

ARPAN

**JOURNAL OF
ENGINEERING
AND
APPLIED
SCIENCES**



Published by
the International Association of
Engineers and Applied Scientists

Volume 4
Number 4
June 2009

ISSN 1819-6469

Published by

Asian Research Publishing Network

London, England

www.arpnjournal.com



ARPN Journal of Engineering and Applied Sciences

[Home](#)

[Archive](#)

[Submit Paper](#)

[Author Guidelines](#)

[Editorial Board](#)

[Publication Fee](#)

Editorial Board

Editor-in-Chief: Engr. J. K. Tarakzai (PAKISTAN)

#	Editors	Country
1	Prof. Dr. R. J. Godwin	UNITED KINGDOM
2	Prof. Dr. Erik Valdemar Cuevas Jimenez	GERMANY
3	Prof. Dr. Hamou SADAT	FRANCE
4	Dr. Mohammad Aminul Islam	JAPAN
5	Prof. Dr. Kui Fu Chen	CHINA
6	Prof. Dr. M. Ashraf Chaudhry	NEW ZEALAND
7	Prof. Dr. A. Sermet Anagun	TURKEY
8	Prof. Dr. Ashraf Mohamed Hemeida	Saudi Arabia
9	Prof. Dr. Krishna Murari Pandey	INDIA
10	Prof. Dr. Magdy A. Ezzat	EGYPT
11	Prof. Dr. Roberto Brighenti	ITALY
12	Dr. Anurag Misra	INDIA
13	Prof. Dr. Adel M. ALIMI	TUNISIA
14	Prof. Dr. Arun Kumar Gupta	INDIA
15	Prof. Demetrios V. Bandekas	GREECE
16	Prof. Dr. Bensafi Abd-El-Hamid	ALGERIA
17	Dr. Rajanish K. Kamat	INDIA
18	Prof. Dr. Asma Thamir Ibraheem	IRAQ
19	Prof. Dr. Sylejman Hyseni	KOSOVO
20	Prof. Dr. Haider Zaman	Saudi Arabia
21	Prof. Dr. Debojyoti Mitra	INDIA
22	Prof. Dr. Pandian VASANT	MALAYSIA
23	Prof. Dr. Prakash MMS Kinthada	INDIA
Associate Editors		
1	Dr. Dongning Li	USA
2	Dr. Suheyra Yerel	TURKEY
3	Dr. Guoxiang Liu	USA
4	Dr. Nadeem Anjum	PAKISTAN
5	Engr. Malini Sarah Philip	NORWAY
6	Dr. K.V.L.N. Acharyulu	INDIA
7	Engr. Mohammad Khalily Dermany	IRAN
8	Dr. Lamyaa- Gamal Eldeen Taha	EGYPT
9	Dr. OM Prakash Singh	INDIA
10	Engr. Seyyed Mohammad Reza Farshchi	IRAN
11	Dr. Muhammad Imran Din	PAKISTAN
12	Dr. José Carlos Páscoa Marques	PORTUGAL
13	Engr. Fawwaz Jinan Jibrael Jabri	IRAQ
14	Dr. Kanad Ray	INDIA
15	Dr. Shamsuddin Shahid	MALAYSIA
16	Engr. Naveenji Arun	INDIA



SUSTAINABLE MACHINING BY OPTIMIZING THE POWER DEMAND THROUGH DRY TURNING OF 316L STAINLESS STEEL

Rusdi Nur

Department of Mechanical Engineering, Politeknik Negeri Ujung Pandang, Makassar, Indonesia

E-Mail: rusdinur@poliupg.ac.id

ABSTRACT

This paper presents the experimental results from modelling and optimization of cutting conditions when turning processes of AISI 316 stainless steel using a central composite design (CCD). Type of AISI 316L, a series of stainless steel, is typical as medical grade that occur difficulties in machining. Power demand and tool life were measured, analyzed and modelled. The results of this experimental work show that the cutting speed has a significant effect on machining responses (power demand and tool life) compared with feed, and that optimum machining parameters was obtained, while following towards sustainability were in terms of minimizing power demand, extending of tool life and improving productivity. The models developed were used for evaluating and optimizing the input process, to obtain optimum machining responses for an overall process improvement.

Keywords: power demand, tool life, turning, and stainless steel.

INTRODUCTION

Machinability is the ability of a material to be machined. Machinability is a term indicating how the work material responds to the cutting process [1]. In the most general case, good machinability means that material is cut with good surface finish, long tool life, low force and power requirements, and low cost. Some researchers have performed investigations on various aspects related to the turning process, i.e. dry turning of AISI 1010 [2] and nitrogen alloyed duplex SS [3], hard turning of AISI H13 steel [4] and MDN250 [5], and turning of AISI 1040[6], etc. The machining process as essential in manufacturing activities that providing input to the global economic growth [7]. The other sides, intensive research work in the machining process improves machining performances through higher machining performances [8]. Therefore, in nowadays more and more important become environmentally and health benign technologies and advanced techniques for achieving cleaner, healthier, safer, and economical machining process. That view presents sustainable machining, through improved information about the environmental impacts of existing manufacturing processes and develops new technological concepts [9, 10].

Sustainable in manufacturing is currently a very important issue for governments and industries worldwide [11]. Sustainable manufacturing must respond to challenge of economical, environmental and social [12]. Most of the manufacturing industries are using mechanical machining which became a big contribution in the demand for energy.

This study presents the approach for optimized the cutting parameters in turning process, based on minimum power demand and longest tool life. This paper makes a contribution to the machining process for minimized the power demand there from generating in reducing emissions.

POWER DEMAND

In the machining process, a number of studies have been carried out, but environmental issues are rarely considered except for the work done by [13], which studied the electrical energy requirements in the milling process. Their approach can be used to evaluate energy consumption in machining processes. Following on earlier their work, the electrical power required, P , for machining can be calculated from the equation as follow:

$$P = P_o + k \cdot \dot{v} \quad (1)$$

where, P is the power [W] required by machining process, P_o is the power [W] required by all machine modules for a machine operating without loading, k is the specific energy requirement [Ws/mm³] in cutting operations, and \dot{v} is the material removal rate (MRR), in [mm³/s]. Value of $k \cdot \dot{v}$ can be summarized as the cutting power.

EXPERIMENTAL DESIGN

Materials and cutting tool

In this study, Austenitic stainless steel AISI 316L with a diameter of 150 mm and length of 300 mm will be used as the workpiece material in the turning process. Detail composition of AISI 316L and some general properties of AISI 316L are shown in Table-1.

The machining test was conducted using the ALPHA 1350S 2-axis CNC lathe machine (8.3 kW of house power and the spindle speed ranges from 100 to 6000 rpm) without fluid. The cutting tool inserts were placed on the tool holder designated as TCLNR 2020K12.

Experimental setup

The experimental setup was developed using Design-Expert software version 7.1. The total number of experiments was eleven as shown in Table-2, where the midpoint was replicated twice to determine the pure error.



Table-1. Composition of AISI 316L.

Items	Min	Max
C	-	0.03
Mn	-	2
Si	-	0.75
P	-	0.045
S	-	0.03
Cr	16	18
Mo	2	3
Ni	10	14
N	-	0.1

Table-2. Cutting parameters.

Levels	Low (-1)	Centre (0)	High (+1)
Cutting speed (m/min)	90	150	210

Feed (mm/rev)	0.10	0.16	0.22
Depth of cut (mm)	0.4		
Coolant	No Fluid		

RESULTS AND DISCUSSIONS

The experimental results for power demand and tool life are shown in Figure-1 and Figure-2.

Power demand

The relationship between the power demand and feed for various cutting speeds was shown in Figure-1. It can be clearly seen that the power demand increases with the increasing cutting speed but the feed rate of increase was generally similar. It was confirmed by [14] stated that the power consumption continuously increase with increasing cutting speed when machining of AISI 1045 steel. Increasing the cutting speed on machining will be more required power consumed to rotate the spindle motor.

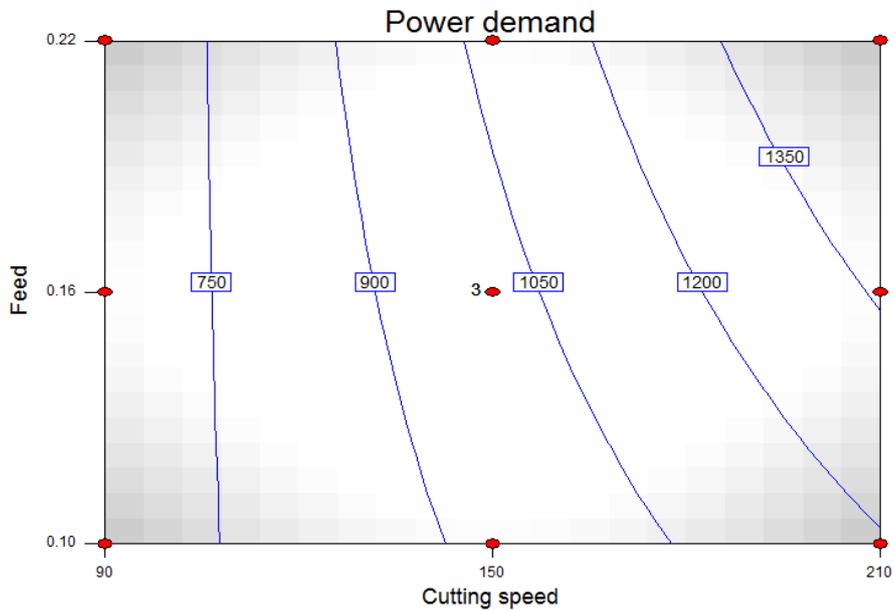


Figure-1. Plotting contour of power demand.

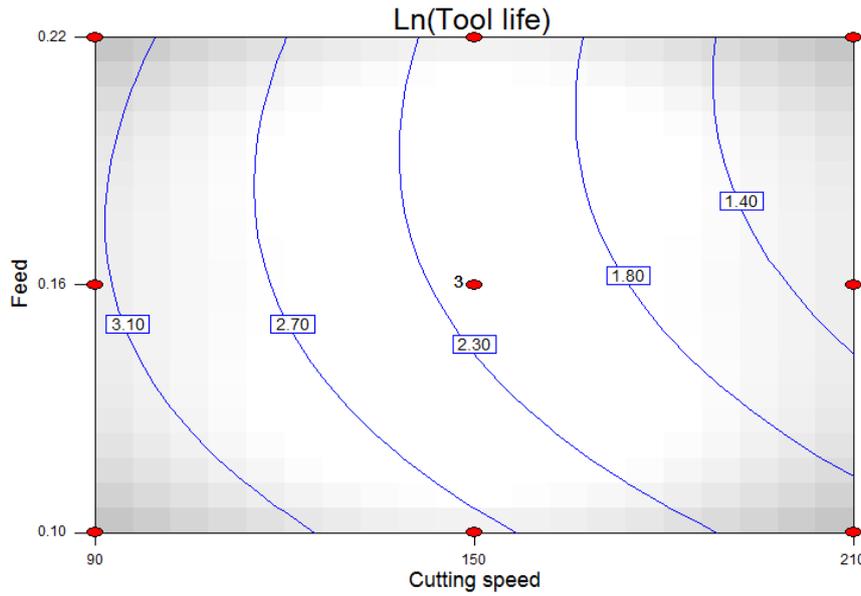


Figure-2. Plotting contour of tool life.

Tool life

The influence of cutting speed and feed rate on the tool life is shown as Figures-2. It showed that the tool life would be decrease for increasing of cutting speed and feed rate. These result was confirmed by [15], it was noticed that with the increasing cutting speed the tool life decreases for each of the feeds when turning of duplex stainless steel using CVD coated carbide (CTC 1135). This phenomenon was due to increasing the cutting speed increases the intensity of wear of the cutting edge. Another confirmation of [16], it founded that tool life reduced with

an increase in cutting speed, most likely due to the increased temperatures generated.

Optimization

The analysis of variance (ANOVA) table for the model of power demand and tool life was shown in Table-3. It indicates the p-value as < 0.0001 which was much lower than the significant level of 0.05. Therefore, from the statistical point of view, this linear and quadratic model was valid.

Table-3. ANOVA analysis for power demand and tool life.

Source	Sum of squares	Degree of freedom	Mean square	F Value	Prob > F
Power Demand					
Model	8.297E+005	3	2.766E+005	64.14	< 0.0001
Vc	7.568E+005	1	7.568E+005	175.52	< 0.0001
F	34916.41	1	34916.41	8.10	0.0248
Vc*f	37999.65	1	37999.65	8.81	0.0208
Tool Life					
Vc	5.46	1	5.46	1377.61	< 0.0001
f	0.64	1	0.64	161.24	< 0.0001
f ²	0.20	1	0.20	49.66	0.0004
Vc*f	0.16	1	0.16	39.28	0.0008

As shown in Table-3, it indicates the p-value as < 0.0001 which was much lower than the significant level of 0.05. Therefore, from the statistical point of view, this linear and quadratic model was valid. Thus, the final equation is obtained in actual factors based on empirical models as below:

$$P = +566.15 + 1.59 * Vc - 2789.73 * f + 27.07 * Vc * f \quad (2)$$

$$\ln(T) = +6.04 - 7.13E-03 * Vc - 21.10 * f + 74.63 * f^2 - 0.06 * Vc * f \quad (3)$$

where Vc is cutting speed (m/min) and f is feed (mm/rev).



The output response can be determined by the influence of each input parameter was measured. It can be performed with creating a model to optimize the range of cutting speed and feed, which will be obtained criteria of power demand and tool life were desired. These criteria were complemented the combination of cutting speed and

feed and shown in the gray zone of plotting overview (Figure-4). The obtained solution was intersection between the power demand criteria (zone left next to the contour P of 750W) and the tool life criteria (zone under the contour T of 25.79 minutes).

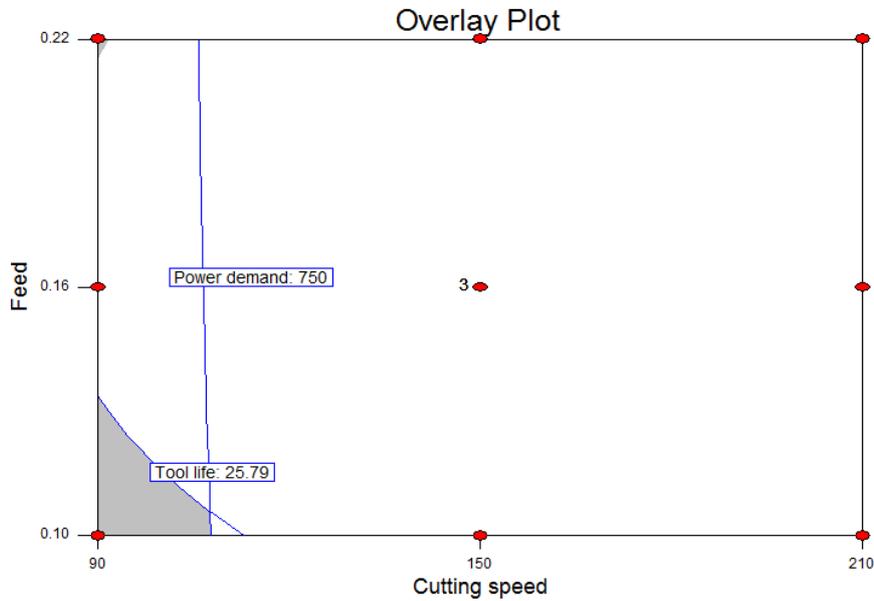


Figure-3. Plotting overlay of the cutting parameters for maximum criteria of 750W-power demand and 25.79 minutes-tool life.

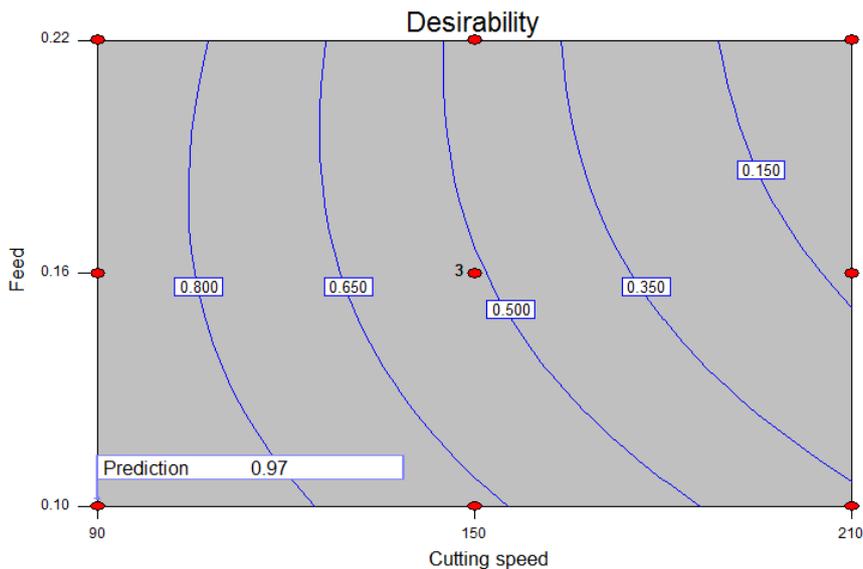


Figure-4. Desirability overview of the input parameters to optimize the power demand and tool life.

The achieved solution can be determined by more particular the responses criteria. This arrangement can be utilized to acquire the minimum of power demand and the longest of tool life, by calculating the desirability from the resulting equations. The calculation indicates that the maximum value of desirability was attained at the low of cutting speed (90 m/min) and feed (0.10 mm/rev) as given

in Figure-5. This result was confirmed by [17] in their paper, it stated that value desirability was found at low feed rate when turning of treated Al-11%Si alloy using TiN coated carbide.



CONCLUSIONS

Investigating the turning of AISI 316L Stainless Steel using an uncoated cemented carbide with different cutting speed (90, 150 and 210 m/min) and feed (0.10, 0.16 and 0.22 mm/rev), it was concluded that power demand increases with the increase of the cutting speed and decrease of the feed for particular machining. Finally the optimal of cutting conditions in terms of power demand and tool life was obtained to be in the low level for both of cutting speed and feed.

REFERENCES

- [1] Knight W.A. and G. Boothroyd. 2005. Fundamentals of metal machining and machine tools. Vol. 69. CRC Press.
- [2] Noordin M.Y., V.C. Venkatesh, C.L. Chan, and A. Abdullah. 2001. Performance evaluation of cemented carbide tools in turning AISI 1010 steel. *Journal of Materials Processing Technology*. 116(1): 16-21.
- [3] Selvaraj D.P. and P. Chandramohan. 2010. Optimization of surface roughness of AISI 304 austenitic stainless steel in dry turning operation using Taguchi design method. *Journal of Engineering Science and Technology*. 5(3): 293-301.
- [4] Özel T., T.-K. Hsu and E. Zeren. 2005. Effects of cutting edge geometry, workpiece hardness, feed rate and cutting speed on surface roughness and forces in finish turning of hardened AISI H13 steel. *The International Journal of Advanced Manufacturing Technology*. 25(3-4): 262-269.
- [5] Lalwani D., N. Mehta and P. Jain. 2008. Experimental investigations of cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel. *Journal of Materials Processing Technology*. 206(1): 167-179.
- [6] Saglam H., S. Yaldiz and F. Unsacar. 2007. The effect of tool geometry and cutting speed on main cutting force and tool tip temperature. *Materials & Design*. 28: 101-111.
- [7] Pusavec F. and J. Kopac. 2009. Achieving and Implementation of Sustainability Principles in Machining Processes. *Advances in Production Engineering & Management*. 4(3): 151-160.
- [8] Kopac J. 2009. Achievements of sustainable manufacturing by machining. *Journal of Achievements in Materials and Manufacturing Engineering*. 34(2): 180-187.
- [9] Jayal A.D., F. Badurdeen, O.W. Dillon Jr and I.S. Jawahir. 2010. Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*. 2(3): pp. 144-152.
- [10] Jawahir I.S. and A.D. Jayal. 2011. Product and Process Innovation for Modeling of Sustainable Machining Processes. *Advances in Sustainable Manufacturing: Proceeding of the 8th Global Conference on Sustainable Manufacturing*. pp. 299-305.
- [11] Seliger G., H. Kim, S. Kernbaum and M. Zettl. 2008. Approaches to sustainable manufacturing. *International Journal of Sustainable Manufacturing*. 1(1-2): 58-77.
- [12] Jovane F., H. Yoshikawa, L. Alting, C.R. Boër, E. Westkamper, D. Williams, M. Tseng, G. Seliger and A.M. Paci. 2008. The incoming global technological and industrial revolution towards competitive sustainable manufacturing. *CIRP Annals - Manufacturing Technology*. 57(2): 641-659.
- [13] Gutowski T., J. Dahmus and A. Thiriez. 2006. Electrical Energy Requirements for Manufacturing Processes. 13th CIRP International Conference on Life Cycle Engineering.
- [14] Bhattacharya A., S. Das, P. Majumder and A. Batish. 2009. Estimating the effect of cutting parameters on surface finish and power consumption during high speed machining of AISI 1045 steel using Taguchi design and ANOVA. *Production Engineering*. 3(1): 31-40.
- [15] Królczyk G., M. Gajek, and S. Legutko. 2013. Effect of the cutting parameters impact on tool life in duplex stainless steel turning process. *Tehnički Vjesnik-Technical Gazette*. 20(4): 587-592.
- [16] Sharman A., J. Hughes and K. Ridgway. 2004. Workpiece surface integrity and tool life issues when turning Inconel 718™ nickel based superalloy. *Machining Science and Technology*. 8(3): 399-414.
- [17] Nur R., D. Kurniawan, M. Noordin and S. Izman. 2015. Optimizing Power Consumption for Sustainable Dry Turning of Treated Aluminum Alloy. *Procedia Manufacturing*. 2: 558-562.

Documents

Nur, R.

Sustainable machining by optimizing the power demand through dry turning of 316L stainless steel
(2017) *ARPJ Journal of Engineering and Applied Sciences*, 12 (6), pp. 1885-1889. Cited 2 times.

Department of Mechanical Engineering, Politeknik Negeri Ujung Pandang, Makassar, Indonesia

Abstract

This paper presents the experimental results from modelling and optimization of cutting conditions when turning processes of AISI 316 stainless steel using a central composite design (CCD). Type of AISI 316L, a series of stainless steel, is typical as medical grade that occur difficulties in machining. Power demand and tool life were measured, analyzed and modelled. The results of this experimental work show that the cutting speed has a significant effect on machining responses (power demand and tool life) compared with feed, and that optimum machining parameters was obtained, while following towards sustainability were in terms of minimizing power demand, extending of tool life and improving productivity. The models developed were used for evaluating and optimizing the input process, to obtain optimum machining responses for an overall process improvement. © 2006-2017 Asian Research Publishing Network (ARPJ). All rights reserved.

Author Keywords

And stainless steel; Power demand; Tool life; Turning

Correspondence Address

Nur R.; Department of Mechanical Engineering, Politeknik Negeri Ujung PandangIndonesia; email: rusdinur@poliupg.ac.id

Publisher: Asian Research Publishing Network

ISSN: 18196608

Language of Original Document: English

Abbreviated Source Title: ARPJ J. Eng. Appl. Sci.

2-s2.0-85015989449

Document Type: Article

Publication Stage: Final

Source: Scopus

ARNP Journal of Engineering and Applied Sciences

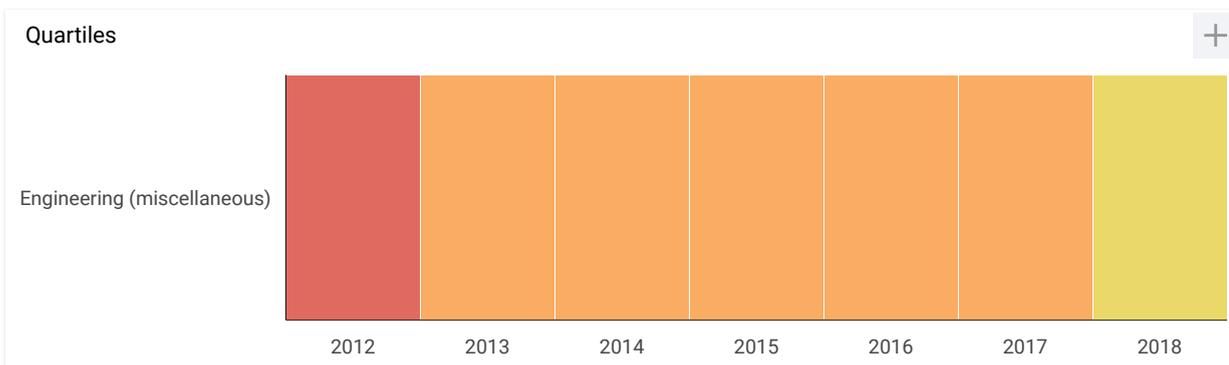
21

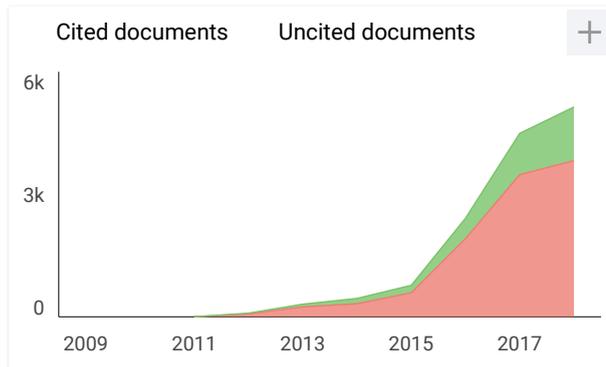
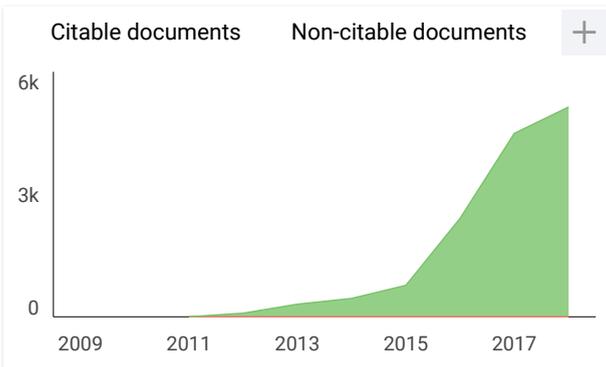
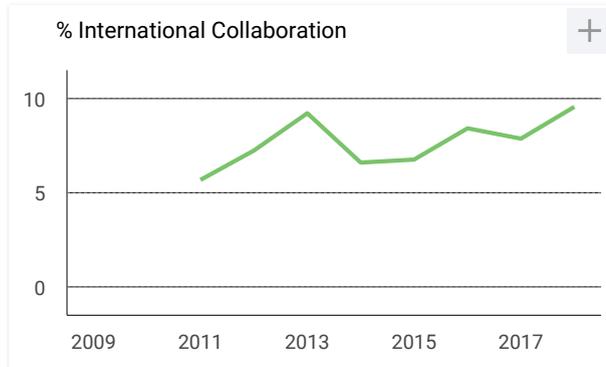
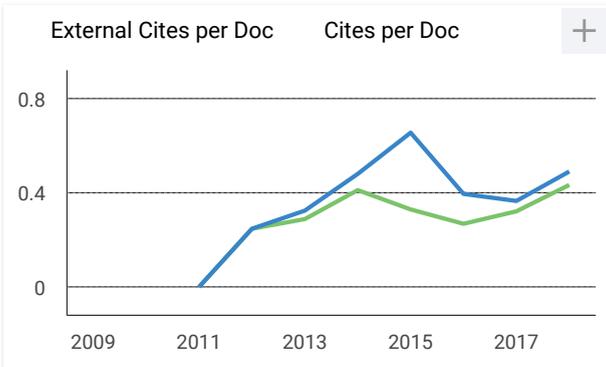
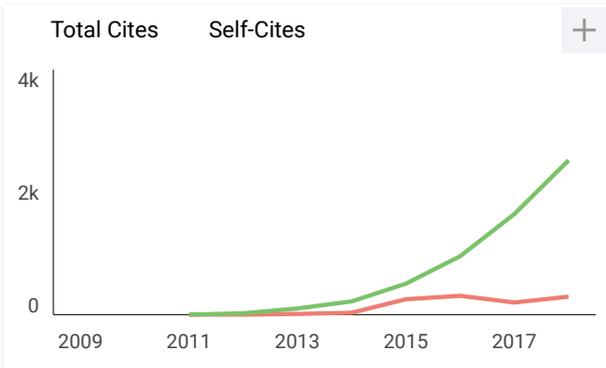
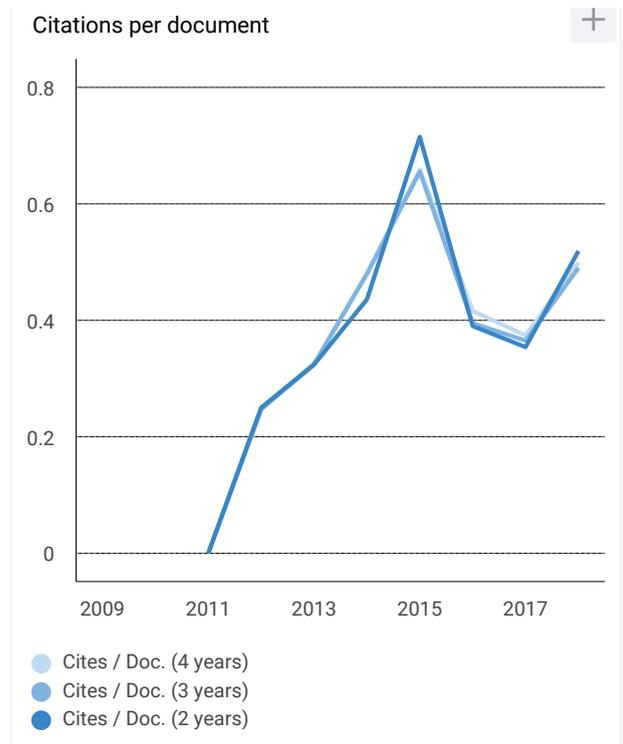
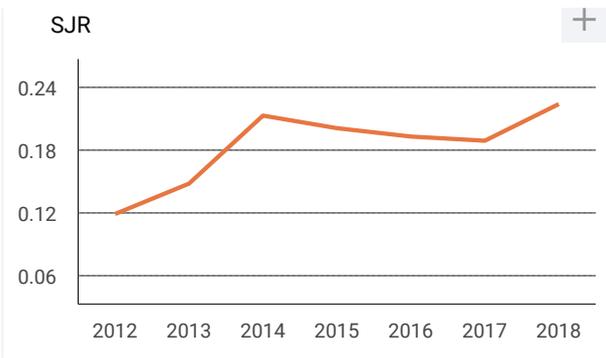
H Index

Country	Pakistan -  SIR Ranking of Pakistan
Subject Area and Category	Engineering Engineering (miscellaneous)
Publisher	Asian Research Publishing Network (ARNP)
Publication type	Journals
ISSN	18196608
Coverage	2011-ongoing

Scope ARPN Journal of Engineering and Applied Sciences (ISSN 1819-6608) is an online peer-reviewed International research journal aiming at promoting and publishing original high quality research in all disciplines of engineering sciences and technology. All research articles submitted to ARPN-JEAS should be original in nature, never previously published in any journal or presented in a conference or undergoing such process across the globe. All the submissions will be peer-reviewed by the panel of experts associated with particular field. Submitted papers should meet the internationally accepted criteria and manuscripts should follow the style of the journal for the purpose of both reviewing and editing. Our mission is -In cooperation with our business partners, lower the world-wide cost of research publishing operations. -Provide an infrastructure that enriches the capacity for research facilitation and communication, among researchers, college and university teachers, students and other related stakeholders. -Reshape the means for dissemination and management of information and knowledge in ways that enhance opportunities for research and learning and improve access to scholarly resources. -Expand access to research publishing to the public. -Ensure high-quality, effective and efficient production and support good research and development activities that meet or exceed the expectations of research community. Scope of Journal of Engineering and Applied Sciences: -Engineering Mechanics -Construction Materials -Surveying -Fluid Mechanics & Hydraulics -Modeling & Simulations -Thermodynamics -Manufacturing Technologies -Refrigeration & Air-conditioning -Metallurgy -Automatic Control Systems -Electronic Communication Systems -Agricultural Machinery & Equipment -Mining & Minerals -Mechatronics -Applied Sciences -Public Health Engineering -Chemical Engineering -Hydrology -Tube Wells & Pumps -Structures

-  [Homepage](#)
- [How to publish in this journal](#)
- [Contact](#)
-  [Join the conversation about this journal](#)





ARPJ Journal of Engineering and Applied Sciences ← Show this widget in your own website

Q2 Engineering (miscellaneous)
best quartile

SJR 2018
0.22

powered by scimagojr.com

Just copy the code below and paste within your html code:

```
<a href="https://www.scimagojr.com" style="border: 1px solid #ccc; padding: 2px 5px; display: inline-block;">https://www.scimagojr.com
```

A

ahmed abed 4 weeks ago