Data Article

Dataset on flank wear, cutting force and cutting temperature assessment of austenitic stainless steel AISI316 under dry, wet and cryogenic during face milling operation

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Abstract

The contemporaneous examination focuses on the impact of spindle speed as well as an eco-pleasing cooling strategy in the midst of processing of AISI316. Investigations were executed at three different machining approaches viz. dry, wet and cryogenic (LN2) using cemented carbide inserts. Water dissolvable oil was used as a cutting fluid for flood cooling approach. The workpiece was processed under three distinctive cutting speeds i.e. 1000, 2000 and 3000 rpm however feed rate and depth of cut were kept consistent at 450 mm/min and 1 mm separately. An exhaustive investigation on the cooling impacts of LN2 technique on a segment of the significant machinability perspective, for instance, cutting force (Fx), insert wear, surface quality and processing temperature is delineated. The beforehand specified processing responses were documented and contrasted all together to demonstrate the reasonableness and achievability of LN2 approach in examination with dry and wet machining methodology. The outcomes accomplished in the midst of the examination obviously settled the commonness of realizing LN2 for achieving upgraded machinability inside a predetermined scope of process parameters.

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1. Data

Data presented in the article is pertaining to AISI 316 stainless steel behavior under different machining environments. The experiments were performed to evaluate the behavior and effects of fluids on AISI 316 in face milling process. Table 1 indicates the experimental conditions utilized to carry out the machining environments with various process parameters such spindle speed of 1000–3000 rpm, feed rate of 450 mm/min and depth of cut of 1mm. The Output Variables such as Cutting temperature, flank wear, chip morphology is experimentally investigated (Raw) and Cutting force experimentally investigated (Calculated-using indirect method -ethernet cable -FANUC-servo...
guide software). Later the data has been compared inorder to investigate the effect of responses under different considered environments.

2. Experimental design, materials and methods

2.1. Test equipment

Table 1 represents the investigational conditions utilized in the present work. CNC Spark DTC-12 was used to complete processing investigates AISI 316 stainless steel. LN$_2$ cryogenic experimental arrangement is described in Fig. 1. Trial experiments were completed for 1000, 2000 and 3000 rpm. Constant feed rate and depth of cut of 450 mm/min, 1 mm respectively. The limit furthest reaches of parameters relied upon the preparatory investigations directed.

![Variation of Cutting Temperature at speed of (a) 1000 rpm (b) 2000 rpm (c) 3000 rpm.](image)

**Table 1**

| Workpiece Material & Size | AISI 316 (110 mm × 38 mm × 25mm) |
|---------------------------|----------------------------------|
| Face Milling Process Parameters | Spindle Speed: 1000, 2000, 3000 rpm |
|                           | Feed Rate: 450 mm/min,          |
|                           | Depth of Cut: 1mm               |
| Environments              | Dry,                             |
|                           | Wet,                             |
|                           | Cryogenic (LN$_2$).             |
2.2. Method: cryogenic cooling method

An insignificant cost setup of cryogenic cooling was used to infringe the LN\textsubscript{2} at the tool workpiece interface. The setup incorporates TA55 cryocan, it is used to stock up the LN\textsubscript{2} by means of the air compressor. Flow of pressurized LN\textsubscript{2} is given through the specially designed nozzle to the tool-workpiece interface with the pressure of 3 bars and rate of flow of LN\textsubscript{2} is 0.33 l/min.

2.3. Measurement of performance characteristics

The surface roughness of each LN\textsubscript{2} machined surface was measured utilizing the Mitutoyo surface roughness analyzer [1,2]. Three readings at various areas were measured on each machined surface and the normal of it was considered as the definitive estimation of surface roughness estimation [3,4,6]. Infrared thermometer was used to evaluate the cutting temperatures at the instrument workpiece interface.

2.3.1. Cutting temperature (CT) variation in different environments

Cooling strategies are employed by an objective to diminish the CT [7]. These are likewise help-full in keeping the cutting tools from extreme impairment like adhesion, diffusion and abrasion which are emphatically co-identified with machining temperature. In addition, at machining AISI316 at raised temperature prompts to swift device wear. The disparity attained in CT amid examination is appeared in Fig. 1. It’s clear through Fig. 1 that, as the spindle rotational speed increases, the processing heat increases linearly at machining sector because of enhanced friction at device work interface. In case of LN\textsubscript{2}, the machining temperature was relatively cut down for considered scope of spindle speeds in contrast to dry and flood strategies. Remarkable diminishments in processing heat were seen under

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2.png}
\caption{Variation of Cutting Force at speed of (a) 1000 rpm (b) 2000 rpm (c) 3000 rpm.}
\end{figure}
### Table 2
Optical Microscopic Images Depicting progression of Flank Wear.

| Input Variables | Machining Type | Time in seconds |
|-----------------|----------------|-----------------|
|                 |                | 30  | 60  | 90  |
| Spindle speed   | Dry            | 1000rpm |       |     |
| Feed rate       | Wet            | 450 mm/ min |     |     |
| Depth of cut    | LN₂            | 1mm  |     |     |
| Spindle speed   | Dry            | 2000rpm |       |     |
| Feed rate       | Wet            | 450 mm/ min |     |     |
| Depth of cut    | LN₂            | 1mm  |     |     |
| Spindle speed   | Dry            | 3000rpm |       |     |
| Feed rate       | Wet            | 450 mm/ min |     |     |
| Depth of cut    | LN₂            | 1mm  |     |     |

(continued on next page)
LN₂ circumstance than that of other strategies (dry, flood). This is on the grounds that, the heat exchange happens amid LN₂ processing approach over convection and dissipation. Utilization of LN₂ superbly encourages the liquid beads to reach at device workpiece interface which offer a proficient warmth exchange in this manner gives enhanced lubrication prompting to low CT. Hence it may be added to prevalence of coolant particles to enter efficaciously in to the cutting zone.

2.3.2. Cutting force (Fx) variation in different environments

The investigation explores divergence of Fx in dissimilar machining conditions since it show a relationships with the further crucial cut attributes, for example, tool wear, processing temperature at cutting zone, surface finish [1,5]. Fig. 2 depicts the variety in Fx response concerning processing span (time) under dry, with wet and LN₂ strategy for face milling. Fig. 2 demonstrates the Fx response which shows an expanding pattern with processing condition. It adds to warm mollifying of the workpiece at raised heat condition and spindle rotational speed. Rapid consistent processing in like way contributes in cutting down the shear quality of the workpiece and subsequently decreases the Fx. Captivatingly, LN₂ method of machining brought exceptional diminish in cutting force intensity to 43% and 16% in examination with dry, flood circumstances exclusively [7–9]. It is evident from Fig. 2, that cryogenic strategy helps in diminishment of Fx hence, attainable inferences like reduced tool wear and better external finish is achieved. Likewise, noteworthy variation in Fx is attained via flood and LN₂ mode for speed range of 1000–3000 rpm.

2.3.3. Investigation of flank Wear(FW) variation in different environments

Tool wear amid processing of AISI316 was described by flank wear, in this way contemplated with the assistance of SEM. Table 2, demonstrates the movement of average FW for various processing span at the spindle speed of 1000, 2000, 3000 rpm via dry, flood and LN₂ cutting strategies. A quick development in FW seen after 60 seconds machining at spindle speed (2000–3000 rpm), particularly while machining under dry cutting condition. Then again, no huge variation was noticed at first up to 60s for all the examined scope of spindle speeds in all machining condition. However, the prevalence of using LN₂ was a prominently obvious for greater spindle speed as it enhances cooling in contrast to dry and flood strategies, thus prompts to lower FW. Along these lines LN₂ emerged as a reasonable option for machining AISI316.

Table 2, exhibits the microscopic pictures of flank wear alongside machining span under all machining conditions. High substance reactivity of AISI316 prompts adhesion of the material to tool confront which brings about the creation of built up edge (BUE) [10]. The higher friction was observed
in machining span of 60 seconds under strategies (dry, flood) in contrast to LN2. Table 2 likewise shows inclination of BUE generation was more conspicuous amid dry mode when contrasted with wet mode. Tremendous cooling in mix with great lubrication brought about critical decrease in friction and along these lines added to the remarkable cutting inserts performance especially under LN2 mode even at higher spindle speed.

2.3.4. Investigation of chip morphology (CM) variation in different environments

The CM is delivered in the milling of the workpiece was profoundly analysed with the assistance of the SEM pictures as portrayed in Fig. 3. Generally, AISI316 is described by notched chips as confirmed in Fig. 3. It is fundamentally credited to shear localisation and plastic distortion of the workpiece amid processing. In addition, processing AISI316 at elevated spindle rotational speed (3000 rpm) leads to high rate of friction at contact asperities in turn leading to higher rate of plastic deformation thus creates more notched chips via dry strategy. Along these lines, level of serration was seen to be more under dry condition when contrasted with that of wet machining condition. It may be credited to greater CT development at cutting precinct in dry strategy. Thus,
high CT prompts a noteworthy upgrade in the plasticity of the machined samples [8,9]. At the other cases of machining, the distortion of the machined samples via flood and LN2 strategy was less because of lower CT. This may be due to the side stream of chip material, as apparent through previously mentioned Fig. 3.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104389.

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