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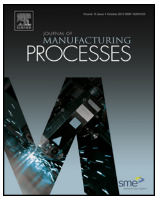

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Understanding flexible abrasive brush behavior for double disk magnetic abrasive finishing based on force signature☆

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ABSTRACT

The Double disk magnetic abrasive finishing process (DDMAF) poses better finishing characteristics while finishing paramagnetic thin work piece, when compared to plain magnetic abrasive finishing. This is due to the significant change in the behaviour of the flexible magnetic abrasive brush (FMAB) formed in two cases under similar conditions. Observing and comparing the behaviour of FMAB in action visually is a difficult task. However, FMAB average behaviour can be understood by observing the force signature. Thus present work aims at developing a setup that can be used to capture force signature for the two cases and then understand the FMAB behaviour. The present work present the FMAB force signature obtained while performing finishing with MAF with single disk and double disk. The force signature and the basic magnetic principle have been used to understand the FMAB behaviour and thus understand implications on the finishing process.

1. Introduction

Magnetic Abrasive Finishing (MAF) process is used for polishing of work piece. MAF uses a magnetic field producing source, which is usually an electro magnet [1] or permanent magnet [2], and a mixture of iron powder and abrasive powder. The magnetic source is used to produce a magnetic field in the working gap between the source and the work piece. In the working gap a mixture of iron and abrasive powder, also called magnetic abrasive particle(s) (MAP(s)), is placed. The powder mixture forms a chain like structure in the working gap [3]. Each chain is composed of large number of MAPs. These chains like structures are collectively called as Flexible Magnetic Abrasive Brush (FMAB). The FMAB works as a multi-point finishing tool [4].

In the process, two forces are generally responsible for material removal, the normal force and the tangential or circumferential force. The normal force acting through FMAB chain produces micro-nano indentations on the work piece surface [5]. A relative motion between FMAB and work piece need to be provided for machining to happen through plowing and shearing mechanism. The relative rotation between magnet and work piece provides the tangential machining force. The normal and tangential machining forces can be controlled by various process parameters like magnetic field intensity in the working gap, circumferential speed, percentage weight of abrasive mixture etc.

Attempts have been made by various researchers [6,7] to establish a relationship between various process parameters and machining forces. Singh et al. [6] in their work developed adequate regression model to relate process parameters, like current, working gap, rotational speed, lubricant and finishing time, with response variables, like normal force, tangential force and surface finish [6]. They also tried to find out the correlation between machining forces and surface finish. Mulik and Pandey [7] developed a mathematical model to predict normal and tangential force acting in case of ultrasonic assisted magnetic abrasive finishing (UAMAF) process. The model assumed a tetrahedron shape of abrasive. They also developed a statistical model which described normal and tangential forces as a function of process parameters like voltage to electromagnet, rotational speed, abrasive size, percentage weight of abrasive and pulse on time for ultrasonic vibration. In the analysis normal force and tangential force were mostly affected by voltage to electromagnet and working gap. Their analysis confirmed the fact that magnetic force density plays a very important role in deciding the magnitude of cutting forces.

In other words, the magnetic field density in the gap has been found to be one of the important factors that decides the stiffness of the chains formed, i.e., higher the Magnetic Flux Density (MFD)

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Nomenclature

DDMAF	Double disk magnetic abrasive finishing
FMAB	Flexible magnetic abrasive brush
MAF	Magnetic abrasive finishing
MAP	Magnetic abrasive particle

higher the stiffness of the chains. Other process parameters that also affect the stiffness of the FMAB are ferromagnetic powder particles size and ratio of ferromagnetic to abrasive powder. By varying the stiffness of the FMAB the different values of surface finish and material removal rate can be achieved [8].

Working in the area of MAF, Girma et al. [9] presented a difference in mechanism for material removal between cylindrical and planar MAF [9]. Cylindrical MAF is widely applied for ferromagnetic and para/diamagnetic cylindrical work pieces while planar MAF is widely used for planar ferromagnetic work piece. Planar MAF is considered ineffective for hard para/diamagnetic work piece. This owes to low MFD generated in the working gap [10]. In a work done by Kwak et al. [11] tried to improve machinability of a para/diamagnetic work piece by using a permanent mag10net beneath the work piece. They observed an appreciable improvement in surface finish. In addition, attempts have been made to modify the conventional MAF to suit different requirements and increase its potential [12–15,16]. In a similar direction Kala et al. [17] has developed a new setup for polishing planar para/diamagnetic work piece. For a better understanding capability of the double disk magnetic abrasive finishing process DDMAF process a setup was fabricated which was used to capture finishing forces in case of MAF or DDMAF process. The machining forces so obtained have been used to understand the behavior of FMAB in case of conventional MAF and DDMAF for a flat copper work piece. Further the effects of varying rotational speed and working gap on machining forces, in case of DDMAF, have been studied.

2. Experimental setup and procedure

The experimental setup used for measuring finishing forces for the case of magnetic abrasive finishing and double disk magnetic abrasive finishing is shown in Fig. 1(a) and (b). The setup consisted of two rotating magnetic disks, between which the workpiece was placed. The experiments for the magnetic abrasive finishing were performed by removing the bottom disk while for double disk magnetic abrasive finishing both of the disks were used. The finishing forces have been measured using the dynamometer (Make: Schunk: DELTA sensor with SI-330-30 Calibration, accuracy:0.1 N).

The gap between the two disks was too small for dynamometer to be placed, hence a special fixture (shown in Fig. 1c) was fabricated which could transfer the finishing forces, acting on the workpiece surface to the dynamometer. The upper plate of the fix-

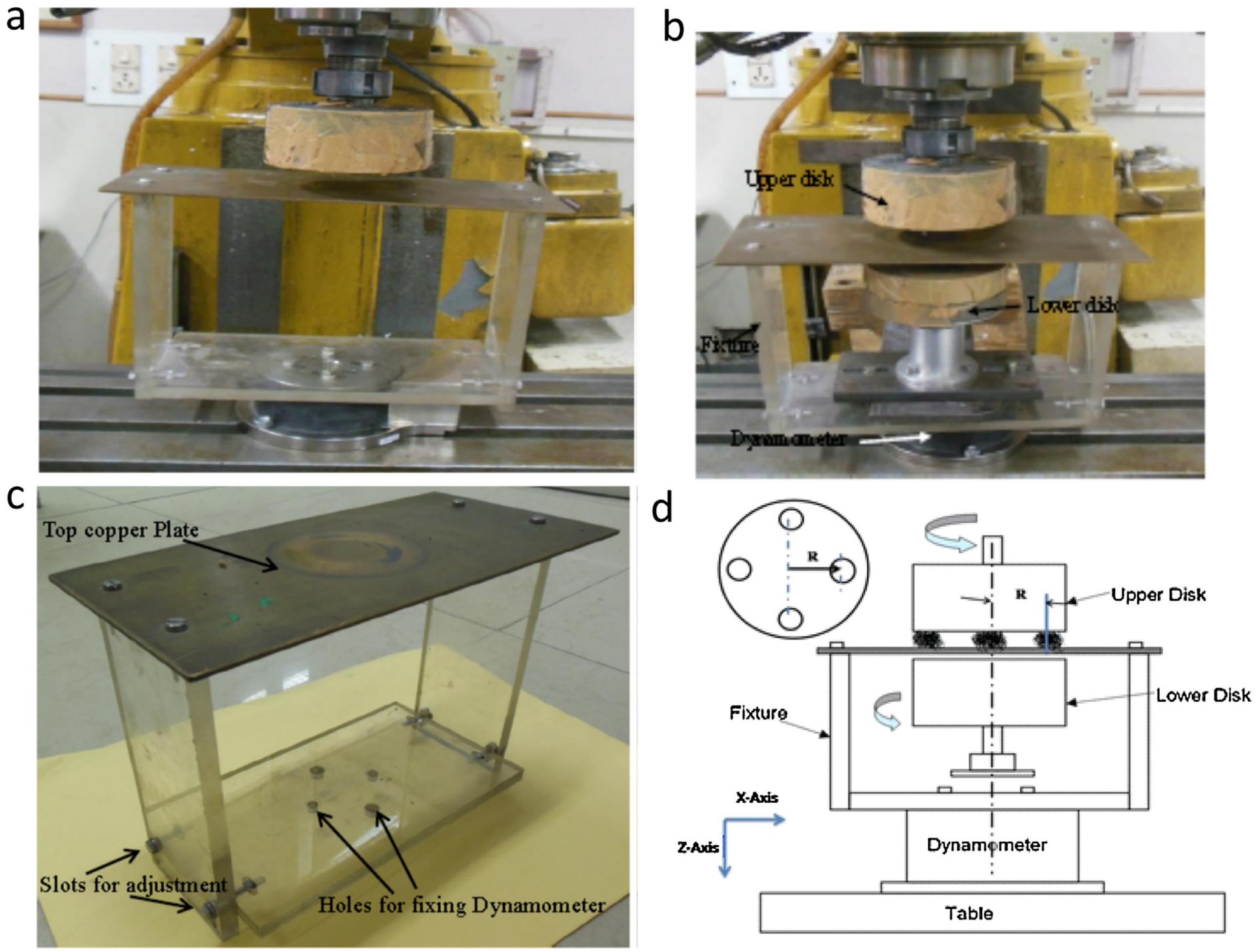

Fig. 1. Setup used for measuring forces for magnetic abrasive finishing and double disk magnetic abrasive finishing (a) Setup for measuring force in magnetic abrasive finishing; (b) Setup for measuring forces in double disk magnetic abrasive finishing; (c) Fixture for accomadating dynamometer, (d) Schematic view showing arrangement of dynamometer and fixture in double disk arrangement.

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