Engineering and Technology Journal e-ISSN: 2456-3358
Volume 07 Issue 12 December-2022, Page No.-1769-1773
DOI: 10.47191/etj/v7i12.02, I.F. – 6.484

Utilisation of Small Industrial Solid Waste Welding Workshops Carbide as a Raw Material for Gypsum ($CaSO_4$) Production

Nyoman Sri Widari
Food Technology, University of Ciputra Surabaya, Indonesia

ABSTRACT: In order to increase the effectiveness of the clean production program in the small carbide welding workshop industry, it is necessary to make efforts to reduce the existence of the waste produced because it pollutes the soil, water and air environment. To minimize the presence of waste, research was carried out by utilizing solid carbide welding waste as a raw material for making gypsum ($CaSO_4$) which is widely used for industrial needs. The implementation is by reacting the waste with various concentrations of H_2SO_4 solution by adjusting the reaction time and reaction temperature. The results of the initial analysis of carbide welding workshop solid waste in the form of $Ca(OH)_2$ slurry contained relatively high levels of CaO, namely 71.58%. From the results of the research that has been done, it can be concluded that the largest conversion value of 34.98% was obtained by using 12N H_2SO_4 with a reaction temperature of 50^oC and a reaction time of 40 minutes.

KEYWORDS: carbide, welding, waste, H_2SO_4, gypsum, manufacture

I. INTRODUCTION

The existence of small carbide welding workshop industries in urban areas in Indonesia is growing with increasing people's living standards. Carbide welding workshop services offer a lot of work that can be done including repairing motor vehicles, making fences and other constructions. This activity generates a lot of waste in the form of water and $Ca(OH)_2$ waste in the form of solid slurry or paste and has materials that are difficult to dissolve in water, has a pungent odour and has a pH between 12 – 13. This waste includes hazardous waste with the hazard category 2 according to PPRI No 101 of 2014 concerning the management of Hazardous and Toxic Waste which just piles up around the workshop and disturbs environmental sanitation, causes an unpleasant odour and can reduce the quality of the water around it and if it is piled up on vacant land it can cause the soil to dry out and arid.

In accordance with the Indonesian government program, every industry must implement clean industrial management with the 6R principles, namely Reuse, Reduce, Recycle, Replace, Refill and Repair [1]. In waste management, Reuse is the utilization of waste that can be utilized directly according to its function and recycling, namely recycling waste so that new products are obtained that have economic value and more benefits. The recycling method is the easiest method to implement so that a clean industrial program can be achieved. There have been several studies utilizing this solid waste as a mixture in the manufacture of tiles, paving blocks, mortar, and concrete tiles [2][3][4][5] with positive results. Carbide welding waste can also be used to absorb heavy metal content in woven fabric washing liquid waste. utilizing carbide waste and industrial soda wastewater to produce $CaSO_4$ where the greatest conversion was achieved at a reaction temperature of 60^oC with a reaction time of 40 minutes and a ratio of 1:3 reactants, the largest conversion was obtained at 46.36% with a $CaSO_4$ content of 25.96%. However, in the field, there are still many solid wastes that have piled up unutilized, so researchers are trying to recycle solid waste from carbide welding workshops by using it as a raw material for gypsum production. In Indonesia, gypsum is found in the form of sediment in a relatively limited amount by means of extraction which is quite difficult. Areas that are often found include Cirebon, Rembang, Cepu, Madur and on the south coast of Java Island, with relatively low quality [7] while the need for gypsum as an industrial raw material is increasing every year.

The aim of the research is to fulfil the clean industry program, namely by recycling solid waste from carbide welding workshops into a new product in the form of gypsum by reacting the waste with various concentrations of H_2SO_4 solution by adjusting the reaction temperature and reaction time.

II. THEORETICAL BASE

Small Industrial Solid Waste Carbide Welding Workshop

The small welding workshop industry provides welding and metal cutting services for building construction, repair of motorized vehicles and manufacture of household and agricultural equipment. Calcium abide or carbide used as a

raw material for carbide welding is a chemical compound with the chemical formula $CaCl_2$, in its pure state it is colourless and has a pungent odour, but the calcium carbide used in welding workshops is grey or brown in colour with a $CaCl_2$ content (80 – 85)% and the rest is in the form of compounds CaO, Ca_3P_2, CaS and so on [7]. Acetylene gas with the chemical formula C_2H_2 is colourless, has a characteristic odour and is toxic, is explosive and is used in the chemical industry for the synthesis of certain products [8]. The provision of ethylene gas in the small carbide welding industry is obtained by reacting calcium carbide compounds with water, with the following reaction [9].
This process is very simple with a very low cost, so it is widely used by small welding workshop industries, while the negative impact of this welding workshop industry is the production of waste in the form of water and the compound Calcium hydroxide [$Ca(OH)_2$] in the form of a slurry or paste and if left alone takes a long time to become dry and hard and difficult to dissolve in water, at 0^oC the solubility in 100 parts (g) is 0.185 and at 100^oC is 0.77. $Ca(OH)_2$ is white with a density of 3.34 g/cm^3[10][11].

Sulfuric Acid (H2SO4)
Sulfuric acid is a colourless liquid and is hygroscopic, corrosive and can mix with water in all ratios by releasing heat. Its concentrated acid contains more than 98% acid with a specific gravity of about 1.838 g/ml and a boiling point of 338^oC[11]. Sulfuric acid is not a very strong oxidizing agent but is a strong dehydrator for carbohydrates and other organic acids because it can break down carbohydrate compounds. to be elemental carbon. Sulfuric acid is a type of acid that is most widely used among other acids so the progress of a country's chemical industry is often equated with the need for sulfuric acid in that country [12].

Gypsum
The compound CaO or Calcium oxide is one of the compounds that make up the chemical formula of gypsum and is more often used in chemical processes is a compound that is unstable and very easily combines with water to form the compound calcium hydroxide [$Ca(OH)_2$] [13]. The gypsum compound contains a fairly high CaO content, which is around 28.11%, making it possible to use carbide welding waste as a raw material in its manufacture [14] considering that carbide welding waste also has a CaO content of around 72.37% [4].

Gypsum, commonly known as calcium sulfate dihydrate [$CaSO_4$ $2H_2O$], is a white powder with a purity of 91-92%, a melting point of 150^oC, a density of 2.32 g/cm^3 and solubility in water (20^oC): 0.21 g $CaSO_4$ $2H_2O$ / 100 g solution [10]. Based on the difference in the molecular weight of calcium sulfate, 3 types are known, namely: Calcium sulfate dihydrate [$CaSO_4$ $2H_2O$], Calcium hemihydrate [$CaSO_4$ $1/2H_2O$] and calcium sulfate anhydrous [$CaSO_4$]. Theoretically, the change point for pure gypsum is as follows [12].

$CaSO_4\ 2H_2O\ (c) \rightarrow CaSO_4\ 1/2\ H_2O\ (c) + 3/2H_2O(g)$ (at 120 – 150^o C temperature)

$CaSO_4\ 1/2\ H_2O \rightarrow CaSO_4$ (at 190^oC temperature)

The temperature change is strongly influenced by the amount and type of impurities contained therein so it will also affect the chemical and physical properties of gypsum.

In the formation of gypsum compounds, there are several factors that must be considered in order to obtain the expected quality and quantity, these factors are [9] [15]
The concentration of a reactant will greatly affect the rate of reaction and the amount of product produced. To increase the product of the reaction is to make excess H_2SO_4 to the amount of CaO being reacted.
In general, the higher the reaction temperature, the greater the rate of formation of reaction products, but in the gypsum formation reaction, the reaction temperature can determine the properties of the gypsum obtained.
The duration of the reaction process will affect the number of reaction products obtained, but up to a certain point, the number of products produced becomes constant because one of the reactants has finished reacting.
The stirring process also helps the movement of the reacted particles so that the composition of the reactants is evenly distributed at each point. Moving particles will cause collisions between molecules thereby accelerating the reaction process.
Calcium hemihydrate ($CaSO_4 1/2H_2O$) also known as gypsum plaster is a compound that is difficult to dissolve in water or other organic solvents, is white in colour with a molecular weight of 145.15, melting point is 163^oC and the solubility per 100 g in water at 25^oC is 0. 3 g [11]. With the development of various types of industry, the need for gypsum plaster as a raw material is also increasing including being used in the industrial sector [8] As a retarder in cement factories which functions to regulate cement hardening time, widely used for making sculptures, lamp bases and other artistic items. Very pure and high-quality plaster casts are widely used in dentistry and orthopaedic surgery. Other uses as a colour fixing agent in the paint industry, for enamel, used in the manufacture of mortar, marble cement, paper industry and so on.

III.METHODOLOGY
In carrying out the research used equipment in the form of a three-neck flask, Erlenmeyer, stirrer and electric heater, thermometer, furnace, oven, scales and filter paper. While the materials needed are carbide welding industrial solid

waste, H_2SO_4, NaOH, EDTA, $MgSO_4$, $AgNO_3$ and distilled water. Fixed variable: Weight of CaO = 2 gram; Stirring = 100 rpm; 100 ml of H_2SO_4 solution with various concentrations. Variable changes: 1) Concentration of H_2SO_4(N): 9; 10; 11; 12. 2) Reaction temperature (°C): 30; 40; 50; 60 and 3) Reaction time (minutes): 20; 30; 40; 50; 60.

Research Procedure

Carbide welding workshop waste from the welding workshop area in Surabaya in the form of slurry [$Ca(OH)_2$] was analyzed specifically for the CaO content contained therein, then slurry [$Ca(OH)_2$] in a certain amount according to the experimental needs was heated in a furnace at 600°C so that CaO compounds were obtained. Then a three-neck flask was installed with a stirrer placed above the electric heater, then put 2 grams of CaO and 100 ml of H_2SO_4 solution were with the concentration adjusted to the variables that had been set as well as the reaction temperature and reaction time. After the reaction is complete, the results are filtered and weighed, and then the conversion is calculated

IV. DISCUSSION

As we know, carbide welding workshops produce solid waste in the form of calcium hydroxide compound [$Ca(OH)_2$] which is waste with hazard category 2. The results of the analysis of carbide welding workshop solid waste from the welding workshop area in Surabaya obtained CaO levels. 71.58%; Si_2O_3 0.76%; Al_2O_3 2.85% and other compounds 24.81%. Meanwhile[4] shows carbide waste from one of the gas industries in East Java containing 95.37% CaO; Si_2O_3 0.94%; Al_2O_3 0.61% and other compounds 3.08%. This analysis shows that the CaO content is the highest, making it possible to use it as a raw material for gypsum manufacture. The first step taken in this study was to heat the waste [$Ca(OH)_2$] in the furnace to a temperature of 600°C to form CaO. Furthermore, the CaO obtained was reacted with a solution of H_2SO_4 with various concentrations and stirring was carried out at various temperatures and reaction times, so that the reaction was perfect. Then the reaction results were filtered using filter paper and then weighed and the reaction conversion was calculated. The reactions that occur in the process of making gypsum from carbide welding workshop solid waste are as follows[9]

Furnace at 600°C : $Ca(OH)_2 \rightarrow CaO + H_2O$

Reaction the form of gypsum : $CaO + H_2SO_4 \rightarrow CaSO_4 + H_2O$

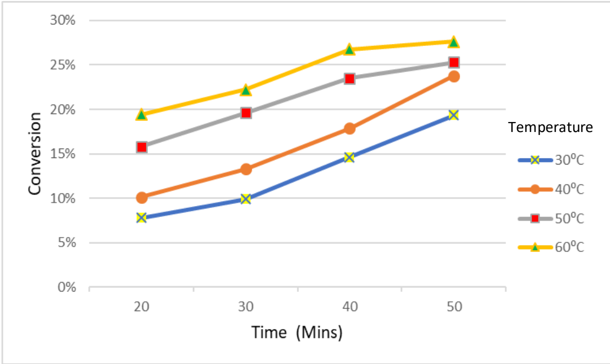

Figure 1. Conversion of gypsum produced by using 9N H_2SO_4 solution with various reaction temperatures and reaction times.

Figure 1 shows the use of a 9N H_2SO_4 solution, the conversion value obtained is still low, but the changes can be read. It can be seen that the higher the reaction temperature, the higher the conversion obtained, this is by [9][15] which states that the reaction rate increases with increasing reaction temperature, usually with an increase in temperature of 10°C it will be able to increase two to three times the reaction rate between molecules. reacting molecules. With an increase in temperature, the percentage of collisions between molecules that result in chemical reactions will be greater. It can be seen that at 30°C the reaction conversion produced was the smallest, while at 60°C the highest conversion was obtained. The longer the reaction process, the greater the conversion of the reaction because the opportunity for contact between the reacting molecules increases. When using 9N H_2SO_4 solution, the largest conversion of 27.65% was obtained at a reaction temperature of 60°C and a reaction time of 50 minutes. The conversion obtained is still low, this is because the conversion reaction is strongly influenced by the concentration of the H_2SO_4 solution.

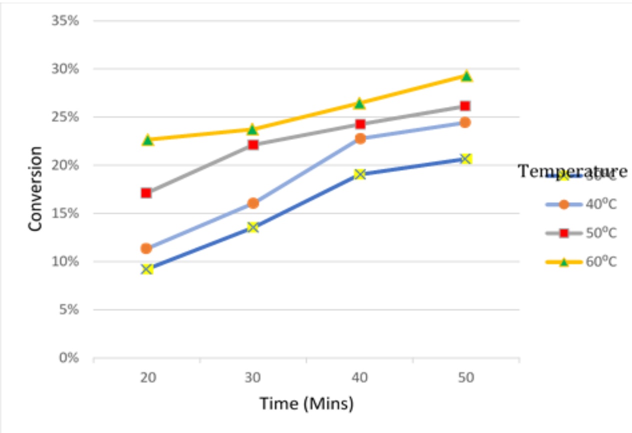

Figure 2. Conversion of gypsum produced by using 10N H_2SO_4 solution with various reaction temperatures and reaction times.

Figure 2 shows the use of 10N H_2SO_4 solution, the conversion value obtained has begun to increase, it can be seen that the higher the reaction temperature, the greater the conversion, as well as the addition of reaction time. In the 10N H_2SO_4 solution the number of SO4 $^{-2}$ ions is more than in the 9N H_2SO_4 solution, as a result, there are also more reactions between SO_4^{-2} ions and Ca^{+2} ions originating from CaO so that more reaction products can be produced. By using the reactant 10N H_2SO_4 the greatest conversion of 29.32% was obtained at a reaction temperature of 60°C and a reaction time of 50 minutes, but under these conditions, it still showed a trend of increasing yields.

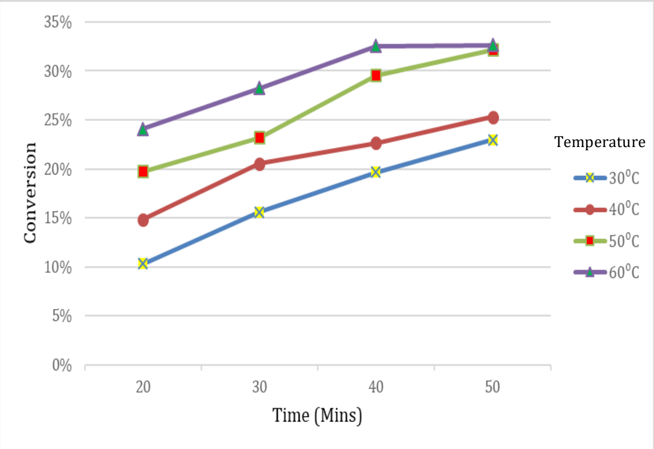

Figure 3. Conversion of gypsum produced by using 11N H_2SO_4 solution with various reaction temperatures and reaction times.

Figure 3 shows the use of 11N H_2SO_4 solution at a temperature of 30°C to 50°C and with increasing reaction time it can be seen that the conversion value is still experiencing an increasing trend, which means that SO_4^{-2} ions from H_2SO_4 and Ca^{+2} ions from CaO are still present and with increasing reaction time and increasing the increase in reaction temperature will still be able to produce the expected product. However, at a reaction temperature of 60°C with a reaction time of 40 minutes and 50 minutes, a conversion of 32.53% and 32.55% were obtained, respectively, and it seemed almost constant, so at a concentration of 11N H_2SO_4 an optimal conversion of 32.53% was obtained at a reaction temperature of 60°C with a reaction time 40 minutes.

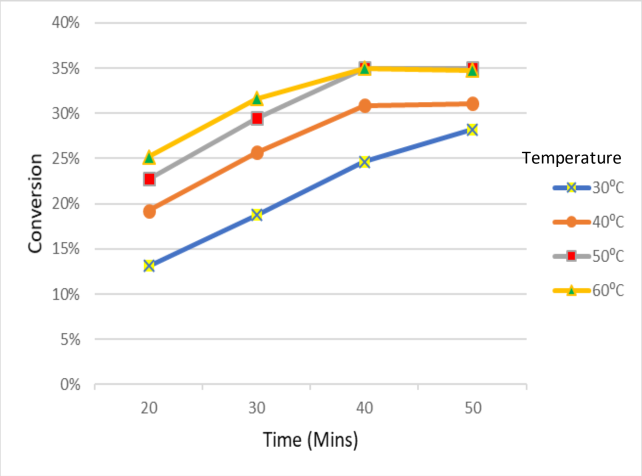

Figure 4. The conversion of gypsum was produced by using 12N H_2SO_4 solution with various reaction temperatures and reaction times.

Figure 4 shows the use of 12N H_2SO_4 solution, it can be seen that the conversion value obtained at each run is much greater than the previous reaction conditions. In order for a more perfect reaction to occur, it is necessary to have an excess of SO_4^{-2} ions so that the available Ca^{+2} ions can react more to form $CaSO_4$. At a reaction temperature of 50°C with a reaction time of 40 minutes and 50 minutes the conversion values obtained were 34.98% and 34.99% respectively. Here with an increase in reaction time of 10 minutes the reaction conversion can be said to be constant. Whereas at a reaction temperature of 60°C with a reaction time of 40 minutes and 50 minutes the conversion value is also close to constant, namely 34.97% and 34.98% so it can be concluded that using a 12N H_2SO_4 solution the optimal conversion of 34.98% is obtained at a reaction temperature of 50°C with a time 40 minutes reaction

V. CONCLUSION

Based on the results of the initial analysis of carbide welding workshop solid waste in the form of $Ca(OH)_2$ slurry containing a high enough CaO level of 71.58% the research was continued by utilizing carbide welding workshop solid waste as a raw material in the manufacture of gypsum ($CaSO_4$) by regulating the concentration of reagent H_2SO_4, reaction time and reaction temperature. From the data obtained, it can be concluded that the largest conversion value of 34.98% was obtained using 12N H_2SO_4 with a reaction temperature of 50°C and a reaction time of 40 minutes. In this study, the conversion value is still very low, so there is a need for suggestions to improve the results obtained so as to reduce the presence of carbide welding waste which can pollute the environment.

REFERENCES

1. Fernando,N.J. (2012) Kajian Eksperimen Genteng Hasil Daur Ulang Kotak Minuman Dengan Ukuran Cacach campuran 75 mm x 5 mm dan 50 mm x 5 mm . Sekripsi tidak diterbitkan. Depok: PPs Universitas Indonesia.
2. Dewi,N.R., Ashari, M., Dermawan, D. (2018) Studi Pemanfaatan Limbah B3 Karbit dan Fly Ash Sebagai Bahan Campuran Pembuatan Beton Siap Pakai (BSP) . Study Kasus Di PT . Varia Usaha Beton .Politeknik Perkapalan Negeri Surabaya. Surabaya.
3. Ian Syahrial, H., Suprapto. (2016) Pengaruh Penambahan Limbah Gas Asetilen Sebagai Pengganti Fly Ash Terhadap Kualitas Genteng Beton Sesuai Dengan SNI 0096: 2007. Rekayasa Teknik Sipil Vol.7 , No.1/rekat/ 16(2016) . 01 – 06.
4. Nuris Sidah, P., Moch. Lukman, A., Ridho, B . *Conference Proceeding on Waste Treatment Technology*. Progrsm Studi D4 Teknik Pengolahan Limbah. Politeknik Perkapalan Negeri Surabaya. ISSN . No. 2623 – 1727. Hal 7 – 11.
5. Arief Krim,H.M., Heni Junia. (2018) Pemanfaatan Limbah Karbit Sebagai Adsorben Penurunan Kandungan Logam pada Pengolahan Limbah Cair Pencucian Kain Tenun. Diatilasi, Vol.3, No.2, September 2018, Hal. 1 – 9.
6. Sani . Pemanfaatan Limbah Padat Pabrik Gas Asetilen dan Limbah Cair Pabrik Soda Untuk Pembuatan CaSO4. Jurnal Ilmiah Teknik Linkungan UPNV Jawa Timur . Vol 1. No.1. Hal 58 - 66
7. https:// id. Wikapedia. Org > wiki > Kalsium_Karbida. Diunduh tanggal 5 Oktober 2022.
8. [8] Hawley, G.G. (1971*) The Condensed Chemical Dictionary, Eighth Edition, Van Nostrand Reinholh Company*.
9. Vogel. 2005. Bulu Teks Analisis Anorganik Kualitatif Makro dan Semimikro. Edisi ke lima. PT. Kalman Media Pustaka. Jakarta.
10. Perry,R.H., and Green,D.w. (2008) *Perry's Chemical Engineers, 7 th ed McGraw Hill Companies Inc-USA.*
11. Kirk, R.E., and Othmer, O.F. (1988) *Encyclopedia of Chemical Tecnology. 4 th ed The Interscience Encyclopedia, Inc, New York.*
12. Austin,G.T. (1985) *Shreve's Chemical Process Industries. Fifth edition. Mc Graw-Hill Book Company* .
13. Naini , A., Rahmawati, D.(2010) *Composition Analysis of Calcium and Sulfur on Gypsum at the Purger District Jember Regency as an Alternative Gypsum Dental Material. Dentika Dental Jurnal, 2010; 15(2); page 179-183.*
14. Widya,P.S., Satria,Y.,Fitria,C. (2021) Uji Komposisi Gipsum tipe III Pabrikan dan Gipsum Tipe III Daur Ulang Dengan Teknik X-RAY Fluoresence Spectrometer (XRF) Dalam Upaya Pemanfaatan Limbah Gipsum Kedokteran Gigi. Menara Ilmu, Vol.XV, No. 01, Januari 2021. ISSN, 1693-2617. LPPM.UMSB, page 1-5.
15. Smith,J.M. (1981) *Chemical Engineering Kinetics. Third Edition . International Student Edition. McGraw-Hill Chemical Engineering Series.*