



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**EFFECT LOADING FORCE AND NUMBER OF OBSERVATION ACCURACY OF
AGED INCONEL 718**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process)(Hons.)

by

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ABSTRAK

Eksperimen ini dilakukan untuk mengkaji kesan daya muatan dan bilangan pemerhatian terhadap penuaan Inconel 718. Penuaan Inconel 718 ini telah diketahui nilai kekerasan iaitu 450 HV dan adalah salah satu bahan yang penuaan pada suhu 680 darjah Celsius. Selepas itu, eksperimen ini mengkaji terhadap sampel yang sama dalam pelbagai beban tersusun. Ini berlaku disebabkan oleh masalah dalam kesan saiz lekukan iaitu pada kadar beban yang sangat rendah terhadap keputusan ujian ke atas bahan yang sama tidak malar. Selain itu, dari segi ujian Vickers dengan beban gunaan 0,05-0,03 kgf, nilai kekerasan diukur biasanya bersamaan dalam ketepatan statistik. Perubahan HV telah dilihat di dalam kadar beban yang berbeza dan terhadap bilangan pemerhatian. Ia mendapati bahawa bagi bahan yang sama, kekerasan mikro berlaku penurunan dengan peningkatan beban ujian. Bilangan pemerhatian juga telah dikaji. Ini adalah untuk menentukan yang terbaik daripada beberapa bilangan pemerhatian untuk mendapat nilai kekerasan yang tepat. Oleh itu, eksperimen ini telah menentukan iaitu sebanyak 20 kali pengukuran memberikan tepat nilai-nilai yang diperlukan. Akhirnya, ia boleh dibuat kesimpulan bahawa perubahan beban dilekukan adalah memberi kesan kepada nilai-nilai kekerasan yang diperlukan.

ABSTRACT

This experiments was investigated the effect loading force and number observation accuracy of aged Inconel 718. Aged Inconel 718 have known hardness value which is 450 HV is one material that aging at 680 degree Celsius. After that, this experiment applied in the same sample over a wide range of loads indented. This caused of problems in indentation size effect which is at very low loads test results on a same material is not constant. Besides that, in term of Vickers tests with an applied load of 0.05 to 0.03 kgf, measured hardness values are usually equivalent within statistical precision The variation HV was observe in term of different load indented and number of observation. It found that for the same material the Vickers microhardness decrease with increasing of test loads. Number observation also was investigated. This is for determine the best of number observation in term of getting the accurate value hardness. So, this experiment determines 20 times of measurement give the accurate of required values. Finally, it concluded that variation of load indented was affect to values of hardness required.

DEDICATION

For my beloved family:

Zulkeflee Bin Abdul Hadi

Zarina BintiMohamed Amin

And

BMFP's Students

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ESI	-	Effects Size Indentation
Hv	-	Hardness Vickers
°C	-	Degree Celsius
%	-	Percentage

CHAPTER 1

INTRODUCTION

This section introduces the properties and application of Inconel in industry. Besides that, this section mentions about the problem that need to encountered, objective and the scope of work for this project. The work motivation and the organization of report dissertation also included in this chapter.

1.1 Project background

Inconel 718 is a one of the super alloy categories which are nickel super alloy. From aspect properties, Inconel 718 are consists of high hardness, low thermal conductivity, and high strength at high temperature. Besides that, the application of Inconel 718 are also frequently used in fabricating aerospace, aircraft industry such as blades, disks, and shaft in gas turbines engines (M. Bengersallah, 2013).

However, variety of method used to characterize the properties of aged Inconel 718. One of the method used to determine or characterize the mechanical properties such as hardness of the material is Vickers microindentation testing. Vickers microindentation hardness consists of diamond indenter. The indenter in a pyramidal shape with an angle 136 degrees between opposite faces assures a constant value for HV at all test loads (Voort, April 2012).

Inconel 718 with hardness value 450 HV is one material that aging at 680°C. (C. Slasma, 2000). In this experiment, aging of Inconel 718 to be tested with 0.05 to 0.03 kilogram force (kgf) load and also in a different of number observation during the testing. This caused of problems in indentation size effect which is at very low loads test results on a same material is not constant. Besides that, in term of Vickers tests with an applied load of 0.05 to 0.03 kgf, measured hardness values are usually equivalent within statistical precision. The literature based on (Gabriela Strnad, 2014) related to hardness Vickers at low loads carried out by four trends such as:

1. Hardness value decreases when load force decreases;
2. Hardness value increases when load force decreases;
3. Hardness value is essentially constant as load varies;
4. Hardness value increases when load force decreasing.

There are various factors that affect the result accuracy of Vickers hardness testing which are human error, speed of loading, indenter shape of deviations, quality of specimen preparation, indentation time and magnification (Gerberich W.W, 2002). Therefore, different load of indenters and number of observation in implementing the experiments will prevail.

After that, aged Inconel 718 have a specific characteristics and microstructures, so their hardness depends on the indentation loads but the lack of this information makes it difficult to determine or compare the results which have the same purpose but using the different indentation of loads. From of that, these experiments are investigating the effect loading force of microhardness accuracy of aged Inconel 718.

1.2 Problem Statement

By theory, the value of microhardness should be constant when the load applied is different (Chanya Chuenarrom, 2009). But in low load, the test results on a material are not constantly. (Voort, April 2012). That means, the value of microhardness is not accuracy of the same sample testing. Then, in term of using by microhardness Vickers testing also related with an accuracy and repeatability of reading (McGhee, 2008). Repeatability is one factor that measure of how well the instrument is able to duplicate its results on recognized hardness standards (McGhee, 2008). To obtains the accurate result of microhardness value, so it must use the correct information. The lack of this information makes it difficult to compare the previous studies of result and also difficult to identify the suitable load to use on material. Here, to get the accuracy on the results, the suitable load of indentation and suitable repeatability in measurement of sample material is interdependent.

1.3 Objective

The main purposes of this project are:

- a) To study variation HV of different indentation load.
- b) To investigate the suitable number observation reading in term of getting the best value of hardness.
- c) For determination of the optimum in producing the desired response.

1.4 Scope of Project

This research focuses to study on the effect loading force on microhardness accuracy of aged Inconel 718. Using a microhardness tester (Mituyoyo HM 200 Series), Inconel 718 specimen was impressed with loads of 0.05 kgf, 0.1 kgf, 0.2 kgf and 0.3 kgf using a Vickers indenter. Dwell time is set of 10 sec. The minimum spacing of indents was 2.5 times the indents diagonal which is 3-5 mm. Location indenter of specimen is random. Then, each test will repeat three times with the same load and time. The average three reading was recorded in HV value of a specimen. Lastly, the value obtained will be analyzed by using mini tab software.

1.5 The Organization of Report Dissertation

Project organization is needed to make this project more organized so that all the details from the start and by the end of the project can be gathered.

In chapter one there will be project overview that consist the overall of the project, that is specify to investigate the effect of loading force on the microhardness accuracy of Inconel 718. The problem statement is about the problem or lack information to obtain the accurate result of microhardness value. The objectives of the project are to determine the suitable indentation load against of aged Inconel 718, to evaluate the effect of indentation loads on Vickers microhardness test for Inconel 718 and investigate the suitable frequency reading in term of getting the best value of hardness. Scope the project which is most probably concern method for measured the hardness used of aged Inconel 718, load indenter, dwell time, and frequency taken during the experiment section.

Chapter two will content the literature review using resource for books, journal, websites about the composition and properties of aged Inconel 718, previous research related of aged Inconel 718, Vicker testing, equation of hardness, effect loading force for reading.

Chapter three, the methodology that been used in this project which contain the details about the material selection, material preparation, and in analysing result.

Chapter four will be the result and analysis of the best load indenter, repeatability reading that be used for Inconel 718 and effect reading indifferent load indenter.

Chapter five is summary and conclusion that will conclude and summarize overall about the project. It also contains the recommendation for the future work. Figure 1 below shows the organization of report dissertation.

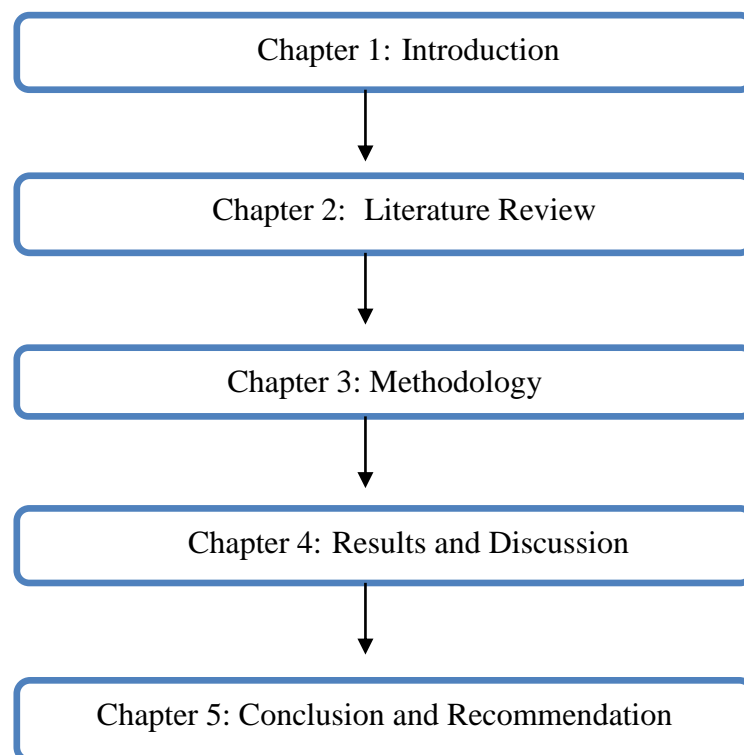


Figure 1.1: Organization of Report Dissertation

1.6 Summary

This project is about the study variation HV of different indentation load and number observation in term of determination of the optimum in producing the desired response for aged Inconel 718. This chapter mention about the problem to be encountered, objective of project and the scope of works. Next chapter will review all the information regarding this project. The review process is based on the research from books, journal, and websites about the properties of Inconel 718, load indenter, previous research, and repeatability of reading. Lastly, the effect of loading force on microhardness will recover.

CHAPTER 2

LITERATURE REVIEW

This chapter will be discussed about the reviews from previous researches regarding to effect loading force on microhardness and number of observation accuracy of Inconel 718. The research also focuses on the variety of loads using during the Vickers hardness and the concept for analyzed the results.

2.1 Aged Inconel 718

Basically, Inconel 718 is a nickel-based material that is in the super alloy categories. Then, as well known, it is a difficult to cut material because Inconel 718 have a high strength at high temperature and high hardness. Table 2.1 below show the compositions of Inconel 718. But in this experiment use an aged Inconel 718 because is usually used by researches and this material, it aging at high temperature which 680 degree Celsius and hardness values obtained is 450 HV (C. Slasma, 2000).

Table 2.1: Major composition of Inconel 718

(D.G. Thakur, 2010)

Elements	C	Mn	Si	Ti	Al	Co	Mb	Cb	Fe	Cr	Ni
Percentage	0.08	0.35	0.35	0.6	0.8	1.0	3.0	5.0	17.0	19.0	52.82

2.2 Research of effect variation HV on different indentation load

Gabriela Strnad and Laszlo Jakab-Farkas (2014) purposed to investigation of improving the accuracy of low-load Vickers microhardness testing of hard thin film. This research activity was aiming to get the accurate value on hardness by using a wide range load. Besides that, also investigate the influence of micro loads on accuracy of Vickers microhardness indentation. Two samples with known Vickers microhardness which are 718 HV and 466 HV were used. Then, the load force applied for this experiment consists of 10 gf until 1000 gf. Other than, the result was determined by percentage of HV error. Table 2.2 below show the results of Vickers microhardness for the sample and Figure 2.1 shows the plotting graph for effect of load force on Vickers microhardness. Based on the results, it shows one of the trends which is when load force increases the value hardness is increased. So, the results with high error are not acceptance. After that, Figure 2.2 shows the results of measuring error.

Table 2.2: Results of Vickers microhardness sample

(Gabriela Strnad, 2014)

Load force F [gf]	Vickers microhardness HV [kgf/mm ²]	HV error [%]	Vickers microhardness HV [kgf/mm ²]
1000	727.47	1.32	470.29
500	733.83	2.20	465.22
300	739.00	2.92	457.51
200	728.17	1.42	461.00
100	730.58	1.75	450.63
50	698.65	-2.69	449.50
25	630.43	-12.20	412.70
10	536.69	-25.25	341.81

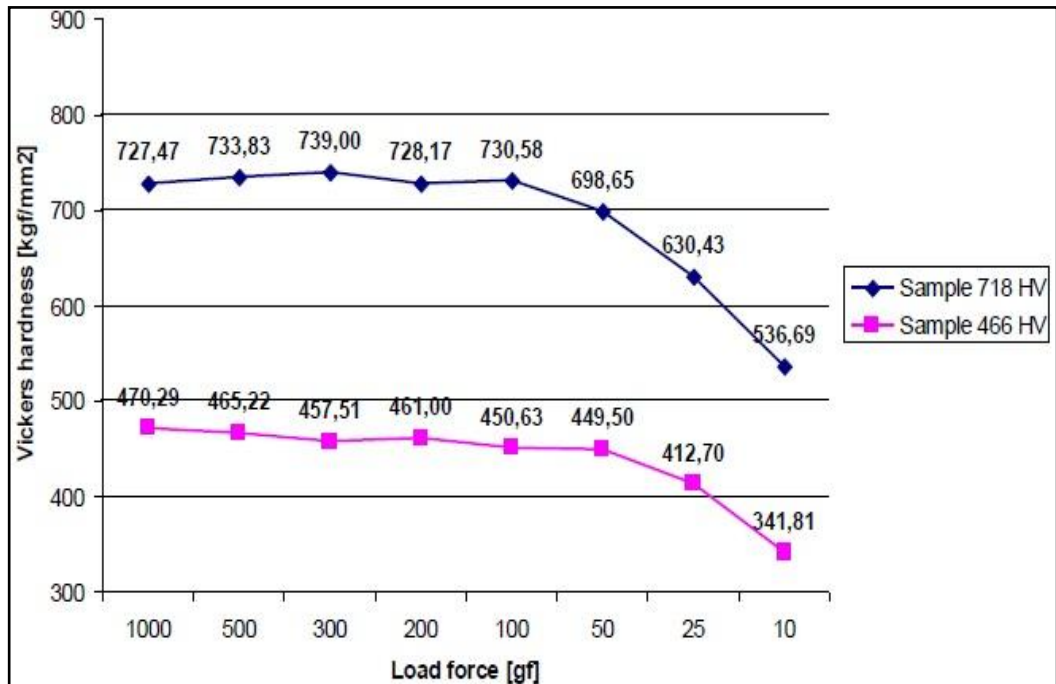


Figure 2.1: Effect of load force on Vickers microhardness.

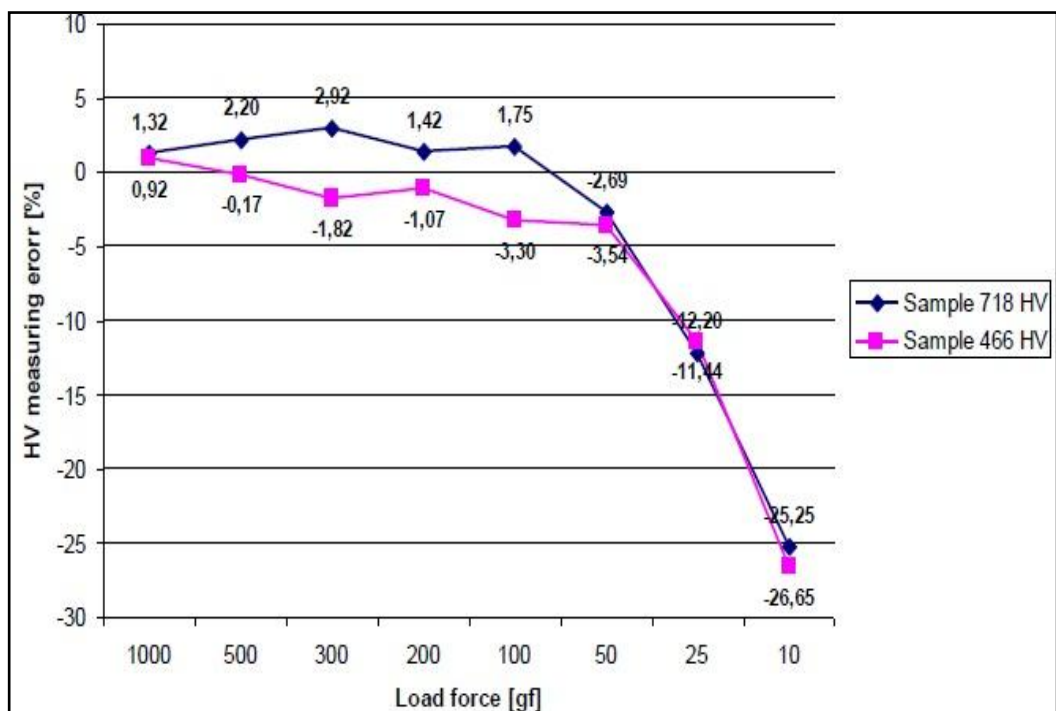


Figure 2.2: Percentage of measurement error.

Chanya Chuenarom and Pojjanut Benjakul (2009) were investigating the effect on a variation of indentation load. In the same time, also study effect of time indentation on the Knoop and Vickers hardness for enamel and dentin. In this experiment, 20 enamel and 20 dentin specimens were prepared. The specimen was separated with 10 dentin and 10 enamel samples that be used for Vicker hardness. Then, the rest of sample used for Knoop microhardness. The load force applied for enamel consists of 100 to 300 gf. Besides that, for dentin was applied 10, 25, and 50 gf . The both of the process set in a difference time indentation which are 10, 20, 30 seconds. Based on the results showed the difference in time indentation was not affect on hardness values but was affected by variation indentation loads. Figure 2.3 shows the Vickers indentation marks on enamel of variation indentation load and average Vickers hardness at different indentation load and time indentation.

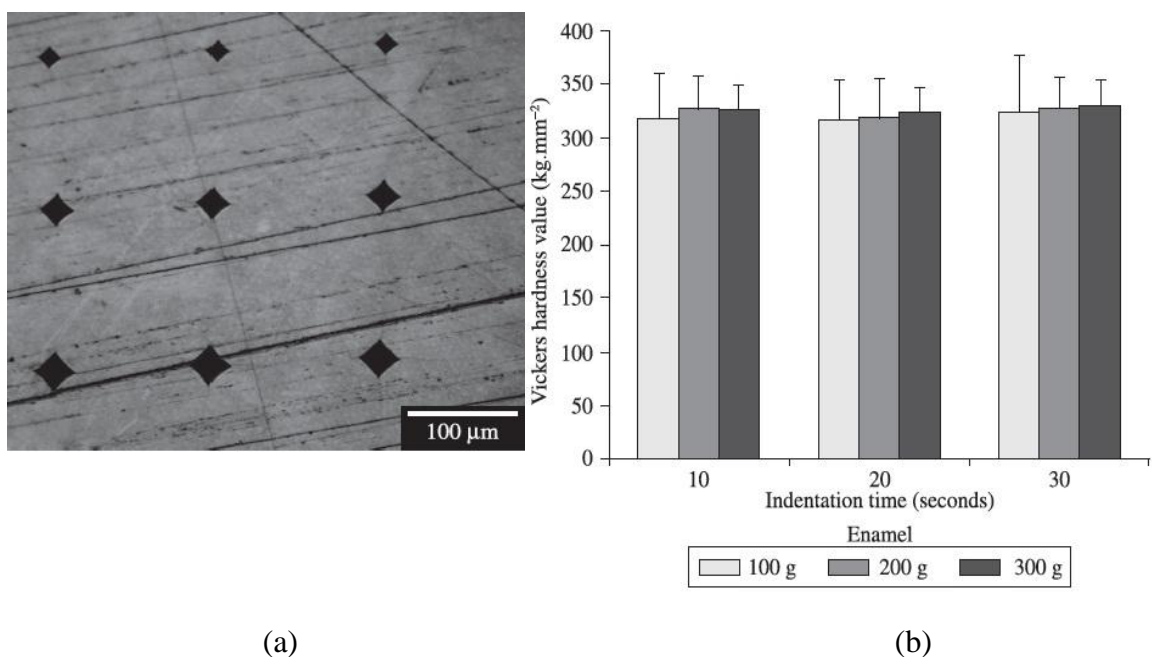


Figure 2.3: (a) Vickers indentation marks on enamel of variation indentation load and (b) Average Vickers hardness at different indentation load and time indentation. (Chanya Chuenarom, 2009)

Leposava Sidjanin (2007) was studied in measurement of Vickers hardness on ceramic floor tiles. This experiment, the load applied consists of 0.1 kgf, 0.2 kgf, 0.5 kgf, 1.0 kgf and lastly 5.0 kgf. The aim for this experiment was compared between macrohardness and microhardness value in a variation of indentation for two types of clays materials which are kaolinite and illete-carbonate. Based on the results show when the microhardness testing applied, the measurements of value hardness decrease when the test load increased. So, variation of the indentation was affected to value hardness. Figure 2.4 below shows the results of Vickers hardness value with different indentation load.

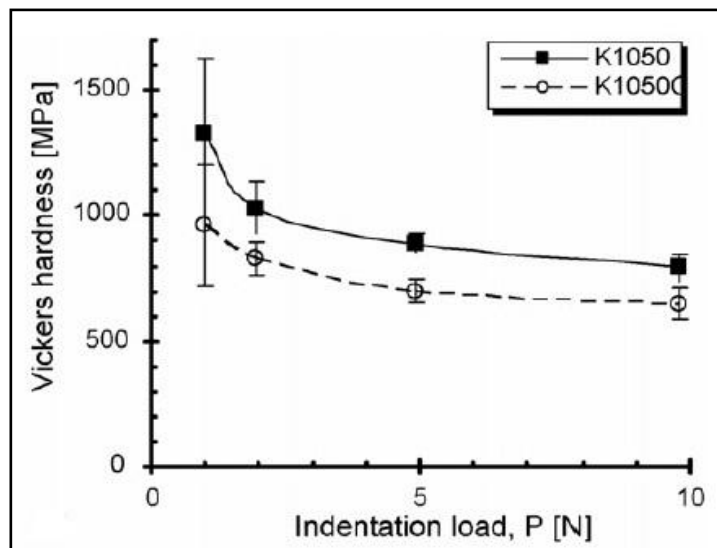


Figure 2.4: Vickers hardness value with different indentation load.

D. Chicot (2007) was study the comparison between Knoop and Vickers hardness of various on soft materials and also hard ceramic. In this experiment also applied variation of indentation load which are 0.1 kgf, 0.25 kgf, 0.50 kgf, 1.0 kgf, 2.0 kgf, 3.0 kgf, 5.0 kgf, and 10.0 kgf. Based on the results shown in Table 2.3 below, the load applied is increase and then, the value of hardness obtained is decrease. It is clear to see that variation of load indentation can affect to value of hardness. This experiment can conclude that Knoop hardness is always lower than Vickers values of hardness.

Table 2.3: Vickers and Knoop measurement of hardness value for two light alloy materials.

(D. Chicot, D. Mercier, 2007)

Load (N)	Al-Cr-Zr-Mn		Mg-20 wt.% li	
	VHN	KHN	VHN	KHN
0.1	1.61	1.98	1.37	1.50
0.25	1.55	1.78	1.39	1.43
0.50	1.60	1.75	1.39	1.58
1	1.59	1.73	1.42	1.40
2	1.57	1.68	1.38	1.41
3	1.58	1.65	1.37	1.54
5	1.56	1.63	1.39	1.36
10	1.56	1.69	1.37	1.43

Susmita Karan (2005) was investigating the Vickers microhardness on solution-grown single crystal of magnesium sulphate hepta-hydrate. This research also used variation of indentation load for (0 1 0) and (1 0 0) faces. Based on the Figure 2.5 below, clearly shows that value of hardness for 2 faces are decrease with increase the load applied from 0.01 kgf until 0.05 kgf. But in range of load 0.06 until 0.08 kgf the measurements of hardness is appears to level off.

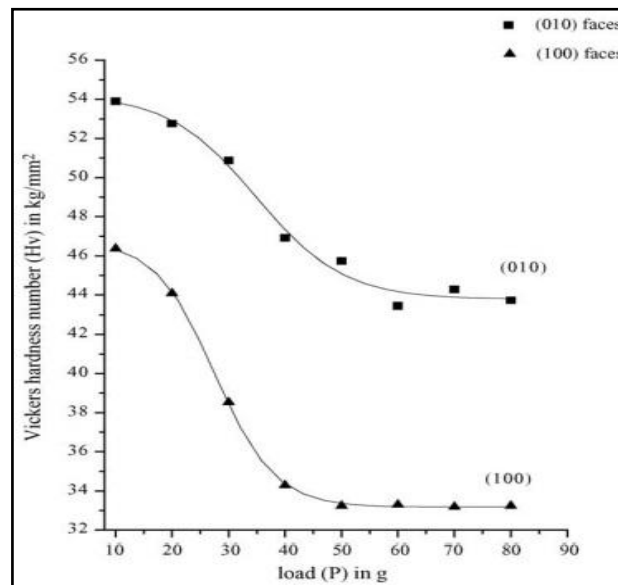


Figure 2.5: Value of Vickers hardness with variation of indentation loads.