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# A Bibliometric Analysis of Ultrasonic Vibration Assisted Turning

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**Abstract.** Ultrasonic vibration-assisted turning (UVAT) is a new crossover in machining techniques which uses high frequency, low amplitude sound waves which are further superimposed on the cutting tool in traditional turning. This innovative technology is being utilized over the decades due to its conspicuous influence contrasted with traditional approach particularly in turning of hard-to-machine materials. This present paper analyses the past explores in the arena of ultrasonic vibration-assisted turning, by a far-reaching bibliometric investigation. The analysis is carried out by scrutinizing the studies through Science Direct and Scopus database to select the peer-reviewed papers. The advanced research tools like the word cloud and global heat map have additionally been utilized for introducing the investigation deliberately. The quantum of exploration is restricted yet a growing trend is seen since from the year 2018. From the information base of Science Direct and Scopus, it is perceived that the publications on ultrasonic vibration-assisted turning are 90 and 221 respectively. The study uncovered that the maximum publications of ultrasonic vibration turning are in journal articles from the subject area of an engineering stream. The Chinese lead the number of publications followed by Iran and the United Kingdom. The paper summarises that this research field is recent and more exploration is required in the domain of hard turning using ultrasonic vibration assisted turning.

**Keywords:** Ultrasonic, Turning, Vibration Machining.

## 1 Introduction

Recent past has been the new era of modern machining industries as there are colossal upgrades in terms of PC coordinated assembling measures, robot-controlled machining technology, vision sensors etc. [1]. The key explanation for the upgradation of the machining systems is the dependency on the dimensional precision and the accuracy of the finished product. Because of these rigid prerequisites, the utilization of traditional machining measure especially for hard-to-machine materials is a significant challenge for machining industries. Hard turning is where the machining operations are carried on the workpiece whose hardness is more than 45 HRC with convincing manageability and with higher material removal rates [2, 3]. Still this operation involves higher cutting forces, rapid tool wear and higher residual stresses resulting into improper machining with high rate of power consumption. Use of coolants to reduce the machining temperature accommodated the process a bit but handling and disposal is the still major hindrance. Along these lines, dry machining operations are monetarily effective and environment-friendly as it obliges the contracting of carbon footprints [4, 5].

Hence taking this into account, ultrasonic vibration-assisted turning (UVAT) is hybrid and eco-friendly machining technique which have drawn the consideration of the analysts because of its significant benefits in the machining process. This technique uses high frequency and low

amplitude sound waves which are superimposed on the cutting tool in traditional turning for the removal of chips.

Ultrasonic is the branch of acoustics with an assortment of utilizations in the field of non-destructive testing, ultrasonic cleaning, ultrasonic welding [9], ultrasonic drilling [9] and ultrasonic milling [11] in medical technology etc. Ultrasonic vibration assisted turning (UVAT) comprises of the ultrasonic generator and ultrasonic vibratory tool (UVT). The generator converts the power supply voltage in a voltage with high frequency which relates to the resonant frequency of the system. Later on, the transducer changes over the electrical energy into translational vibrations with the use of piezoelectric parts [10, 11]. The function of booster is to enhance the signals coming and horn or sonotrode goes about as a tool holder. The experimental setup of ultrasonic vibration assisted turning (UVAT) is shown in Fig. 1. [10, 12].

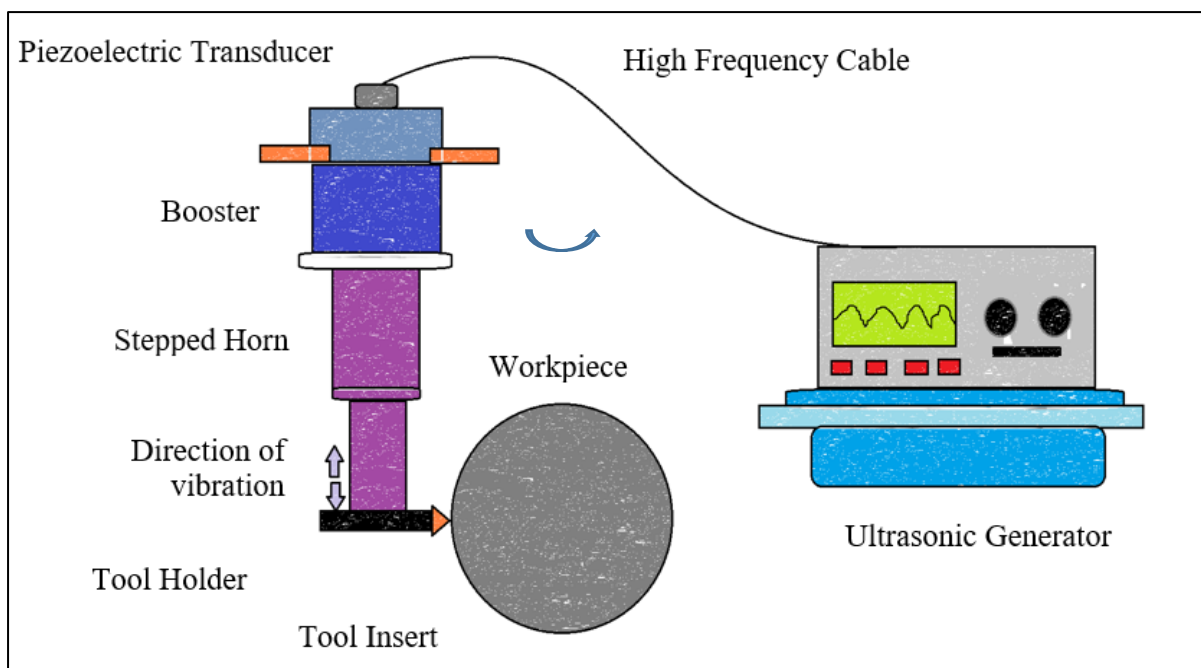


Fig. 1. Experimental Setup of UVAT

Ultrasonic vibration assisted turning (UVAT) is generally grouped in three unique sorts relying on the direction of vibrations i.e. tangential (longitudinal), axial (feed) and radial (transverse) direction. At the point when the ultrasonic vibrations are applied in tangential (longitudinal) direction then the mathematical relationship between the cutting velocity ( $V_C$ ) and the tip velocity ( $V_T$ ) is given by the following equation 1.

For Tangential direction:

$$V_C = \frac{\pi ND}{60} < V_T = 2\pi af \quad (1)$$

Where,

$N$  = rotational speed of workpiece,  $D$  = diameter of workpiece,  $f$  = frequency of vibration,  $a$  = amplitude of vibration.

The resonant length (L) of the horn is divided in two parts with radius of curvature at the interface so as to reduce the stress concentration. First is input diameter (D<sub>1</sub>) of the horn is equal to the diameter of the transducer and the second is output diameter (D<sub>2</sub>). Total resonant length of the stepped horn can be calculated by using an equation 2, 3.

$$L = k_1 \frac{c}{4f} + k_2 \frac{c}{4f} \quad (2)$$

Where,

L = total horn length, k<sub>1</sub>, k<sub>2</sub> = correction factors, and c = speed of the wave.

The simplified form of the equation can be obtained by assuming the correction factors as unity.

$$L = \frac{c}{2f} \quad (3)$$

Here c = speed of the wave can be calculated with the help of equation 4.

$$c = \sqrt{\frac{E}{\delta}} \quad (4)$$

Where,

E = Young's modulus of the material (N/m<sup>2</sup>)

δ = Density of the material (Kg/m<sup>3</sup>).

Ultrasonic vibration-assisted turning (UVAT) is likewise termed as an 'intermittent technique' as in this process the cutting tool and workpiece are periodically isolated and contacted and as a result of which there is no formation of build-up edge.

This process is generally divided into four phases as approach, contact, immersion and back off of the cutting tool insert. As a result of which tool-workpiece contact ratio (TWCR) i.e. summation of tool-workpiece engagement and detachment period in one cycle is less contrasted with traditional turning process. Hence, the significant outcomes of this technique results in lesser cutting forces, less tool wear and low residual stresses, improved surface finish and less power consumption etc. The word cloud image related to ultrasonic vibration-assisted turning (UVAT) is shown in Fig. 2.

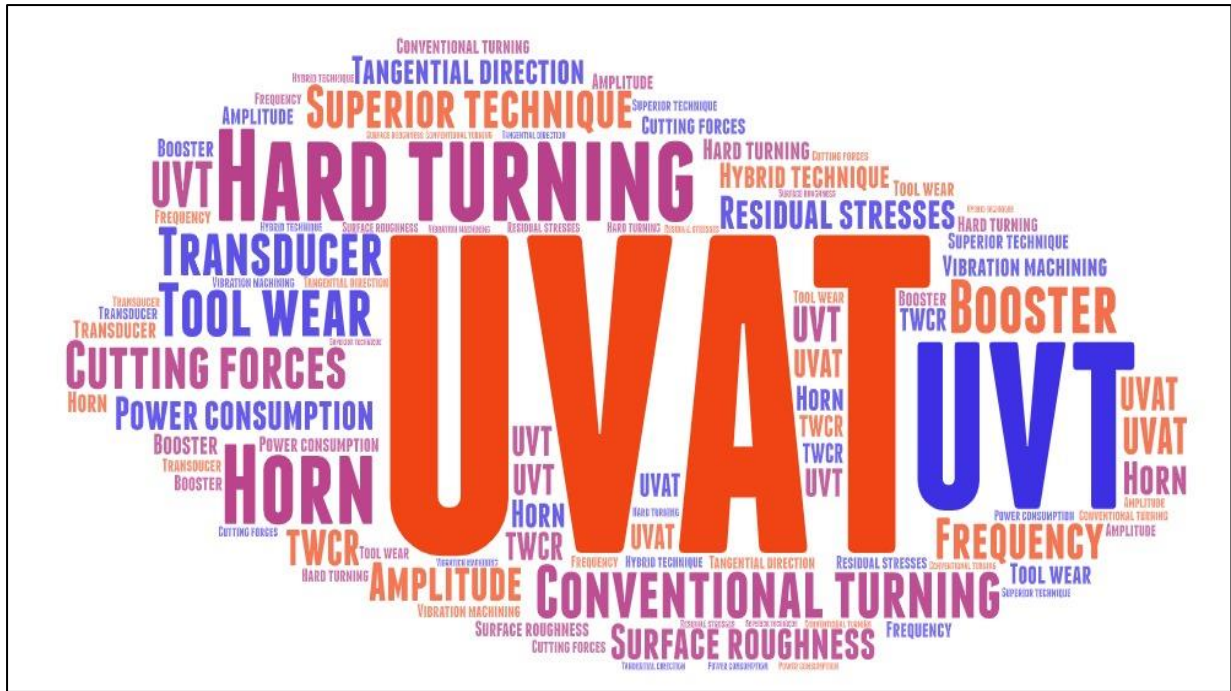


Fig. 2. Word Cloud related to UVAT

## 2 Systematic Data Collection

The definitive point of this paper includes investigation of important explores, researching the contributions of the various studies and to come up with peer conclusions.

### 2.1 Locating Database

The eminent data of publications are Science Direct, Scopus, Web of Science, Google Scholar, ResearchGate, SciELO and a lot more with open and paid access. This paper recognizes the information from Science Direct, Scopus database for the current investigation. Science Direct and Scopus were picked in light of the fact that both have perceived record with a wide of companion peer-reviewed publications and gives dependable bibliographic information. The main keywords which were used are ultrasonic, turning, vibration machining respectively in the database from 1973 to 2021. These keywords have provided 90 number of publications from Science Direct database and 221 number of publications from Scopus database. This current research article is mainly focussing on the ongoing research from the field of engineering stream.

## 3 Analysis and Summary of Data

From the obtainable literature in Science Direct and Scopus database; the analysis is being done with the fundamental channels as type of access, year of publications, type of document, type of subject area, research publishing countries, name of the journals and name of authors etc. All the data are extracted until January 2021 and recorded for the subsequent analysis.

### 3.1 Analysis by type of access

Out of the absolute publications in Science Direct, 56 publications are open access type and can be effortlessly accessed and 69 are other. Along these lines for Scopus database, 35 publications are open access type and can be effectively accessed and 186 are other.

The analysis of the same is listed in the following Table 1.

Table 1. Analysis by Type of Access (Data access till January 2021)

Sr. No.	Type of Access	Number of publications in Science Direct	Number of publications in Scopus
1.	Open Access	21	35
2.	Other	69	186
<b>Total</b>		<b>90</b>	<b>221</b>

### 3.2 Analysis by year of publications

Concerning the accessibility of the information in Science direct and Scopus database, it is obviously seen that an uptrend of the research in the arena of ultrasonic vibration-assisted turning (UVAT) is recently been observed from 2018 onwards. The detailed year wise analysis is shown in Fig. 3.

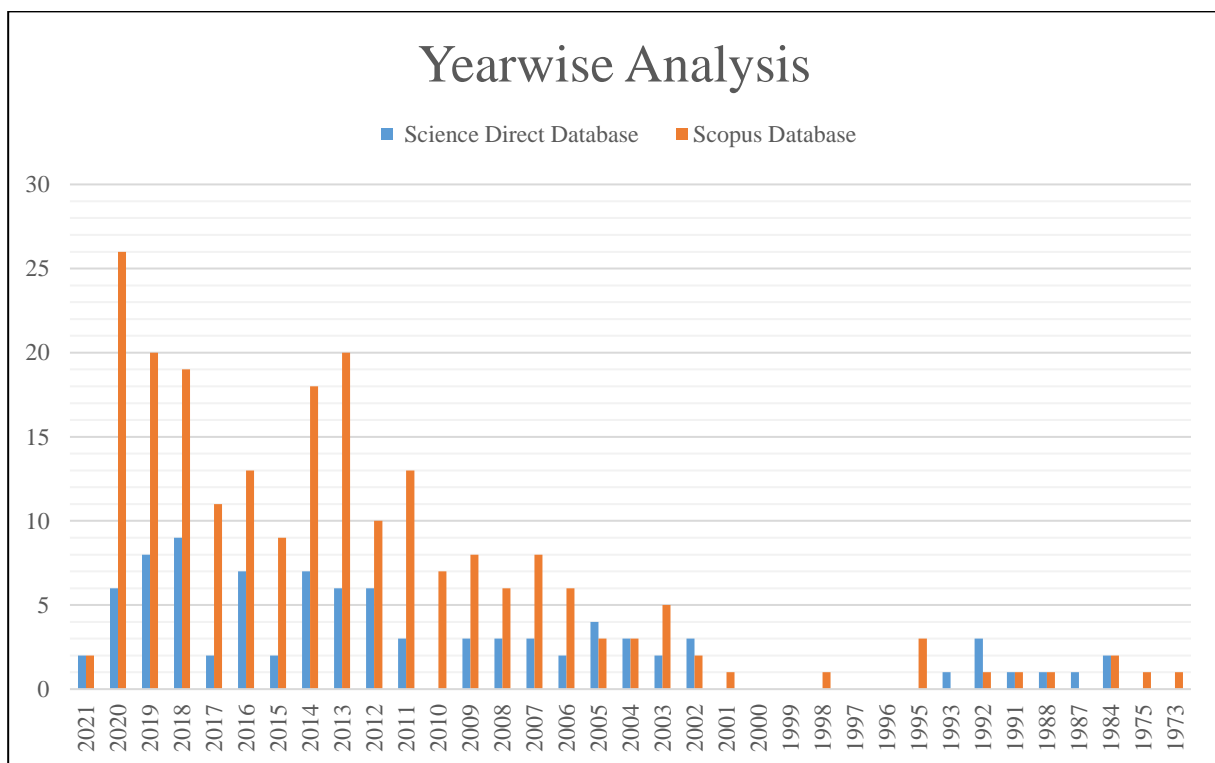


Fig. 3. Analysis by the year of publication (Data access till January 2021)

### 3.3 Analysis by type of document

Analysis by type of document is a method which comes under the umbrella of qualitative research that utilizes a methodical methodology to dissect narrative proof and answers. The detailed analysis by type of document as per the database of Science Direct and Scopus is shown in the Fig. 4 (a) and Fig. 4 (b) respectively.

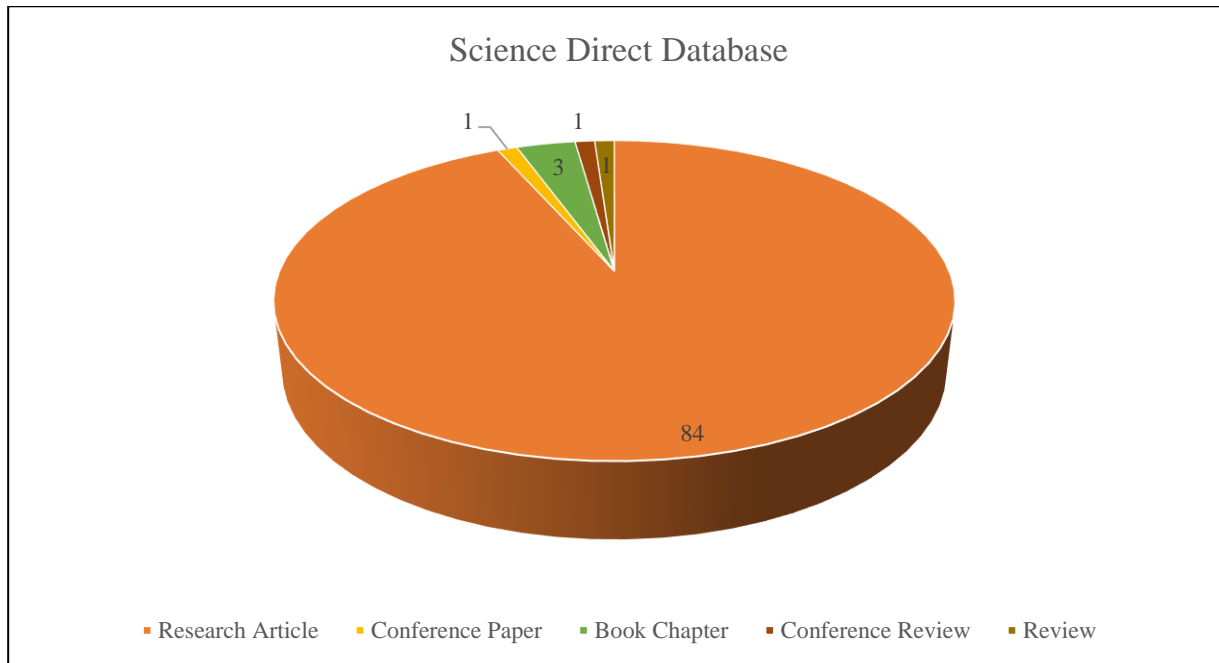


Fig. 4 (a) Analysis by type of document (Science Direct: Data access till January 2021)

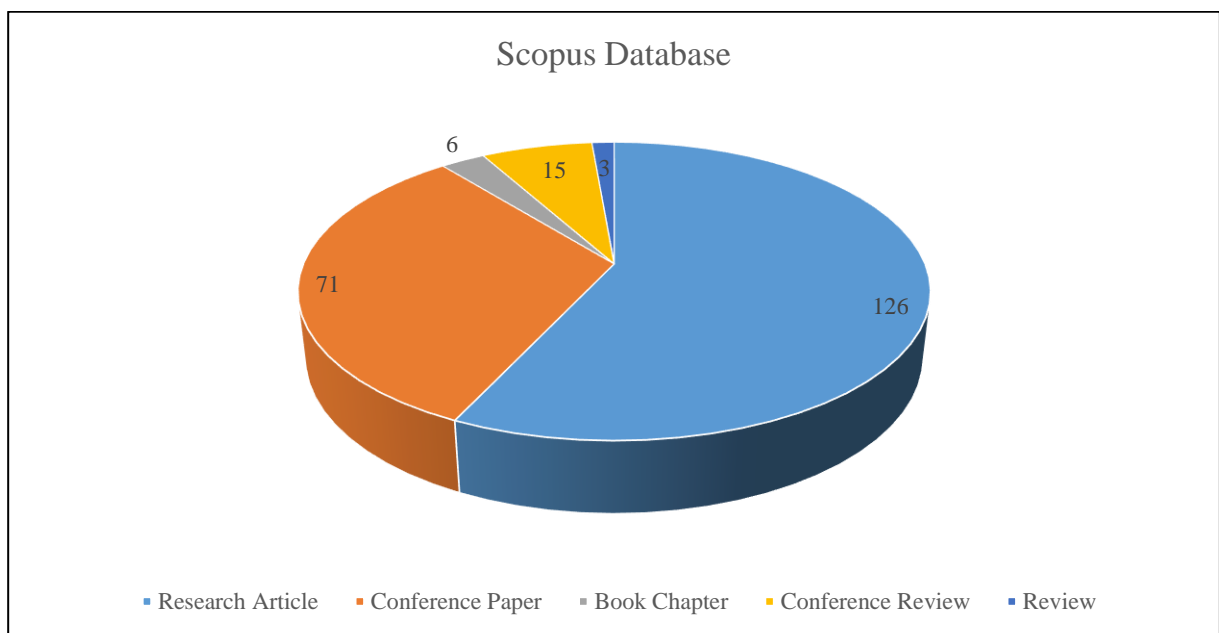


Fig. 4 (b) Analysis by type of document (Scopus: Data access till January 2021)

From the above analysis it very well may be presumed that the maximum number of publications are essentially in the research articles i.e. 84 from the database of Science Direct and 126 from Scopus respectively.

### 3.4 Analysis by subject area

Analysis under the category of subject area is a vast topic which includes diversified fields like agriculture, business, engineering, chemistry, mathematics, computer, environmental, material and decision sciences along with physics and astronomy etc. The present paper focusses on the progressing research in the field of engineering only. The detailed analysis by subject area as per the database of Science Direct and Scopus is shown in the Fig. 5 (a) and Fig. 5 (b) respectively.

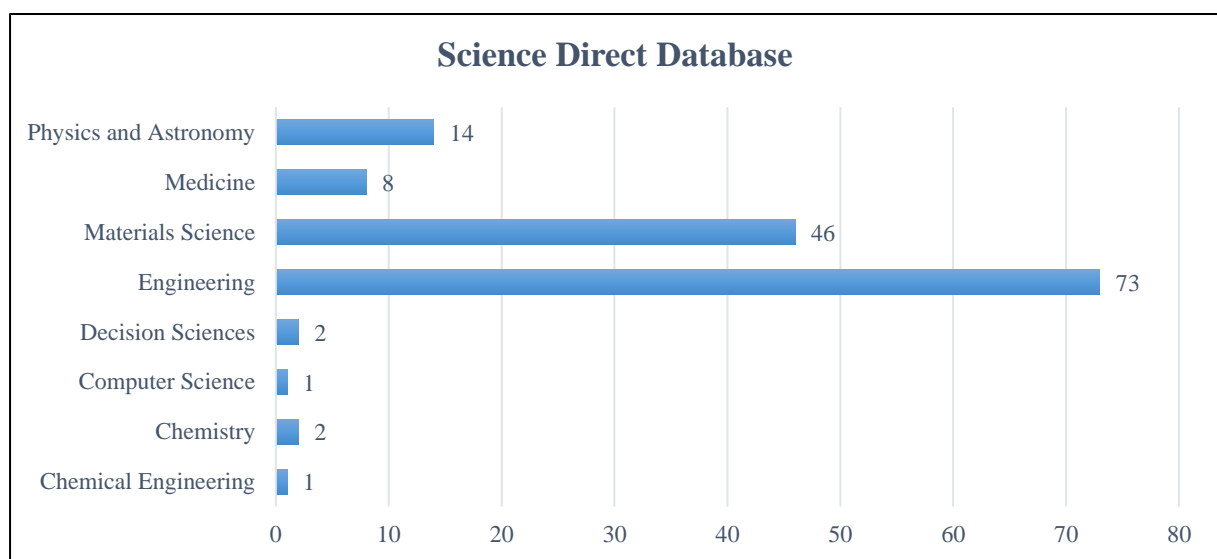


Fig. 5 (a) Analysis by subject area (Science Direct: Data access till January 2021)

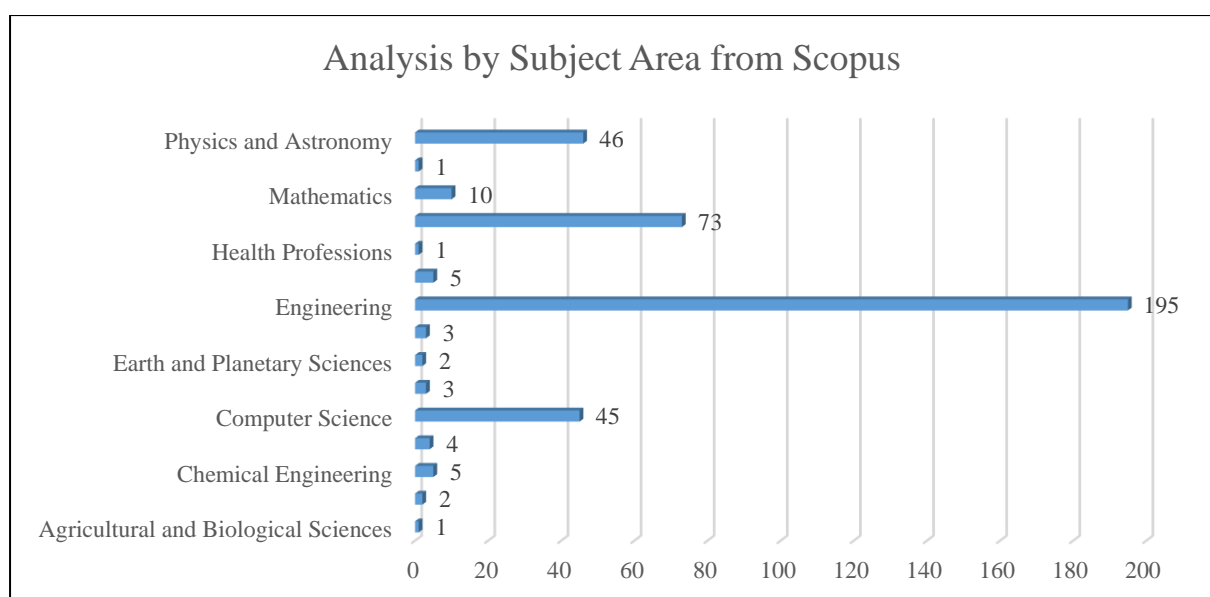


Fig. 5 (b) Analysis by subject area (Scopus: Data access till January 2021)



From the above investigation it can be concluded that the larger number of publications on UVAT are in the field of engineering followed by material science. From the accessible database of Science Direct 73 publications are in the field of engineering and 46 from material science. In line to this 195 publications are in the field of engineering and 73 from material science from the Scopus database.

### 3.5 Analysis by Country

Numerous nations are putting a ton in development to modernize their existing manufacturing setups. This section of analysis examines the main nations in advancement research somewhere from the academic and industrial developments viewpoint. The detailed analysis by country as per the database of Science Direct and Scopus is shown in the Fig. 6 (a) and Fig. 6 (b) respectively.

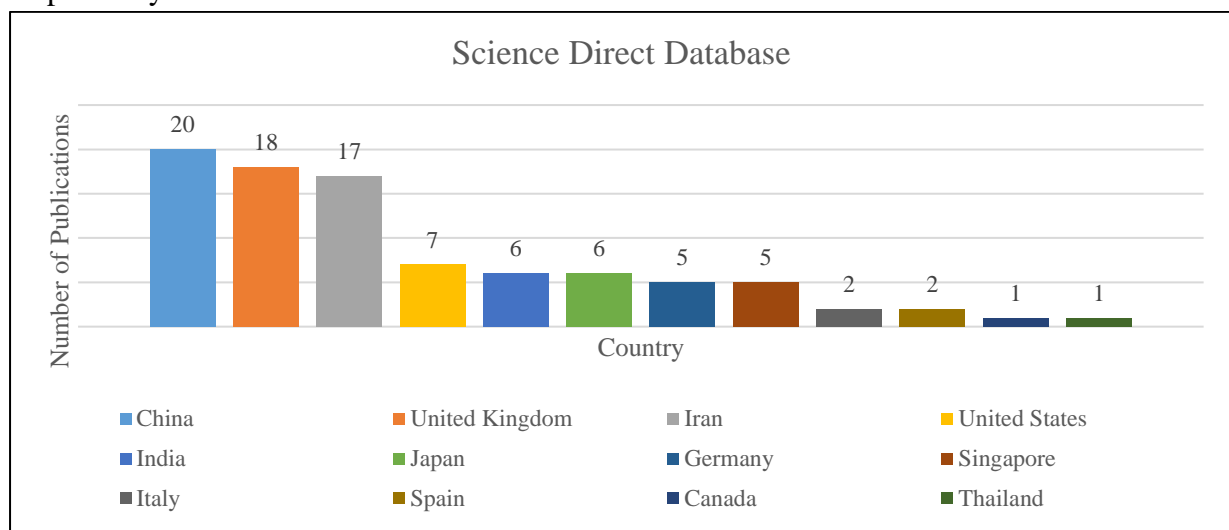


Fig. 6 (a) Analysis by Country (Science Direct: Data access till January 2021)

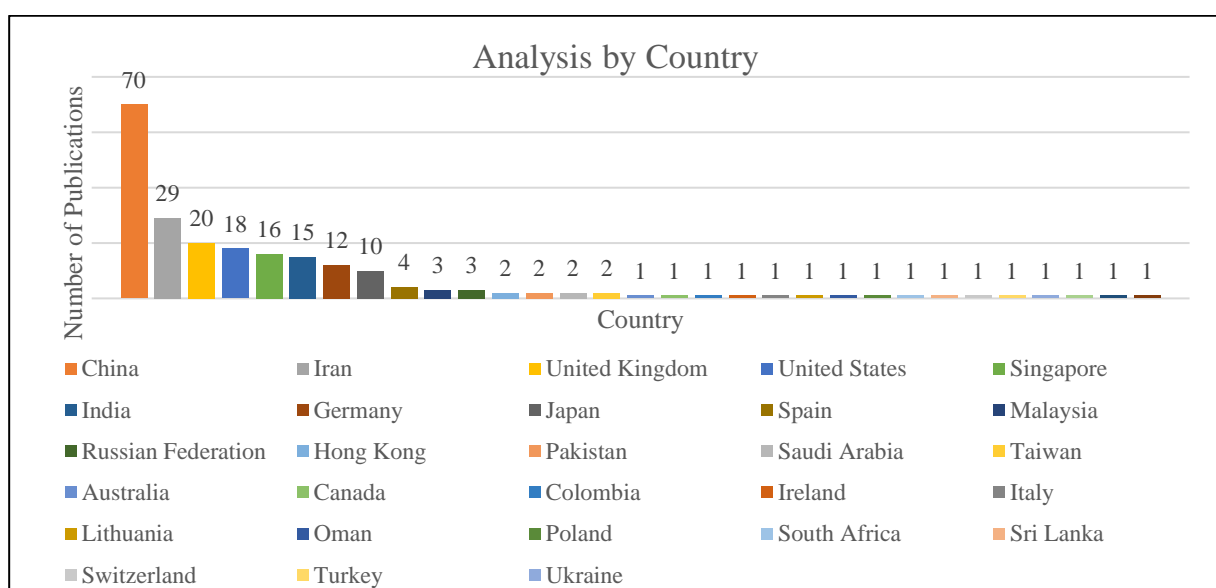


Fig. 6 (b) Analysis by Country (Scopus: Data access till January 2021)

From the above analysis it can be observed that the maximum number of publications on UVAT are from China followed by Iran and United Kingdom. About Indian research in the arena of UVAT, total 15 number of publications are found in the database of Scopus and 6 from Science direct. The global heat map relevant to the ongoing research in the field of UVAT is as per the availability of the data from Science Direct and Scopus is shown in Fig. 7 (a) and Fig. 7 (b) respectively.

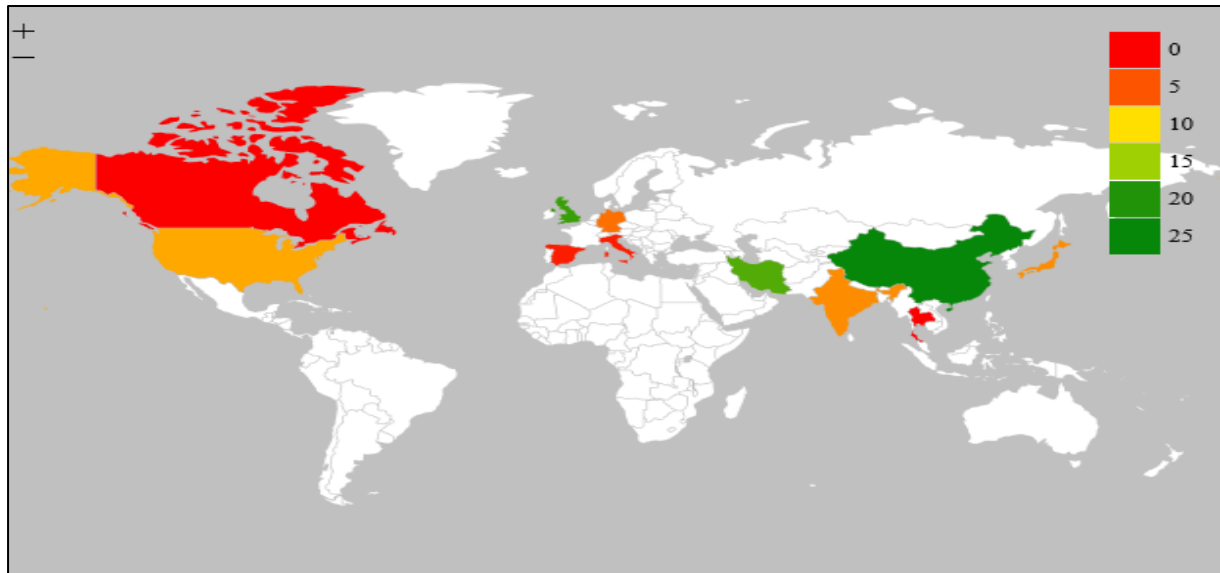


Fig. 7 (a) Global heat map (Science Direct: Data access till January 2021)

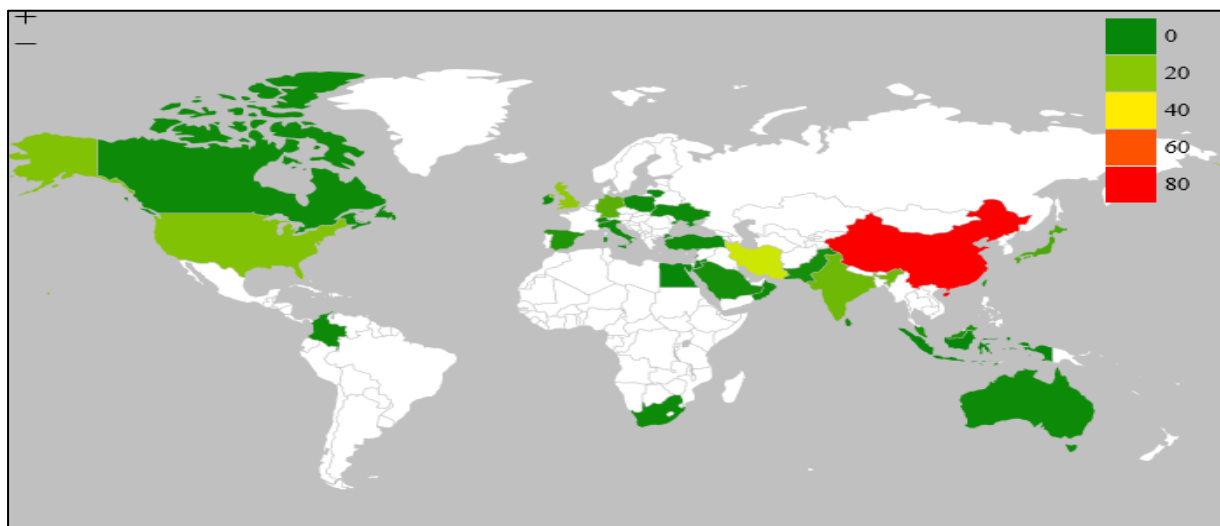


Fig. 7 (b) Global heat map (Scopus: Data access till January 2021)

### 3.6 Analysis by source title

Analysis under the field of source title is one of the principle territory which incorporates the names of the journal publications. For the current analysis, top 10 journals are chosen based on the maximum number of publications in the field of UVAT. The detailed analysis by source

title as per the database of Science Direct and Scopus is shown in the Fig. 8 (a) and Fig. 8 (b) respectively.

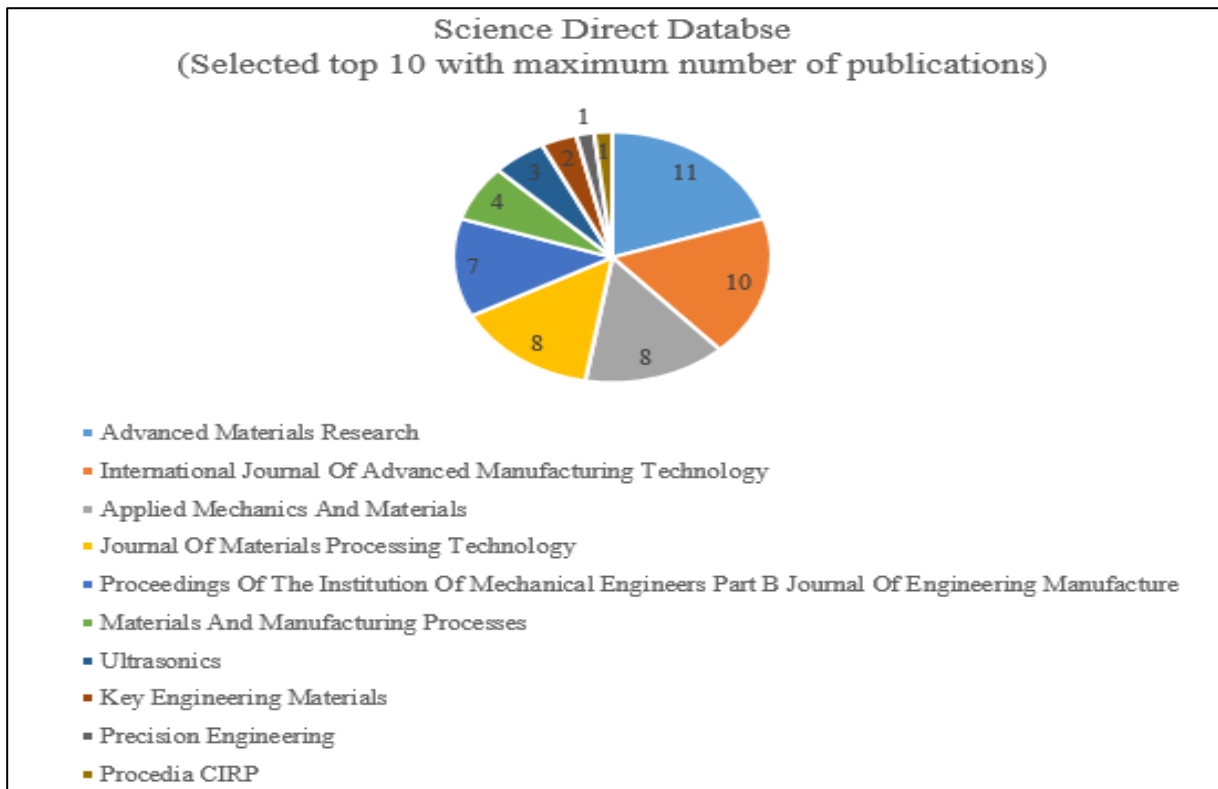


Fig. 8 (a) Analysis by Source title (Science direct: Data access till January 2021)

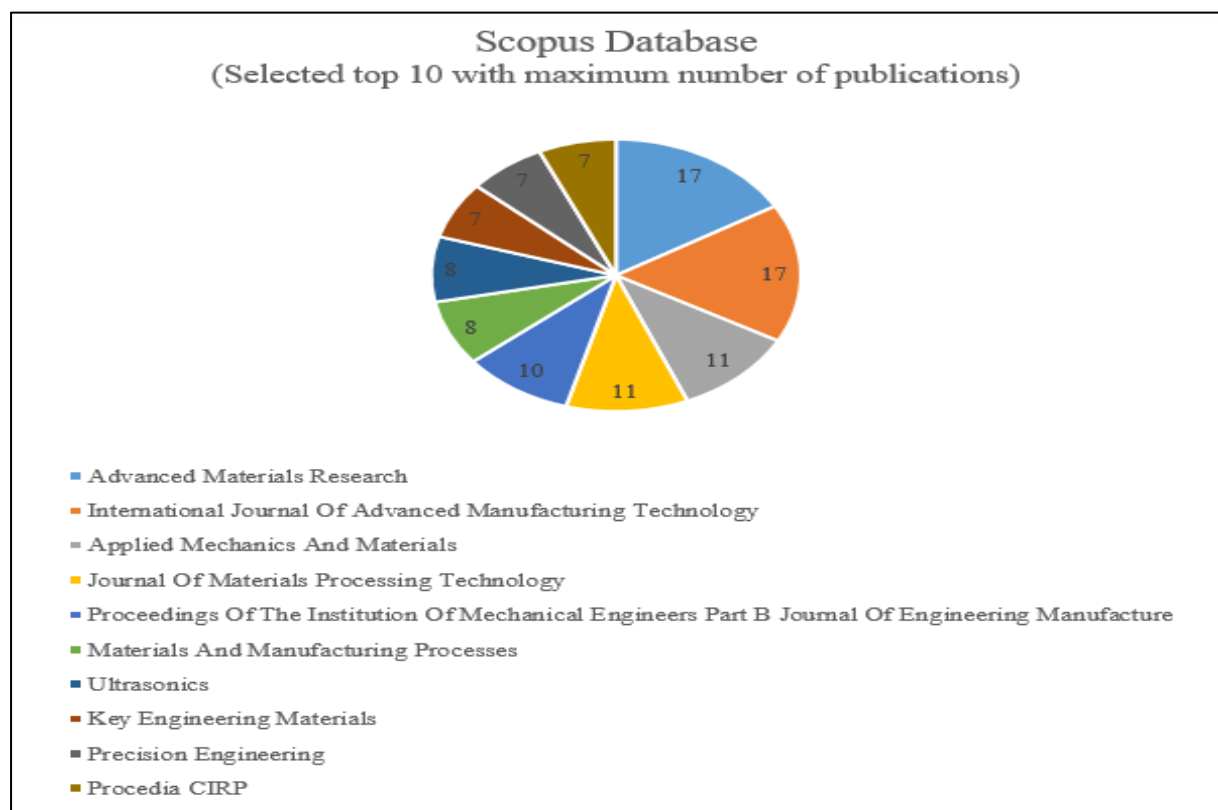


Fig. 8 (b) Analysis by Source title (Scopus: Data access till January 2021)

From the above analysis it can be seen that the maximum number of publications are in the journals namely Advance Materials Research and in International Journal of Advanced Manufacturing Technology.

### 3.7 Analysis by Author

For the current investigation, top 10 authors are selected with maximum number of articles published with the considerable contribution in the relevant field of UVAT. It is found that the profiled author of the relevant research are Muhammad, R. and Silberschmidt, V.V. with 5 and 16 articles published from Science Direct and Scopus database respectively.

The detailed analysis by author name as per the database of Science Direct and Scopus is shown in the Fig. 9 (a) and Fig. 9 (b) respectively.

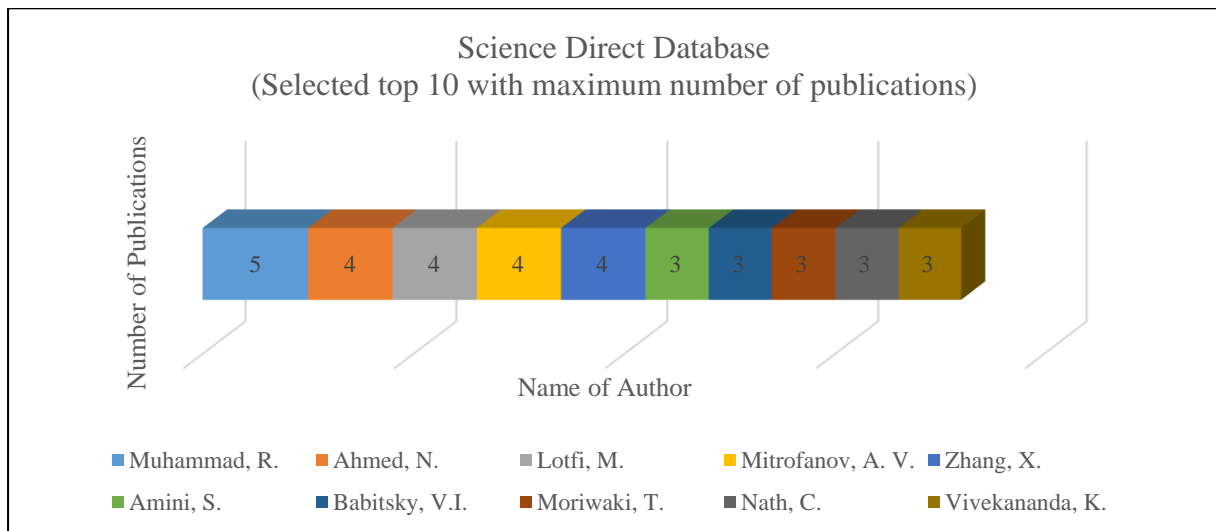


Fig. 9 (a) Analysis by Author (Science Direct: Data access till January 2021)

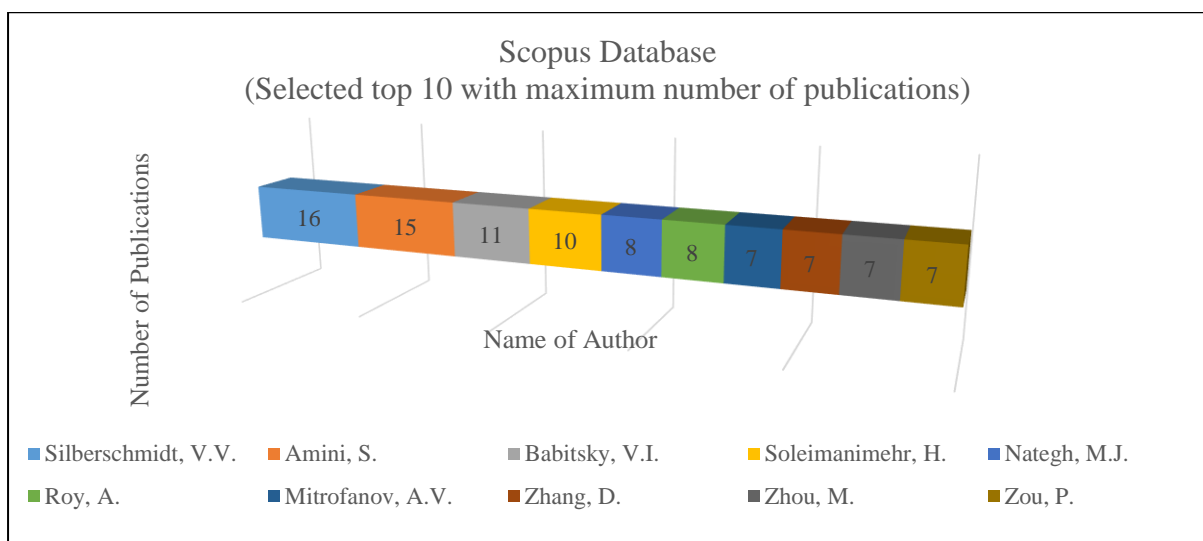


Fig. 9 (b) Analysis by Author (Scopus: Data access till January 2021)

The summary of this research article is to feature the significant advantages of UVAT technique when contrasted with traditional turning process and to mention the importance of UVAT as a trending technique as it is brought again in focus by various authors and countries.

The author wise analysis is systematically presented in the tabular form in Table No. 2.

Table 2. Analysis by Author (Data access till January 2021)

Sr. No.	Name of Author	Reference Number
1.	Muhammad, R.	[18], [19], [20], [21], [22]
2.	Ahmed, N.	[16], [17], [23]
3.	Mitrofanov, A. V.	[26]
4.	Zhang, X.	[27]
5.	Amini, S.	[25]
6.	Nath, C.	[28]
7.	Zhou, P.	[29]

#### 4 Conclusion

From the exhaustive survey of the literature referred from the eminent database namely Science Direct and Scopus it can be concluded that this paper have systematically presented the analysis considering the broader view of UVAT in various aspects specifying the benefits and the uptrend in its utilization in machining operations. One of the major aspect which is observed in this paper is that UVAT is applicable for hard-to-machine materials as well with better outcomes. The exhaustive study of literature interpreted the benefits of ultrasonic vibration assisted turning (UVAT) when compared with traditional turning in terms of improved surface finish quality, lesser tool wear and less power consumed than in CT.

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