Hindawi
Journal of Nanomaterials
Volume 2022, Article ID 8654603, 8 pages
https://doi.org/10.1155/2022/8654603

Research Article

Quality and Tool Stability Improvement in Turning Operation Using Plastic Compliant Damper

G. Sathyapriya,[1] **U. Natarajan**,[2] **B. Sureshkumar**,[3] **G. Navaneethakrishnan**,[4] **R. Palanisamy**,[5] **Mohit Bajaj**,[6] **Naveen Kumar Sharma**,[7] **and Kitmo**[8]

[1]*Department of Mechanical Engineering, University College of Engineering, Ariyalur, 621704, Tamil Nadu, India*
[2]*Department of Mechanical Engineering, Alagappa Chettiyar College of Engineering and Technology, Karaikudi, Tamil Nadu, India*
[3]*Department of Mechanical Engineering, K. Ramakrishnan College of Technology, 621112, Tamil Nadu, India*
[4]*Department of Mechanical Engineering, QIS College of Engineering and Technology, Ongole, Andhra Pradesh 523272, India*
[5]*Department of Electrical and Electronics Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai 603203, India*
[6]*Department of Electrical Engineering, Graphic Era (Deemed to Be University), Dehradun 248002, India*
[7]*Electrical Engineering Department, I. K. G. Punjab Technical University, Jalandhar, India*
[8]*Department of Renewable Energy, National Advanced School of Engineering of University of Maroua, Maroua, Cameroon*

Correspondence should be addressed to Kitmo; kitmobahn@gmail.com

Received 27 June 2022; Revised 7 August 2022; Accepted 18 August 2022; Published 1 September 2022

Academic Editor: Mauro Zarrelli

The major hindrance for any production industry in obtaining higher yield is the lack of achieving full material removal rate in the machine tools. If achieved, the surface quality of the machined works will be compromised. An attempt was made in this work to reduce the compromise of surface finish by integrating a plastic compliant damper that is capable of reducing the effects of unwanted vibrations generated during the machining process. The damper is designed to degenerate the effects of vibration and thereby improve product finish. It is made of acrylonitrile butadiene styrene by fused deposition modelling (an additive manufacturing technique). Measuring the vibration and cutting force is indirectly related to finish in product and tool wear rate. The stability of tool is improved greatly by the new compliant damper possessing displacement resistance. The effect of variation in cutting conditions on the performance of conventional rubber damper and plastic compliant damper was analyzed. The highest speed, feed rate, and depth of cut of 540 rpm, 0.02 mm/s, and 1.5 mm, respectively, found to be cutting condition at which imparted minimum surface roughness values of 2.80 μm and 0.52 μm with conventional rubber damper and plastic compliant damper, respectively. The speed and feed rate and depth of cut are found to be important parameters while studying surface roughness. The peak surface roughness is reduced by 48% by using the proposed compliant damper.

1. Introduction

A compliant mechanism consists of only one flexible member instead of individual components involved in completion of a mechanism. The commercial dampers are made of individual components including fluid medium inside damping part for reducing the vibrational effect on system. The major setback is the proper interfacing of all these various medium for complete dissipation of energy. This was thrown out of the grid by augmenting compliant mechanism in dampers. The proposed system is utilized in a conventional lathe machine tool in this study. The turning operation has been used for basic machining as well as finishing of products over the past few decades. It is a single point material removal operation in which the tool makes contact with a spinning cylindrical work piece. During this phase, a very complicated dynamic system of force comes into existence and act on both tool and work piece. The precision of finished products depends mainly on the continuous contact made by tool. This will not occur due to the presence of self-excited vibrations developed in the system. The primary setback for any machine tool to achieve the higher material removal is the self-excited chatter produced during the machining owing to various parts in motion. The vibrations in any component can be predicted indirectly by measuring the acceleration and force available in them. One of the methods of suppressing chatter in machine tool is passive control, where an additional component or change in design of an existing component is involved. It is observed that a surface integrity, acceleration, velocity, tool life, and cutting force could be improved, and also, tool wear is reduced with the introduction of new innovative compliant dampers. The machining input parameters could be optimized while using the compliant dampers which would give the improved vibration isolation effect. By continuous development through trial-and-error approach of building block positioning and topology optimization, the final design was confirmed. The design chosen for developing compliant damper exhibited the best vibration absorbing nature in simulation. This work is a novel attempt of improving the surface quality of machined product by reducing the chatter with the integration of passive compliant damper into the system. The design of compliant damper was done using the Pro E wildfire 4.0 modeling software with consideration to all the conditions necessary for conducting the experimental runs. A load of 1800 N is applied on the damper top surface with boundary condition of zero displacement at the bottom face. Finite element analysis was carried out using ANSYS 12.0 with different plastic damper materials. The analyzing results for plastic damper of ABS material are presented in Figures 1(a) and 1(b).

The simulation results reveal that there is a maximum deflection of 0.0061458 mm at the loading point. Remaining members do not experience any deflection owing to the absence of joints in entire component. Based on the comparison results obtained, the final material was chosen for fabricating the compliant dampers. The commercially available acrylonitrile butadiene styrene (ABS) material having Young's modulus -1.79 GPA, strength at yield -29.6 MPa, hardness 100, and density 1.060 g/cm^3 is chosen for fabricating the plastic damper. It is chosen in accordance with the stiffness associated with the material. All other materials exhibit almost lower deformation, but their stress values were very poor compared to ABS. Hence, the material for developing plastic damper was chosen to be ABS, and the final fabricated damper is shown in Figure 1(c) and having dimensions of 100∗95∗24 mm, 3 mm horizontal layer thickness, and 1.5 mm cross member thickness.

The design with higher isolation efficiency was finally fabricated using fused deposition modeling (3D printing) of plastic compliant damper which was carried out in Flashforge finder. The supports are placed only for end hanging. Brass was used as an extruder, and also, the filament was not dried before being printed which uses new vacuum packed filament on damper manufacturing.

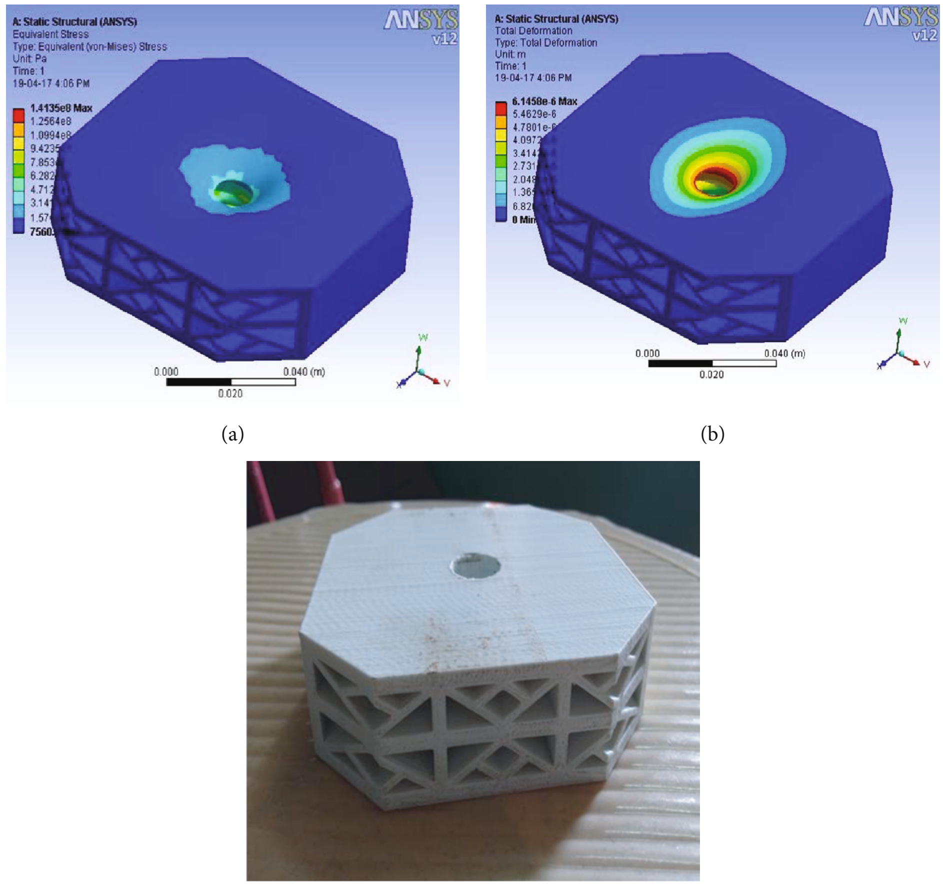
In literature view, general background information is presented about vibration in machining systems and compliant mechanism. The experimental setup section describes details about the proposed approach of utilizing the compliant damper developed in lathe machine tool. The lathe machine is operated under different combination of input parameters for measuring the damper performance on surface roughness. Results and Discussion presents the comparisons and discussions on results obtained from the experiments conducted with various operating conditions. The comparisons were presented on for the results obtained from complaint plastic dampers and conventional rubber damper. Conclusion provides an overview, and outcome of the research is presented with output responses.

2. Literature Review

Munoa et al. [1] reported about the effects of chatter in machined products and machine tool life. The various techniques identified and applied for resolving the chatter problem in machine tools were keenly explained along with their specialties. The stability of the tool during machining is a major challenge faced by industries. Siddhpura and Paurobally [2] presented a detailed study report on the various techniques used for chatter analysis, prediction, and tool stability with respect to chatter, chatter suppression, and relationship between chatter, tool wear, and surface quality of finished product. Urbikain et al. approached the chatter in heavy lathe machines by Chebyshev collocation polynomials method to identify the limiting factors for productivity [3]. From the results obtained, an increment in productivity of 10% is achieved by selecting proper cutting depths for specific designs. Feng and Wang [4] developed a model for predicting the surface roughness of products obtained from turning operation. A nonlinear regression model of logarithmic transforms of data was developed with very small errors (~6.3%) in prediction.

The additive manufactured parts were evaluated with the help of nondestructive testing method by Albakri et al. [5]. Parameters like dimensional inaccuracy and positional inaccuracy are evaluated for the product strength and life. Salgado et al. [6] proposed a model for analyzing the surface roughness of turning during machining operation. The self-adaptive technique is useful in adjusting the parameters from studying the vibrational parameters. The chatter in machine tool has been the reason for poor surface finish. Tantanawat et al. [7] explored active vibration isolation of complaint mechanism application of compliant actuator for canceling. Based on FEA analysis, feed forward disturbance compensation control is effectively isolated sinusoidal displacement disturbance at low frequencies. The nonlinear FEA showed a reduction of 95% at 3.9 Hz and 91% at 35.1 Hz with controlled input of 0.73 mm amplitude as shown in Figure 2. There is an importance of microvibration isolation in spacecraft; then, a novel fluid-based microvibration isolator (FBMVI) was designed and investigated in which physical design parameters (PDPs) are constructed and obtained performance objective indices (POIs) by applying the mechanical independence equivalence presented by Sie Wang and Shongen Zhao [8].

Dimla [9] studied the correlation of tool wear to chatter produced during the machining operation. Tools of P25 and P15 were used, and their effect of chatter parameters on tool wear was observed using time domain features. Major failure occurred in tool nose owing to high resonant. Chelladurai



(a) (b)

(c)

FIGURE 1: (a) Proposed compliant damper and its analysis report from ANSYS. (b) Proposed compliant damper and its analysis report from ANSYS. (c) Proposed ABS compliant damper.

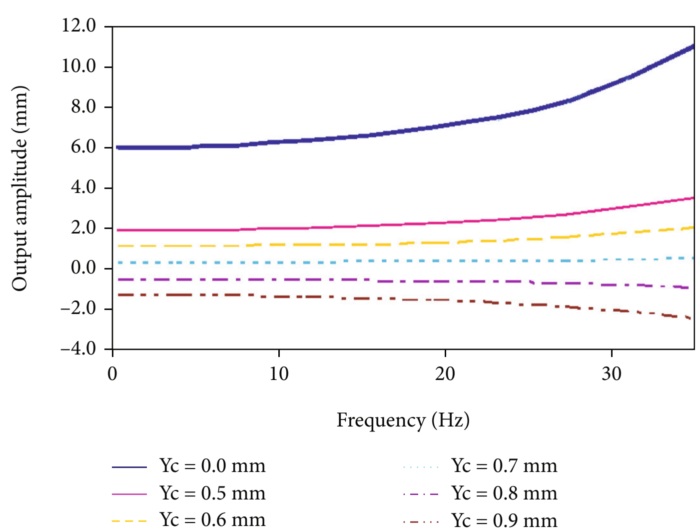


FIGURE 2: Output responses in the low frequency range for different controlled input amplitudes.

et al. [10] went for studying the cutting tool wear and product quality by analyzing vibration and strain in tool. The ANN technique was used to understand and classify the artificial wear in tool at various levels of operation. Fei et al. [11] used stability lobe diagram for improving the milling process performance with flexible materials. A damper which moves along the spindle was proposed for increasing the stability and reducing tool wear. Hessainia et al. [12] developed a prediction model for surface roughness in turning of 42CrMo4 by studying the tool vibration parameters. The quadratic model of response surface methodology was used to analyze and predict the surface roughness. The input parameters were observed from vibrational factors. Optimal cutting parameters were obtained based on desirability approach. Khorasani et al. [13] proved that case-based reasoning approach has produced a lesser mean square error (6.55%) than image processing and machine vision (14.6%) and neural network (8.5%). The CBR approach is useful where no model can be applied for prediction along with the self-learning ability.

Daniel Kirby et al. [14] applied fuzzy net modelling technique to successfully create a system for measuring surface roughness during turning and adapt the feed rate to achieve roughness value lower than desired. The correction in the feed rate is decided by studying the chatter parameters obtained from accelerometer provided closer to the turning insert. Kumbhar et al. attempted to reduce the vibration in automotive using magneto rheological elastomers (MRE) and piezoelectric materials [15]. A simple MR fluid bushing was developed to reduce the effect of noise and vibration in automobiles, especially applied in the engine isolator retrofits. Abu-Zahra and Lange [16] studied the chatter present in tool by using ultrasonic waves and performing wavelet analysis using ANN. The severity in tool chatter is easily noted without any disturbance to the system at different levels. A resonance occurred during the speed of 600–1000 rpm between the machine tool and natural frequency of system. Dinesh et al. [17] attempted to optimize the machining parameters in turning of EN24 alloy steel using response surface methodology. The developed models could be used to predict the MRR and surface roughness with an error of 4.8%.

Mazur et al. [18] designed and manufactured a H13 tool steel cooling channel using selective laser melting process with reduced layer thickness. The roughness of the cooling channel was observed for reasons like fill pattern, unsupported overhanging structure, etc. The compromise between porosity and hole accuracy was achieved at 80 J energy dispersion and 175 W power. Movaffaghi and Friberg [19] made an attempt to place the dampers in exact position following genetic algorithm interfaced with finite element modelling approach. The positioning of viscous damper is applied to structures for reducing effect of unnecessary vibrations. This work is aimed at improving the surface roughness by improving tool stability. The stabilization is increased by introducing a passive compliant damper in the system.

3. Experimental Setup

The experimental procedure was carried out in a conventional lathe machine tool (as shown in Figure 3) with CNMG 120408TK insert made by Kyocera and carbide diagonal HP of chamfered edge used on holder type. Mild steel rods of dimension Φ23mm × 100 mm are used for turning. The diameter of the work piece is reduced to 20 mm in all the runs. The input parameters considered are speed (N), feed rate (F), and depth of cut (D). Three levels in each parameter are chosen, and the full factorial model-based design of experiments results in 27 runs. The additional change in the system is the replacement of rubber dampers with plastic compliant dampers.

3.1. Measurement of Responses. A UIL15 lathe tool dynamometer used to measure the cutting tool forces in all 3 directions. Then, average of the cutting force (CF) is considered for analyzing. The VB-8201HA contact type vibrometer made by Taiwan was made used to measure the various chatter parameters like velocity (v), acceleration (a), displacement (d), and frequency (f). The surface roughness (Ra) was measured by pick up type (TR110) portable surface analyzer in the work piece along parallel axis direction [20–22]. All the experiments were conducted according to the full factorial design, and the results are provided in Table 1.

4. Results and Discussion

4.1. Effect of Damper on Velocity. The velocity is defined as the measure of quickness for a moving object from initial to maximum displacement position. It is measured in inch per second (IPS) usually. In this case, the comparison of velocity obtained for two dampers is shown in Figure 4. The velocity observed for using a compliant damper is higher than for normal rubber damper at high depth of cut conditions. It can be observed that depth of cut increases the velocity of the cutting tool. Maximum velocity is shown for high values of speed, feed, and cutting depth. The velocity doses not show any effect on machine tool system as it is not related to frequency. At lower cutting depth condition, both the dampers exhibit equal velocity.

4.2. Effect of Damper on Displacement. Displacement is a direct relation to frequency of any system. It can be stated as the maximum range an object can travel from one maximum to another in thousandths of one inch. The displacement patterns observed in this experimentation are plotted in Figure 5. The range of displacement of tool varies over a large value for conventional rubber damper. However, the newly designed compliant damper greatly reduces the movement of tool, and the entire range falls between 0 and 0.1 mm. The movement of tool reduces the surface irregularities caused by discrete contact with the work material.

4.3. Effect of Damper on Acceleration. The text book definition of acceleration represents the amount of change in velocity from zero to maximum with respect to time. Figure 6 shows various values of acceleration obtained during the experimentation using both dampers. The acceleration produced by compliant damper is having a wide range of values than that of conventional rubber dampers. This is exactly the opposite phenomenon to displacement. The same trend in values with respect to change of input conditions is obtained for velocity. Unlike velocity, the acceleration is related to frequency. Once again, the depth of cut improves the resultant acceleration at its higher values. Lower depth of cut produced less acceleration on the tool.

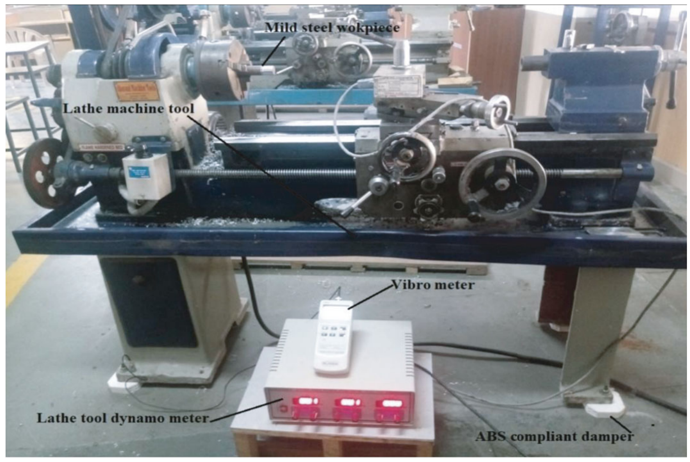


Figure 3: Conventional lathe with proposed compliant damper and data acquisition systems.

Table 1: Experimental data.

Run no.	N (rpm)	F (mm/s)	D (mm)	Conventional rubber damper						Plastic compliant damper					
				a (mm/s^2)	v (mm/s)	d (mm)	f (HZ)	CF (kgf)	R_a (μm)	a (mm/s^2)	v (mm/s)	d (mm)	f (HZ)	CF (kgf)	R_a (μm)
1	356	0.01	0.5	0.0049	0.9	0.331	0.87	7.67	1.63	3.4	1	0.000588	541.1268	9.67	2.12
2	356	0.01	1	0.005	0.9	0.324	0.88	9.67	1.92	5.3	1.1	0.000457	766.8374	14.67	1.76
3	356	0.01	1.5	0.0051	1	0.392	0.81	13.0	2.62	5.5	1.2	0.000524	729.4602	16.33	1.26
4	540	0.01	0.5	0.0081	1.3	0.417	0.99	6.67	0.92	4.7	1	0.000426	748.0282	5.33	1.92
5	540	0.01	1	0.0084	1.5	0.536	0.89	7.33	1.02	10.5	2.5	0.00119	668.4508	13.67	1.55
6	540	0.01	1.5	0.0085	1.7	0.68	0.8	9.67	1.49	12	2.9	0.001402	658.5722	14.33	1.64
7	828	0.01	0.5	0.0013	1.5	0.357	1.34	5.00	1.55	8	1.2	0.00036	1061.033	7.33	1.95
8	828	0.01	1	0.128	1.6	0.4	1.27	12.33	1.01	12.5	1.5	0.00036	1326.291	12.33	1.56
9	828	0.01	1.5	0.137	1.8	0.473	1.21	16.67	1.36	35.2	5.5	0.001718	1018.592	22.67	1.68
10	356	0.015	0.5	0.004	0.8	0.32	0.8	9.67	2.61	4.6	0.7	0.000213	1045.875	7.33	1.71
11	356	0.015	1	0.0042	0.9	0.386	0.74	9.67	3.45	6.4	0.9	0.000253	1131.768	17.00	2.24
12	356	0.015	1.5	0.004	1.1	0.605	0.58	17.33	3.99	4.9	0.8	0.000261	974.824	15.00	1.64
13	540	0.015	0.5	0.0114	0.9	0.142	2.03	8.00	4	7.3	1	0.000274	1161.831	6.33	1.43
14	540	0.015	1	0.0115	1.3	0.294	1.4	13.67	3.73	7.5	1.2	0.000384	994.7184	14.67	1.53
15	540	0.015	1.5	0.0116	1.4	0.338	1.32	24.67	2.25	7.8	1.4	0.000503	886.7203	21.67	0.88
16	828	0.015	0.5	0.0146	1.6	0.351	1.45	7.67	3.08	12.5	2.5	0.0001	795.7747	10.00	1.59
17	828	0.015	1	0.0151	1.7	0.383	1.47	13.33	3.98	14.5	2.6	0.000932	887.5949	15.67	1.45
18	828	0.015	1.5	0.0168	1.7	0.344	1.57	14.67	3.82	19.5	3.4	0.001186	912.8004	27.00	1.31
19	356	0.02	0.5	0.007	0.7	0.14	1.75	10.67	4.26	4	0.6	0.00018	1061.032	12.67	2.34
20	356	0.02	1	0.0074	0.8	0.73	1.47	15.00	3.36	4.2	1	0.000476	668.4508	24.00	0.91
21	356	0.02	1.5	0.0085	0.9	0.191	1.5	22.67	5.49	12.5	3.8	0.00231	523.535	39.00	2.66
22	540	0.02	0.5	0.0125	1.1	0.194	1.81	9.00	4.54	6.7	1.1	0.000361	969.3982	8.33	1.78
23	540	0.02	1	0.0135	1.5	0.333	1.43	24.00	2.92	7.4	1.2	0.000389	981.4554	17.67	1.49
24	540	0.02	1.5	0.0133	1.5	0.338	1.41	29.00	2.81	18.5	5	0.002703	588.8732	40.67	0.52
25	828	0.02	0.5	0.0184	1.4	0.213	2.09	9.00	3.12	10.5	3.7	0.002607	451.655	8.33	1.91
26	828	0.02	1	0.018	1.8	0.36	1.65	18.33	3.41	14.5	2.4	0.000794	961.5611	16.00	0.52
27	828	0.02	1.5	0.0186	1.9	0.388	1.56	27.33	1.08	52.5	12.9	0.006339	647.7236	54.67	1.24

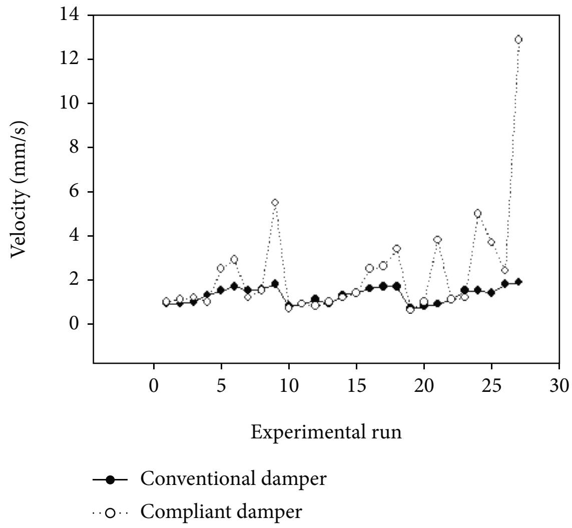


Figure 4: Comparison of velocity for conventional and compliant damper.

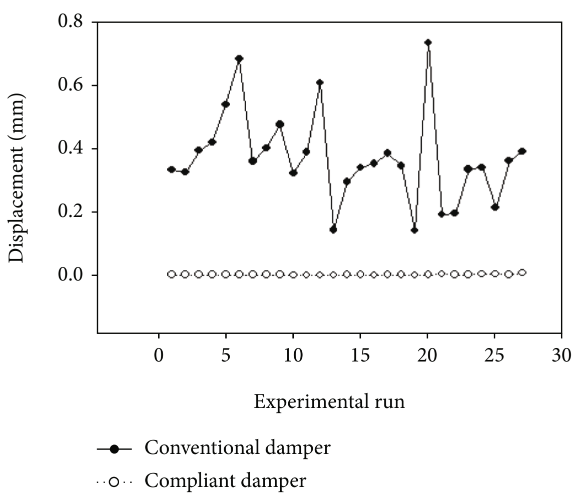


Figure 5: Comparison of displacement for conventional and compliant damper.

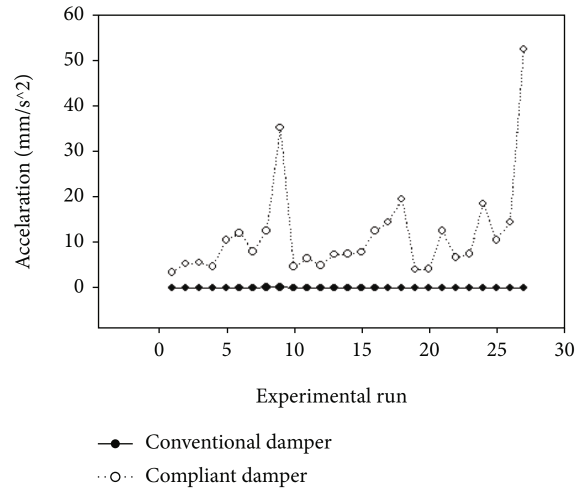


Figure 6: Comparison of acceleration for conventional and compliant damper.

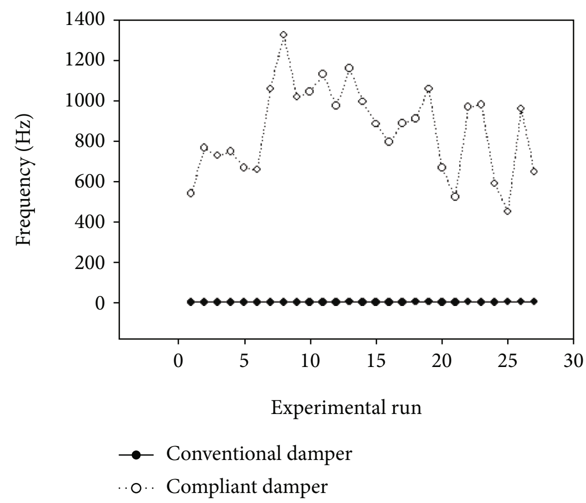


Figure 7: Comparison of frequency for conventional and compliant damper.

4.4. Effect of Damper on Frequency. Frequency is defined as the number of oscillations produced per second. It is usually measured in hertz (Hz). The oscillations produced are higher in compliant damper due to the acceleration available in the system. Though the frequency of the vibrations is higher, the resistance of compliant damper to motion improves tool stability. The continuous contact increases surface integrity of the machined works. The lower value for rubber damper is greatly smaller than proposed model as seen in Figure 7.

4.5. Effect of Damper on Average Cutting Force. The cutting force exerted by the tool on work piece is an important factor for achieving higher material removal. From Figure 8, more amount of cutting force is shown when the compliant plastic damper is used instead of rubber damper. Force is relatively higher in both the runs whenever the depth of cut is higher. Increasing the cutting depth alone will render a poor surface finish of end product. For improving the productivity of any industry, this has to be followed. The cutting force experienced is higher as well as continuous for using compliant damper because the displacement observed is very much low (ranges from 0 to 0.1 mm) as discussed earlier. Hence, the tool is more stable than before, and continuous material removal takes place during the turning operation.

4.6. Effect of Damper on Surface Roughness. Precision and dimensional accuracy also provide for smooth assembling of machine parts. The surface finish of machined product plays a vital role in deciding the dimension. Hence, surface roughness is given equivalent importance as productivity in industries. The surface roughness can be reduced by stabilizing the tool during machining. The roughness is an indirect measure of product quality. The introduction of compliant damper has greatly reduced the surface roughness

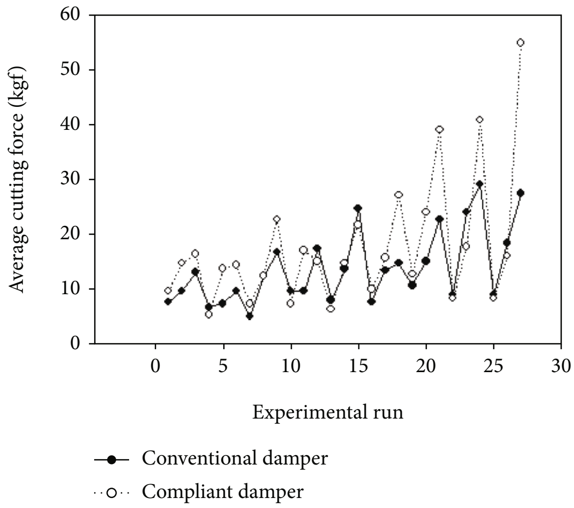


Figure 8: Comparison of average cutting force for conventional and compliant damper.

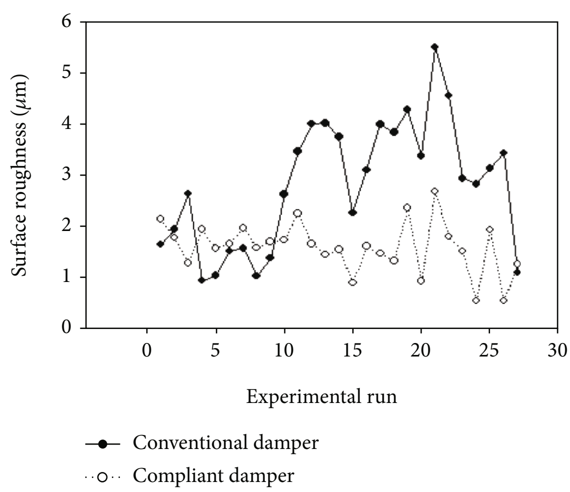


Figure 9: Comparison of surface roughness for conventional and compliant damper.

in this work as shown in Figure 9. The reduction of roughness is mainly obtained from stability of tool, whereas the stability is increased by restricting the movement (displacement). Compliant dampers are comprised of large number of links and elements which are capable of absorbing the vibrations produced during the operation.

5. Conclusion

A complex designed compliant damper was developed and put to use in this work. The experiments were carried out using the full factorial model design of experiment procedure. All the experimental runs were repeated for both dampers, and results were noted. Based on the analysis of data obtained, the following conclusions were arrived:

(i) Velocities for both the dampers are equal except high depth of cut conditions. The compliant damper generates higher velocity with high depth of cut situations

(ii) The compliant dampers have reduced the displacement greatly to a maximum of 0.1 mm. This is achieved due to more number of elements in the compliant damper

(iii) The ABS material used for making the complex design damper is capable of absorbing more vibrations. Hence, tool movement is reduced, and stability is improved

(iv) Acceleration is also exhibiting the same pattern as that of velocity for both conventional and compliant dampers

(v) The frequency produced in compliant damper is higher due to the acceleration in the system

(vi) Cutting force exerted on the work piece is higher while using the proposed compliant damper, because of the improved stability of tool

(vii) Surface roughness of machined work piece is lower for high feed rates

(viii) The peak surface roughness is reduced by 48% using the plastic compliant damper

Data Availability

Data is available on request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] J. Munoa, X. Beudaert, Z. Dombovari et al., "Chatter suppression techniques in metal cutting," *CIRP Annals-Manufacturing Technology*, vol. 65, no. 2, pp. 785–808, 2016.

[2] M. Siddhpura and R. Paurobally, "A review of chatter vibration research in turning," *International Journal of Machine Tools & Manufacture*, vol. 61, pp. 27–47, 2012.

[3] G. Urbikain, F.-J. Campa, J.-J. Zulaika, L.-N. Lópezde Lacalle, M.-A. Alonso, and V. Collado, "Preventing chatter vibrations in heavy-duty turning operations in large horizontal lathes," *Journal of Sound and Vibration*, vol. 340, pp. 317–330, 2015.

[4] X. Wang and C. X. Feng, "Development of empirical models for surface roughness prediction in finish turning," *International Journal of Advanced Manufacturing Technology*, vol. 20, no. 5, pp. 348–356, 2002.

[5] M. I. Albakri, L. D. Sturm, C. B. Williams, and P. A. Tarazaga, "Impedance-based non-destructive evaluation of additively manufactured parts," *Rapid Prototyping Journal*, vol. 23, no. 3, pp. 589–601, 2017.

[6] D. R. Salgado, F. J. Alonso, I. Cambero, and A. Marcelo, "In-process surface roughness prediction system using cutting vibrations in turning," *International Journal of Advanced Manufacturing Technology*, vol. 43, pp. 40–51, 2009.

[7] T. Tantanawat, Z. Li, and S. Kota, "Application of compliant mechanisms to active vibration isolation systems," in *Proceedings of DETC, International Design Engineering Technical Confereence*, pp. 1165–1172, Salt Lake City, Utah, USA, 2004, Volume 2: 28th Biennial Mechanisms and Robotics Conference.

[8] Y. Wang and D. Zhao, "Effect of fabric structures on the mechanical properties of 3-D textile composites," *Journal of Industrial Textiles*, vol. 35, no. 3, pp. 239–256, 2006.

[9] S. Dimla, "The correlation of vibration signal features to cutting tool wear in a metal turning operation," *International Journal of Advanced Manufacturing Technology*, vol. 19, no. 10, pp. 705–713, 2002.

[10] H. Chelladurai, V. K. Jain, and N. S. Vyas, "Development of a cutting tool condition monitoring system for high speed turning operation by vibration and strain analysis," *International Journal of Advanced Manufacturing Technology*, vol. 37, no. 5-6, pp. 471–485, 2008.

[11] J. Fei, B. Lin, S. Yan et al., "Chatter mitigation using moving damper," *Journal of Sound and Vibration*, vol. 410, pp. 49–63, 2017.

[12] Z. Hessainia, A. Belbah, M. A. Yallese, T. Mabrouki, and J.-F. Rigal, "On the prediction of surface roughness in the hard turning based on cutting parameters and tool vibrations," *Measurement*, vol. 46, no. 5, pp. 1671–1681, 2013.

[13] A. M. Khorasani, A. J. Aghchai, and A. Khorram, "Chatter prediction in turning process of conical workpieces by using case-based resoning (CBR) method and Taguchi design of experiment," *International Journal of Advanced Manufacturing Technology*, vol. 55, pp. 457–464, 2011.

[14] E. Daniel Kirby, J. C. Chen, and J. Z. Zhang, "Development of a fuzzy-nets-based in-process surface roughness adaptive control system in turning operations," *Expert Systems with Applications*, vol. 30, no. 4, pp. 592–604, 2006.

[15] S. Kumbhar, S. Maji, and B. Kumar, "Automotive vibration and noise control using smart materials: a state of art and challenges," *World Journal of Engineering*, vol. 10, no. 6, pp. 535–542, 2014.

[16] N. H. Abu-Zahra and J. H. Lange, "Tool chatter monitoring in turning operations using wavelet analysis of ultrasound waves," *International Journal of Advanced Manufacturing Technology*, vol. 20, no. 4, pp. 248–254, 2002.

[17] S. Dinesh, A. Godwin Antony, K. Rajaguru, and V. Vijayan, "Investigation and prediction of material removal rate and surface roughness in CNC turning of EN24 alloy steel," *Mechanics and Mechanical Engineering*, vol. 6, no. 8, pp. 849–863, 2016.

[18] M. Mazur, M. Leary, M. McMillan, and E. M. B. Joe, "SLM additive manufacture of H13 tool steel with conformal cooling and structural lattices," *Rapid Prototyping Journal*, vol. 22, no. 3, pp. 504–518, 2016.

[19] H. Movaffaghi and O. Friberg, "Optimal placement of dampers in structures using genetic algorithm," *Engineering Computations*, vol. 23, no. 6, pp. 597–606, 2006.

[20] V. Y. Bhise and B. F. Jogi, "Effect of cutting speed and feed on surface roughness in dry turning of Inconel X-750," *Materials Today: Proceedings*, vol. 61, pp. 587–592, 2022.

[21] M. Dogra and V. S. Sharma, "Machinability and surface quality issues in finish turning of hardened steel with coated carbide and CBN tools," *Materials and Manufacturing Processes*, vol. 27, no. 10, pp. 1110–1117, 2012.

[22] M. Dogra, V. S. Sharma, A. Sachdeva, N. M. Suri, and S. Dhiman, "Surface integrity a key issue in hard turning–a review," *International Journal of Machining and Machinability of Materials*, vol. 12, no. 1/2, p. 88, 2012.