

Comparative study of forging parameters on microstructures and properties between Aluminum alloys Al6063 and Al7075

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Abstract: - This research were designed and created hot forging moulds of Aluminum alloys to investigate the effect of heating influence on machine qualifications of Aluminum alloys and know the suitable conditions of hot forging. The experimental variable was forging temperature and analyzed the experiment results for determined the suitable condition in hot forging on two types Aluminum alloys AlSi1Mg:Al6063 and AlZn5.5MgCuAl7075. The forming temperature were 300-500 °C and the work pieces was passed heat treatment process for improving microstructure by determined the forming ratio at 50 percent and used the machine which had efficiency about 400 ton. The results of the experimental revealed that the forming temperature effected to the force from Hot forging of Aluminum alloys Pre-heat temperature were higher value, done the forming force were lower and the forming temperature also effected to the material hardness. Aluminum alloys Al6063 had the highness value in forming; grain size of forging temperature at 300°C was 6.72 µm.

Key-Words: - Forging, Pre heat Temperature, Percent Reduction, Grain Size

1 Introduction

At the present, the metal forming industrials have high technology competitions, not only the modernized machinery but also the manufacturing process which reduced the production cost in various ways. The products qualifications considered of the customers requirements first. Choosing the workplaces and manufacturing, for the example was forging forming process of Aluminum alloys using the products were consisted of Aluminum alloys in some products. The forging process was the fast work pieces production and had accurate size when compared with the metal molding process [1-4]. For this reason were necessary to studied for searching several variables such as choosing the kinds of materials which were suitable with hot forming process, forging temperature, shape changing speed of work pieces which effected to several qualifications for searching the suitable conditions on hot forging of Aluminum materials. The most problems in hot forging was Pre-heat temperature was suitable with the work pieces and was also the important variable in grain producing of material and choosing the kinds of materials which were suitable with hot forging forming, the experimental was done by determined the variable forging forming temperature and the experimental results were analyzed for

determined the suitable condition in hot forging on two types of Aluminum alloys AlSi1Mg and AlZn5.5MgCu were able using.

2 Research methodology

2.1 The experimental materials

Two types of Aluminum alloys were AlSi1Mg:Al6063 and AlZn5.5MgCu :Al7075 were designed the work pieces while they were hot because when the materials were hot, they were inflated and the work pieces design had to the conformed on the experimental extent which used the forming percent reduction about 50. Therefore the work pieces design for the Hot forging forming were reserved the shrinkage percent value on the material which used for the experimental work pieces forming of Aluminum alloys sized Ø 50x50 mm.

2.2 The experimental and data collection

Forging forming temperature in this research was 300,350,400,450,500 °C. Before doing hot forging forming, types of Aluminum alloys were passed heat treatment process on ASM standard (American Society for Metal). The experimental designed the moulds which were given heating to kept up the heat with the work pieces for having Isothermal

condition to prevented heat losing of work pieces. The experimental procedure had two study variable- Temperature and Forming force, for marking the experimental was flexibility and efficiency. Therefore the Single factor (One way classification) were chosen by the Mathematics models analyzed force which was used forming and forging forming temperature to analyzed the relation between both of variable – Temperature and forming force.

3 Results and discussion

3.1 Influence of heat had effect to forging to Forming force

The result of the study revealed that Hot forging force had the proportion revered to Pre heat temperature, mean that when pre heat temperature had higher value, forming force would had lower value. Recorded the result of forming force value when compare with forging forming force of Aluminum alloys AlZn5.5MgCu :Al7075 had higher forming force value than Aluminum alloys AlSi1Mg:Al6063 explaining from an Fig. 1. comparison graph of forging force of aluminum alloys.

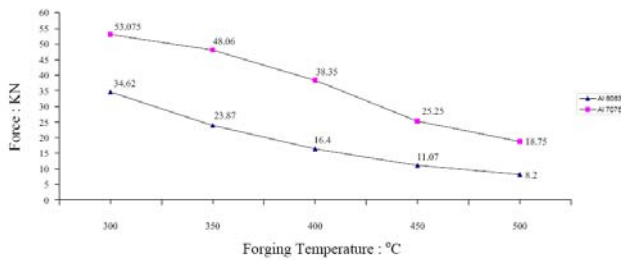


Figure 1 A relation between forging temperature and forging force.

3.2 Influence of heat had effect on hardness

3.2.1 Aluminum AlSi1Mg:Al6063

The result of the study revealed that Pre heat temperature had the effect to the materials hardness after forging forming by measuring the hardness on HB hardness measuring standard with dividing area of hardness measuring along to the axel line X and Y the length from the hardness measuring point for 5 mm. As an illustration 2 show the position of Aluminum alloys hardness measuring.

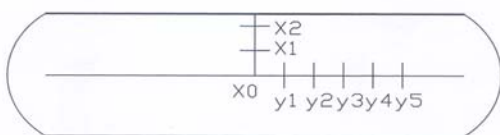


Figure 2 Position for hardness testing.

From measuring of materials hardness, showed the relation between materials hardness on the axel line

and Pre heat temperature of materials Al6063-T6.

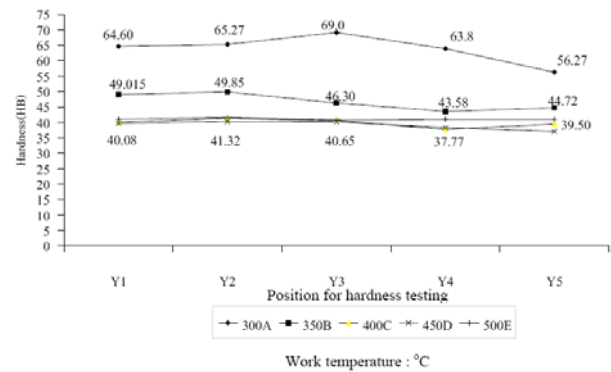


Figure 3 Hardness value of Al 6063 after forging on Y-direction (Remarks : 350, 69 = work temperature, hardness value)

From the Fig. 3. showed that the position of hardness measuring on axel line Y. At Pre heat temperature of 300 °C had the highness of materials hardness value 69 HB and had the tendency of material hardness value were lower when pre heat temperature were higher.

3.2.2. Aluminum AlZn5.5MgCu :Al7075

From the Fig. 4. showed that the position of hardness measuring on axel line Y. At Pre heat temperature of 500 °C had the highness of materials hardness value 111.528 HB and had the tendency of material hardness value.

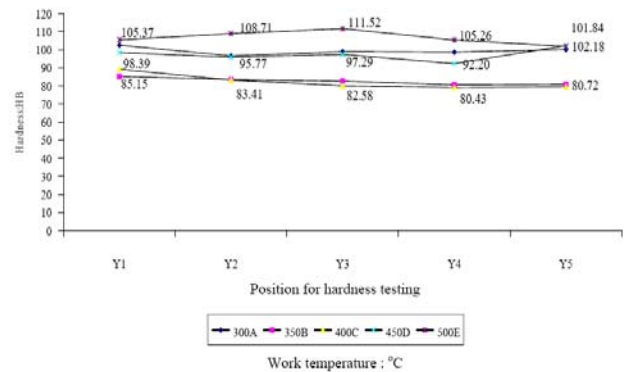


Figure 4 The relation between hardness value on Y-direction and forging temperature of Al 7075-T6 (Remarks: 500E, 101.84=Work temperature , hardness value)

3.3 Influence of heat effected on Grain size

From the study revealed that Pre heat temperature effect to grain size of testing work pieces by found that at pre heat temperature of 300 °C had the average grain size 6.72 μm. Which were the smallest of grain size in this experimental and were effected to work pieces which passed forging forming

process at 300 °C, had more hardness than the work pieces which passed Hot forging at others temperature. Grain size of the work pieces which not passed forging forming was 7.52 μm by had the grain size of bigger than testing work pieces which passed hot forging forming. The study showed that Pre heat temperature effected to grain size of Aluminum materials, the average grain size of Aluminum alloys in grain measuring on this experimental measure at the position of Y3.Y4,Y5 because the position which be the most occurring the shape changed.

From Fig. 5 showed that when pre heat temperature was higher, grain would be bigger too. These were the results from pre heat temperature were in the vicinity to the recrystallization temperature of Aluminum Alloy [6-7]

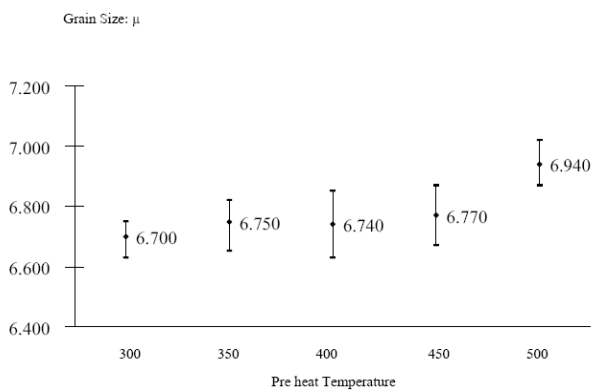


Figure 5 The average grain size of Aluminum alloys (Remarks: 350,6.75=Heat temperature ,grain size)

3.4 The experimental analysis

From the experimental could analyze the relation of variable using in the experimental; with the results. This experimental variable was pre heat temperature, were analyzing the relation between

pre heat temperature and forging forming force.

Table 1 Forming force of Al6063

Forming force (kN)						
Temperature	Sample 1	Sample 2	Sample 3	Sample 4	Yi	Y (Avg)
300	35.56	32.78	31.08	39.06	138.48	34.62
350	24.5	23.8	22.6	24.6	95.5	23.87
400	15.6	14.5	18.5	17	65.6	16.4
450	10.62	11.23	10.36	12.09	44.3	11.07
500	6.77	9.23	7.45	9.35	32.8	8.2
					376.68	94.17

From the result when Pre heat temperature were higher, forging forming force would be lower and when analyzing the relation between pre heat - temperature and work pieces hardness. From the result showed that when pre heat temperature were higher, the work pieces would had the lower tendency of hardness.

The study on the influence of heat which effected to the machine qualification of materials and grain size of Aluminum alloys in forging forming. The variable of this study was pre heat temperature by divided into temperature period of 300,350,400, 450 and 500 °C. From the results showed that pre heat temperature to the machine qualification of testing materials for two type- Aluminum AlZn5.5MgCu :Al7075 and Aluminum AlSi1Mg (Al 6063).

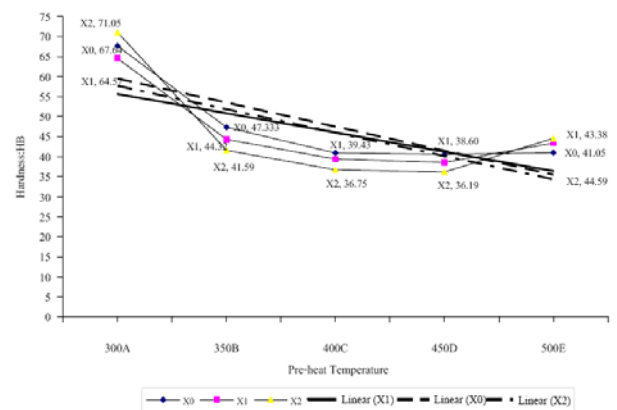


Figure 6 The tendency of material hardness passing forging forming

3.5 The experimental analyzing on statistics

The analyzing on the influence of forging forming force and forging forming temperature by using the calculation of statistics were significantly at the confidence level of 95 percentages as following as Table 1- 4.[5]

From Table 1 can be calculate;

$$SS_T = \sum_{i=1}^4 \sum_{li=1}^5 y_i^2 - \frac{\bar{y}_i^2}{N}$$

$$= (35.56)^2 + (32.78)^2 + (31.08)^2 + \dots + (7.45)^2 + (9.38)^2 - \frac{376.68^2}{20}$$

= 1870.116

$$SS_{Treatment} = \frac{1}{n} \sum_{i=1}^9 y_i^2 - \frac{\bar{y}^2}{N}$$

$$= \frac{1}{4} \left[(138.48)^2 + (95.5)^2 + (65.6)^2 + (44.3)^2 + (32.8)^2 \right] - \frac{376.68^2}{20}$$

= 1815.271

$SS_E = SS_T - SS_{Treatment}$

= 1870.116 - 1815.271

= 54.845

Table 2 The analysis of variances of the influence on forming temperature on forming force of Al6063.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F _o
Treatment	1870.116	4	467.529	127.879
Error	54.845	15	3.656	
Total	1815.271	19		

Form Table 2 can be considering as:

Mean Square = Sum of Square / Degree of Freedom

Mean Square (Treatment) = 1870.116 / 4 = 467.529

Mean Square (Error) = 54.845 / 15 = 3.656

F_o = Mean Square (Treatment) / Mean Square (Error)

= 467.529 / 3.656

= 127.879

At the confidence level of 95 percent revealed that

F_{0.05, 4, 15} = 3.06

Then; F_o > F_{0.05, 4, 15}

The forming temperature which effected to forming force of Aluminum alloys Al 6063 at the confidence level of 95 percent

Table 3 Forming force of Al7075

Temperature	Sample 1	Sample 2	Sample 3	Sample 4	Y _i	Y (Avg)
300	53.12	49.76	51.08	58.34	212.3	53.075
350	45.86	50.98	48.63	46.78	192.25	48.062
400	38.12	35.67	39.07	39.07	151.94	38.35
450	25	24	31	21	101	39.60
500	16.75	20.18	18.24	19.86	75.03	18.75
					732.52	197.85

From Table 3 can be calculate;

$$SS_T = \sum_{i=1}^4 \sum_{li=1}^5 y_i^2 - \frac{\bar{y}_i^2}{N}$$

$$= (53.12)^2 + (49.76)^2 + (51.08)^2 + \dots + (18.24)^2 + (19.86)^2 - \frac{732.52^2}{20}$$

$$= 3533.692$$

$$SS_{Treatment} = \frac{1}{n} \sum_{i=1}^9 y_i^2 - \frac{\bar{y}_i^2}{N}$$

$$= \frac{1}{4} \left[(212.3)^2 + (192.25)^2 + (151.94)^2 + (101)^2 + (75.03)^2 \right] - \frac{732.52^2}{20}$$

$$= 3407.622$$

$$SS_E = SS_T - SS_{Treatment}$$

$$= 3522.692 - 3406.622$$

$$= 126.07$$

Table 4 The analysis of variances of the influence on forming temperature on forming force of Al7075.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F ₀
Treatment	3407.622	4	851.90	101.368
Error	126.07	15	8.404	
Total	3533.692	19		

Form Table 2 can be considering as:
 Mean Square = Sum of Square² / Degree of Freedom
 Mean Square (Treatment) = 3407.622/4 = 851.90
 Mean Square (Error) = 126.07/15 = 8.404
 F₀ = Mean Square (Treatment)/ Mean Square (Error)
 = 851.90/8.404
 = 101.368

At the confidence level of 95 percent revealed that
 F_{0.05, 4, 15} = 3.06

Then; F₀ > F_{0.05, 4, 15}

The forming temperature which effected to forming force of Aluminum alloys Al 6063 at the confidence level of 95 percent

4 Conclusion

4.1 Influence of heat had the effect to forging forming force

The results of this experimental summarized that pre heat temperature affected to forging forming force. When pre that temperature were higher, forming force would had lower value, for the example; material Al 6063 at temperature at 300°C, using forging forming force for 3462 kN and at pre heat temperature of 500°C, using forging forming force for 8.2 kN which had lower value. The experimental revealed that forming force of material Al 7075 had

more value than forming fore of material Al 6063

4.2 Influence of heat had the effect to Aluminum hardness

The results of this experimental summarized that pre heat temperature affected to hardness value of testing material. Material Al 6063 has the most hardness when passed forming on pre heat temperature at 300°C by the average hardness value was 71.052 HB. Material Al 7075 has the most hardness when passed forging forming on pre heat temperature at 500°C by the average hardness value

was 111.523 HB at the confidence level of 95 percent.

Therefore, could be summarized the suitable condition in pre heat temperature of both Aluminum alloys were Al 6063 had the most hardness value both when passed forming on pre heat temperature at 300°C. Material Al 7075 has the most hardness value when passed forging forming on pre heat temperature at 500°C.

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