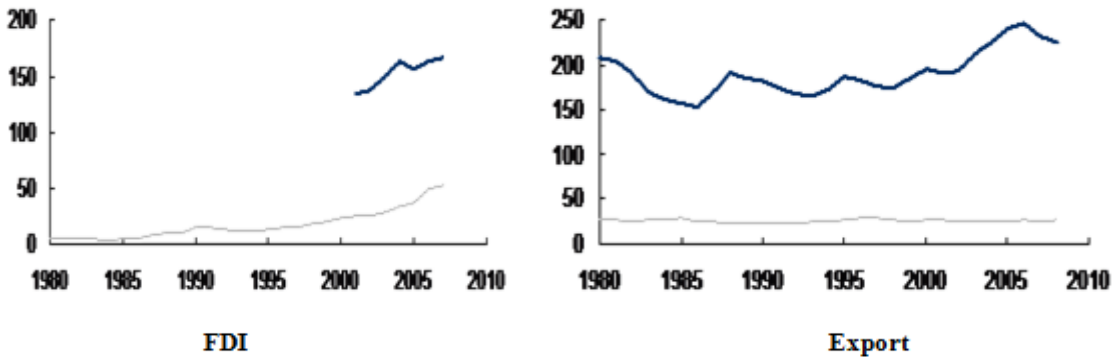


Figure 5: Proportion of businesses, employment and turnover firms at start of 1999 [4]

1.2. Singapore's Productivity growth was associated with FDI, export and R&D [5]



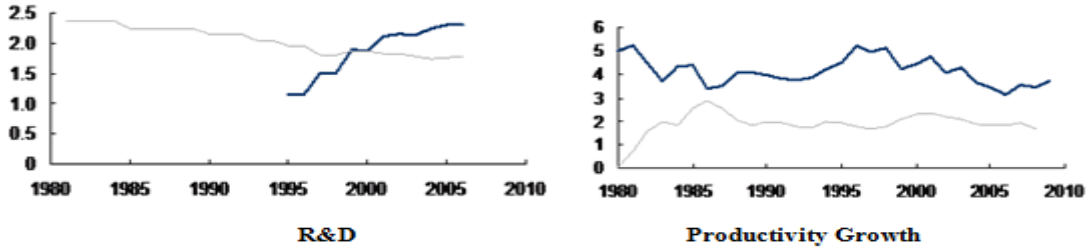


Fig.6. Singapore's Productivity growth

1.3. KEY ACHIEVEMENTS OF SWEDEN

[1] Productivity grew by 2.8% p.a. between 1990 and 2000 – almost twice the OECD average
[2] Private sector productivity growth of 3.3% p.a. was even greater
[3] R&D expenditure of 4.25% of GDP in 2001 second highest in OECD
[4] Exports doubled from 1978 to 2008

- Following the crisis of 1990-93, there was broad acceptance that product market reforms to increase competition were required to restore economic competitiveness. (5) In the retail sector, this was largely achieved through an easing of municipality planning restrictions. Prior to 1992, planning applications from aspirational market entrants were considered by a committee including representatives of from incumbent firms, and were seldom successful
- In 1992, the government changed the municipality guidelines, requiring them to "consider the competitive landscape" when deciding whether or not to award planning permission to new retailers
- This led to a significant increase in competition in retail, and a large increase in large, high-productivity out-of-town stores (see chart to right), which resulted in sectoral productivity growth of 4.5% p.a. (OECD 1.5%)

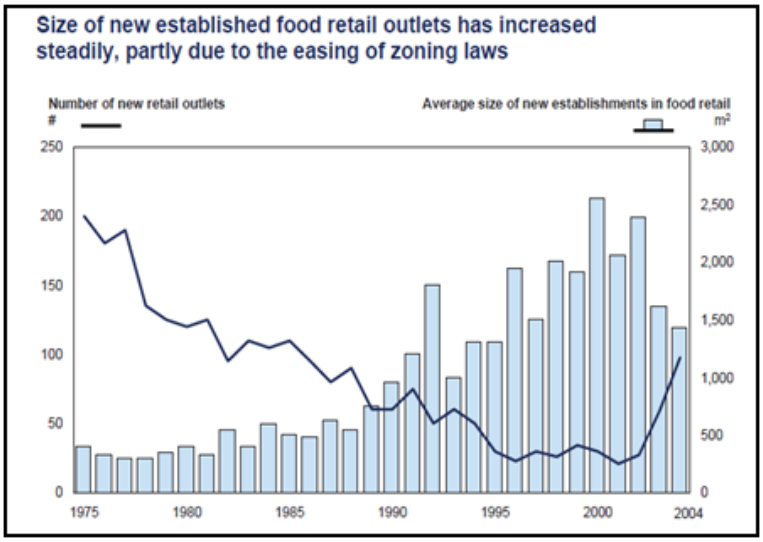


Fig.7. Productivity growth

- The financial sector also experienced significant reforms, including the creation of a government-backed mortgage lender to drive competition. (11)As a result, the market share of the "Big 4" banks fell from 82% to 69%. This resulted in 4.6% p.a. productivity growth in retail banking, as opposed to the OECD average of 3.0%
- These developments contributed to Sweden's high private sector productivity growth of 3.3%, as opposed to OECD average of 2.2% between 1992 and 2004
- Sweden was particularly successful at using the economic crisis of the early 1990s to align the country around a clear vision of change, and driving through reforms by citing national interest

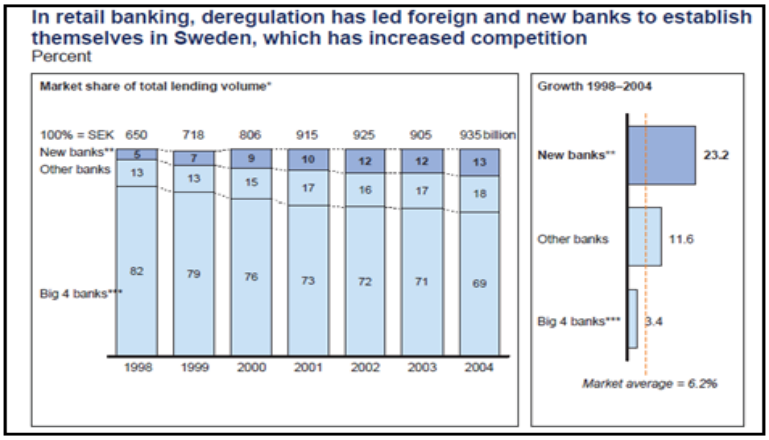


Fig.8. Productivity growth in finance

II. ADJUSTABLE MULTI-SPINDLE ATTACHMENT

Design of this accessory is very simple Fig. 9 and can be manufactured easily in any workshop by using conventional machines and weight is also not heavy. The accessory can be easily mounted on heavy duty vertical milling machines and horizontal boring machines [6]. Its gear box is very simple, changing oil is easy and will not leak even it is mounted horizontally on horizontal boring machine. This is designed particularly for machining three T- slots of either milling machine table or bolster plate of press machine see fig.10 in the machine tool manufacturing industry. It is well balanced by statically and dynamically.

As mentioned, this accessory is designed to perform the machining operation of all the three T-slots at a time for the components of milling tables and bolster plates of press machines in machine building units in mass manufacturing process. There are various methods to perform this operation by using conventional machines like milling, planning and Plano milling machines with standard cutting tools. But there is no possibility of machining all the three T-slots at a time in milling machine, since it has only one spindle possible to mount only one T-slot cutter and same thing in planning machine only one single point tool can be mounted on the cross rail/on clapper box. The operation process in planning machine is first machining the plane slots and using single point T-slot tool left hand at a time and after finishing that, machine right side by using single point T-slot tool right side. This takes three operations and process time will be more. This time can be minimised by performing two cuts of left hand and right T-slots at a time with this adjustable multi spindle attachment

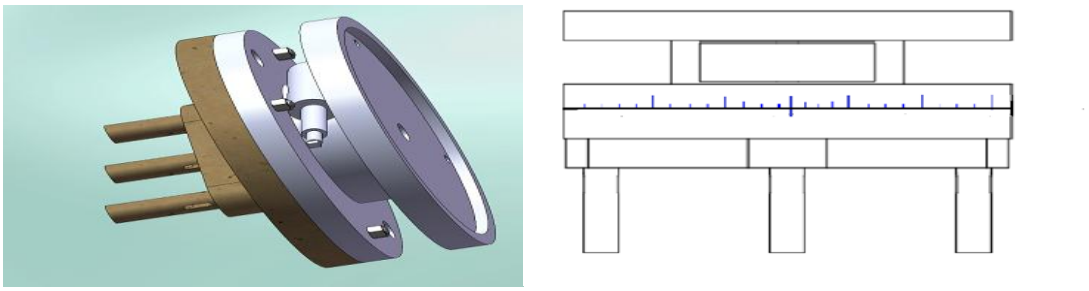


Fig.9. Adjustable multi spindle attachment

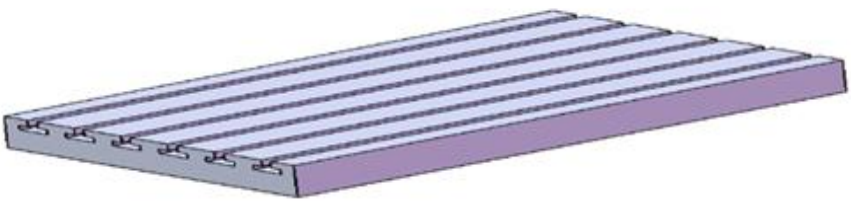


Fig.10. Bolster plate

Similarly in milling machine arrange/mount all the three side and face cutters on arbor like gang milling operation to machine all the three plane slots at a time. As shown in fig.11 Now only T-slots are to be machined, design a special cutter similar to side and face cutter in the shape of T-slot with staggered teeth specially carbide inserts cutter[7] to machine all the three T-slots at a time by mounting all the three special cutters on the arbor replacing that of side and face cutters. This method also increases the productivity by reducing the time of the operation to some extent.

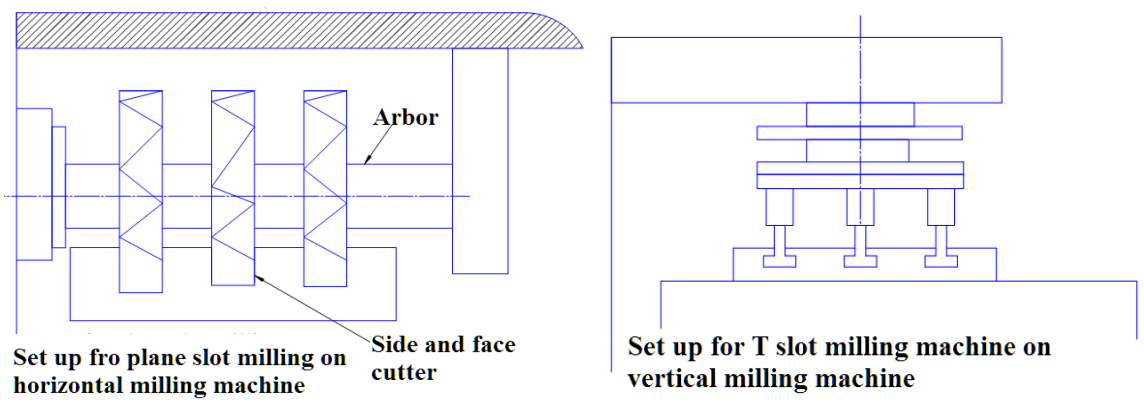


Fig. 11 Set up for T-slot

But in this, the special cutter cost will be more and it is not a standard one, also it is not standard practice of machining. [8]Only standard cutters will be used to machine all the three T-slots at a time with this adjustable multi spindle attachment. Only once the attachment will be mounted on the machine and clamped, simple to mount and clamp, will not consume more time. Cutters can be of quick change type takes less time for mounting and withdrawing from the spindles. They are of standard mores taper shank type.

Before mounting the attachment it is must to mount adapter as shown in fig.12 in the spindle and clamp by draw bolt. This is necessary for getting the drive from the main spindle to the accessory. The central spindle is getting direct drive from the adapter which has external splines engaging with the central spindle internal splines at one end. Simple spur gear is mounted on the central spindle, to drive other two extreme spindles. Intermediate idler gears are provided to have the rotation of the two extreme spindles in the same direction as the central spindle. All these three spindles are provided Morse Taper2 bores to have quick clamping of T-slot cutters, will have self-locking and drive. All the five spur gears are selected from standard gears readily available in the market, two gears used as idle gears are, the remaining three gears as transmission purpose. See fig.13 (gear train)

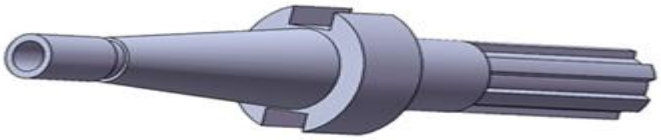


Fig. 12 Adapter

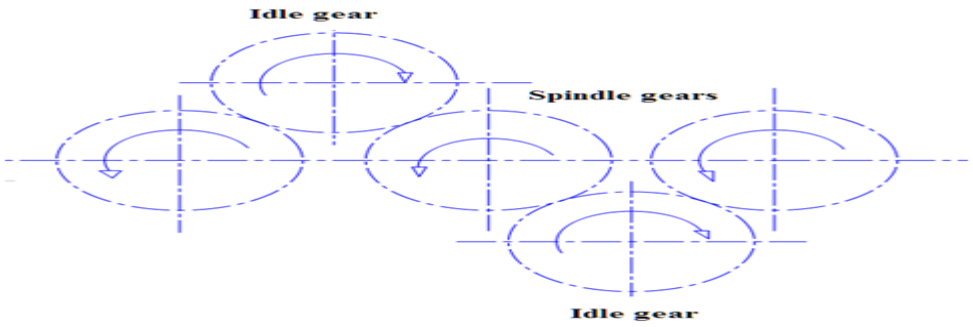


Fig. 13 Gear transmission

2.1. Mechanism of adjusting centre distance of T-slots

As shown in the fig.14 the pitch circle of 160MM is selected to have max. distance between the T-slots as 160MM if the central spindle will run without cutter. That means with this arrangement only two T-slots can be machined. If the distance between T- slots is 80MM, all the three T-slots will be machined and this will be the max. distance and min. will be up to 25MM centre distance. To change the distance a Worm shaft and Helical Gear drive is used. Ref. fig. 15 to index in degree which is graduated on the fixed body housing and a vernier line is marked on the rotating spindle of the attachment. The body is provided with four holes on particularly PCD to facilitate to have four numbers of circular T- bolts of suitable size, and the rotating spindle housing is provided with circular T-slot on the same PCD of hole on the fixed body. After indexing to the required angle to obtain the centre distance of T-slot to be machined, tighten all the nuts on the fixed body.

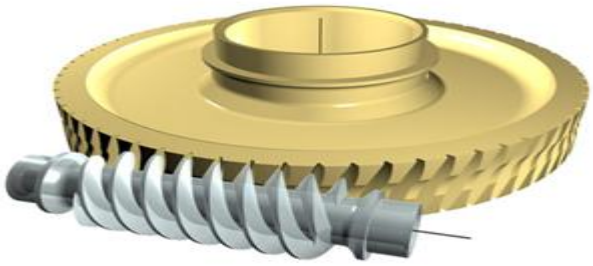


Fig. 15 Worm shaft & Helical gear

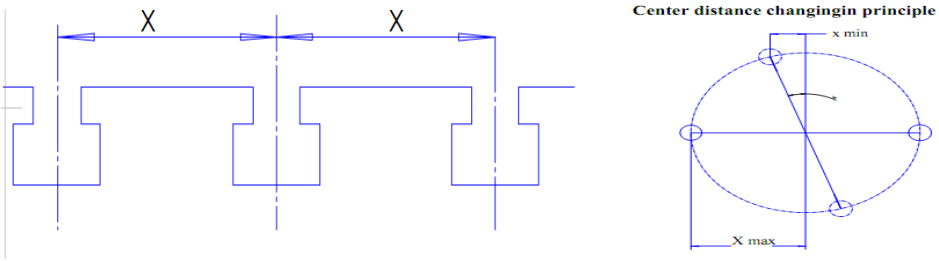


Fig. 14 Centre distance of T- slots

Indexing degree to obtain required centre distance between two T- slots will be $\Theta = \sin^{-1} x/80$

III. CONCLUSION

The productivity improvement tools highlighted in this report are all low-cost; indeed some incur no direct cost at all. They are about working smarter rather than harder. In particular the 5S principles are easy to apply and do not require major capital investment other than training, and they should quickly identify possible areas for further productivity-improvement drives.

A gradual implementation of selected tools and techniques should lead to reduction in production waste and improve the morale of employees involved as they see the immediate visual impact of their productivity improvement ideas.

An agency of the UK Government companies can get advice and information from their contact centre and from their network of local providers, which includes many of the Business Links. These organisations have Innovation and Technology Counsellors, Design Counsellors and other specialist staff, available to provide local advice.As we have seen all the process of T-slots milling, the first one in milling simply plane slot by end mill, and next T-slot milling using the T-slot cutter one by one it takes more and more time than milling all the three plain slots by using side and face cutters three slots at a time and then milling individually each T-slot at a time reduces the operation while compared to the earlier process. Next using planning machine planning single plane slot at a time for all the three T-slots and then using left hand T-slot cutter planning one slot at a time machining individually each T- slot at a time for all the three T-slots and then planning by repeating the same process for right side will take more time. This process of machining will not improve any amount of productivity and will not contribute to save time of machining for that operation. Hence the productivity is zero in this case.

The other case of milling all the three T-slots at a time after all the three plain slots are being machined using side and face milling cutters three at a time arranged on the arbor and then in similar way arrange all the three special T-slot cutters in place of side and face cutters milling three T-slots at a time may save time but there is the cost of cutter involvements and its maintenance cost, with all these it is not economic to go for this method, since this is not conventional way of machining. The productivity also improves by using carbide inserted side and face cutters instead of standard HSS cutters to some extent.

In order to reduce the time of machining for cutting all the T-slot it is suggested to go for multiple milling operations at a time, since it will save the time of operation and save the cost of operation thereby the productivity will be increasing considerably for the whole batch of mass production. The lean manufacturing process also suggest for this process and encourage such type of process to minimize the time and cost of operation. In fact this accessory has been designed manufactured and successfully utilised by one of the reputed machine building industry in India. It is proved that the rate of production is enhanced to more than 60% by using this accessory.

Finally to say by using accessory of adjustable multi spindle attachment the machining time will be reduced considerably. It has to be used exclusively to machine all the three slots in one pass. Milling plain slots is time consuming process and it is not economical process. Also it will not contribute to productivity. Hence for milling multiple T-slots at a time, first start with milling plain slots as gang milling operation, mounting all the three side and faces cutters on arbor and after that machine three T-slots using the accessory. This will give better results in machining operation and reduce machining time considerably. This accessory can be further improved with simplifying other mechanisms and can be designed for wide distance between T-slots for heavy duty machines.

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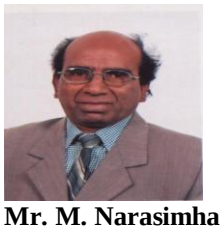

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