# Evaluation of Mechanical Properties of A356 Alloy Based Hybrid Composite at Different Aging Conditions

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***Abstract-*** In the field of material science, a large number of research is going on composite materials in current industries. The Aluminium metal matrix composite material has a characteristic of low density, cast ability, low thermal coefficient and machinability properties. Due to these properties researchers are concentrating towards Aluminium metal matrix composite material. The stir casting process was used to fabricate A356 alloy based hybrid composites reinforced with various weight fractions of 1%, 2%, 3%, 4% & 5% RHA and $Al_2O_3$ particulates in equal proportions. Tensile strength and Hardness of the composites have been evaluated. Significant improvement in the properties was been observed with the addition of reinforcement. Further, properties of heat treated composites were enhanced when compared to as cast composites.

***Index Terms***- Hybrid composites, A356, Rice Husk Ash, $Al_2O_3$

## I. INTRODUCTION

The requirement of space industries is to use the material having light weight and high strength leads to the development of new type of materials called composites. The Aluminium matrix composites are normally used in the areas where the weight is constraint [1], since they are light in weight and having a high strength to weight ratio.The aluminium alloys with reinforcement of ceramic particles leads to the latest generation of engineering materials with improved mechanical properties to weight ratio [2].

Few studies have shown, with the practical reinforcement, enhancement to the mechanical properties of Aluminium matrix composites can be achieved. The united advantages of the constituting materials can be achieved by development of composite materials. Metal Matrix Composites reinforced with various particles results in improvement in the properties processed by traditional routes [3].

In the process of reinforcement of aluminium alloy composites, $Al_2O_3$ is the most general particle added as a reinforcing agent. The properties of the aluminium matrix can be enhanced by including ceramic particles as strengthening materials. Wide varieties of materials for light weight applications has been developed using this method. For the manufacturing of the aluminium particles, reinforced composites stir casting method emerge as an encouraging method for various traditional processing methods. The process of Heat treatment can change the aluminium alloy composite microstructure. Many investigating experiments on composites of aluminium using SiC, Graphite, Fly ash, MgO, $B_4C$ and Zircon are done by researches. These composites of aluminum are available in market in different structural forms [4].

Ramesh D et al.,[5] studied the tensile strength of frit reinforced aluminium metal matrix composites, revealed improved tensile strength with the increase in frit particle content to aluminum matrix. Rangnathan et al.,[6] studied hybrid aluminium composites reinforced with Mica/SiC particulates and concluded that better mechanical properties are exhibited by hybrid composites. Nall Ramanaiah et al.,[7] has done investigation on the mechanical behavior of hybrid composites done by reinforced RHA and concluded that Rice Husk Ash acts as a guaranteed complementing reinforcement material for manufacturing of products which involves less cost. Zagade S et al.,[8] have reported the mechanical behavior of aluminium /fly ash/alumina hybrid composites, exhibited excellent tensile and hardness strength.A comparative study by Honnaiah C et al.,[9] tensile strength of alumina reinforced aluminum metal matrix composites revealed improved tensile strength with the decrease in particle size. Shenoy G et al., [10] have described in their work that the tensile strength of Al/Mica/E-glass fiber can be improved by solution heat treatment and aging conditions.

## II.AIM OF THE PRESENT STUDY

In this present investigation, A356 aluminium alloy based hybrid metal matrix composites have been developed by using RHA and $Al_2O_3$ particulates with stir casting method. The outcome of reinforcement weight fraction on microstructure and mechanical properties of the hybrid composites have been investigated.

## III. MATERIAL SELECTION

In the present work, the matrix material used for experiment is A356 alloy. The table 1 shows the matrix material chemical composition. The reinforcement materials used are $Al_2O_3$ and RHA. The average size of the $Al_2O_3$ particulates is of 100µm and average size of the RHA particulates is of 75µm. Table 2 shows the RHA chemical composition. To enhance the wettability between the matrix and the reinforcements during manufacturing of hybrid composites, wetting agent is required and magnesium was used as a wetting agent here.

| Element | Si | Mg | Fe | Ti | Cu | Mn | Zn | Ni | Al |
|---|---|---|---|---|---|---|---|---|---|
| Weight% | 6.6 | 0.45 | 0.10 | 0.10 | 0.05 | 0.055 | 0.005 | 0.005 | Bal. |

**Table -1: A356 Chemical composition**

| Element | Silica | Graphite | Calcium Oxide | Magnesium Oxide | Potassium Oxide | Ferric Oxide |
|---|---|---|---|---|---|---|
| Wt % | 90.23 | 4.77 | 1.58 | 0.53 | 0.39 | 0.21 |

**Table-2: The RHA Chemical composition**

## IV. EXPERIMENTAL STUDY

The rice husk is burned and ash obtained as result is washed thoroughly with water. Washing with water removes all dirt then the resultant material is dried for 24 hours at normal room temperature. The moisture content and organic matter should be removed by heating the cleaned rice husk up to 200°C for 60 min. Then carbonaceous material has been removed by heating it to 600°C for 12h [1]. The ash, thus collected, was used as reinforcement material in the preparation of hybrid composites.

A356 aluminium alloy was charged in the electric furnace and superheated to a temperature of 800°C. RHA and $Al_2O_3$ particulates were preheated to a temperature of 450°C for 1h to remove moisture and absorbed gases. Degasing of liquid metal was done by hexa-chloro-ethane tablets. Liquid metal temperature was maintained at 750°C with sufficient viscosity. The molten metal was stirred at a speed of 500rpm for 5 - 10min with the help of impeller to create sufficient vortex. The stir speed chosen is high enough to get a sufficient vortex for proper mixing of the ceramic particles with the liquid metal and at the same time it is low enough to avoid the gas and air entrapment in the liquid metal. The preheated particles were introduced laterally in to the vortex of the molten metal. One percent Magnesium was added to increase the wettability of the particles. Stirring speed was maintained at 500rpm for next 10min to ensure the proper mixing. After this stage, the molten mixture was drained in to the mould. To accomplish the uniform solidification of the molten metal the mould was preheated to 200°C for 30min. Thus, particle strengthened hybrid composite materials are formed by adopting the stir casting process and 1%, 2%, 3%, 4% and 5 % by equal weight proportions of RHA and $Al_2O_3$ are thus used.

### Heat Treatment Procedure

The following steps are involved in heat treatment procedure:

i. Solutionizing

ii. Quenching

iii. stretching/straining

iv. Aging

a) Single aging step at lower temperature

b) Double aging step at higher temperature

***Solutionizing and Quenching****:* Solutionizing at 540°C for 6 Hrs followed by quenching in to water at room temperature.
***stretching/straining***: This is a particular condition where, instantaneously after the heat treatment and quenching, before precipitation starts and the hybrid composite material become harder. One set of prepared samples is permanently deformed by 8 % to 10 % by applying external force (before 5Hrs).
***Single aging***: After quenching single aging is at the temperature of 140°C for about 12 Hrs of period is carried out.

***Double aging****:* The Second step of aging procedure also done for the 12 Hrs of time and at a temperature of 190°C.

## V. RESULTS AND DISCUSSION

The samples were machined according to the ASTM specifications. The samples were exposed to the solution heat treatment. The resulting A356 hybrid composite material mechanical properties have been investigated.

### Microstructure Analysis

The metallurgical microscope has been used for microstructure observation of matrix material. Some qualitative evidences of particulate distribution of combined RHA and $Al_2O_3$, quality of bonding between two particulates and the matrix are obtained. The specimens observed at various magnifications and photomicrographs. The captured microstructures were studied to predict the existence of two particulates in the alloy matrix. After the study of microstructure we can conclude that there is a uniform distribution of reinforcements in the alloy matrix. The bonding between particulates is acceptable and finer grains of alloy matrix are found.A part of casting was taken and following procedures are done.

- The specimen is belt grinded for first.
- Then using various grade emery papers, specimens are polished.
- Then specimens were washed and polished in cloths and then washed, dried and etched with Keller's reagent and then examined through optical microscope.

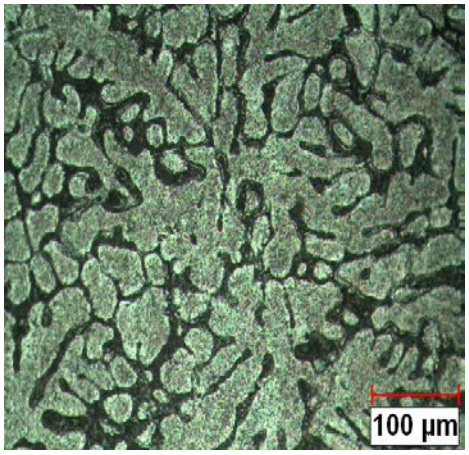



**Fig -1:** Microstructure of As-cast A356 composite (4% RHA and 4% $Al_2O_3$**)**

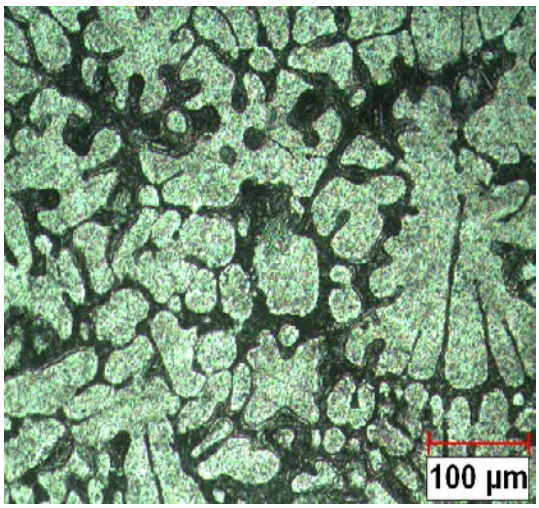



**Fig -2:** Microstructure of Single aged A356 composite (4%RHA and 4% $Al_2O_3$**)**

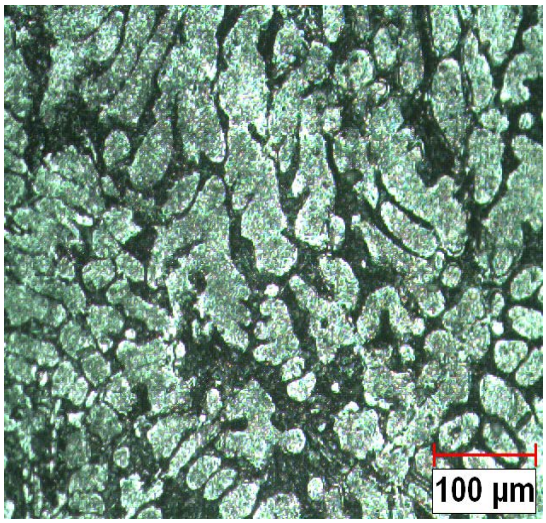



**Fig -3:** Microstructure of Double aged without strain A356 composite (4%RHA and 4% $Al_2O_3$**)**

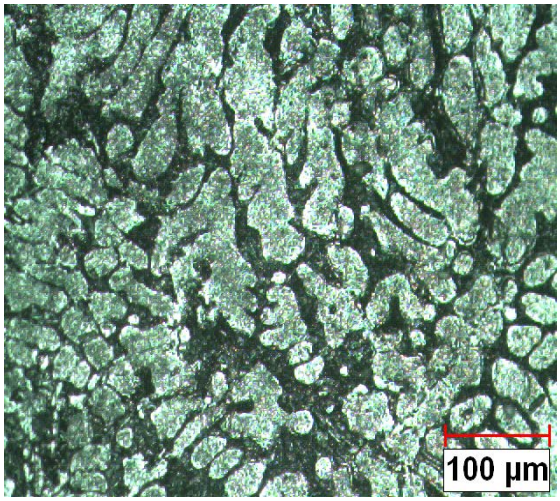
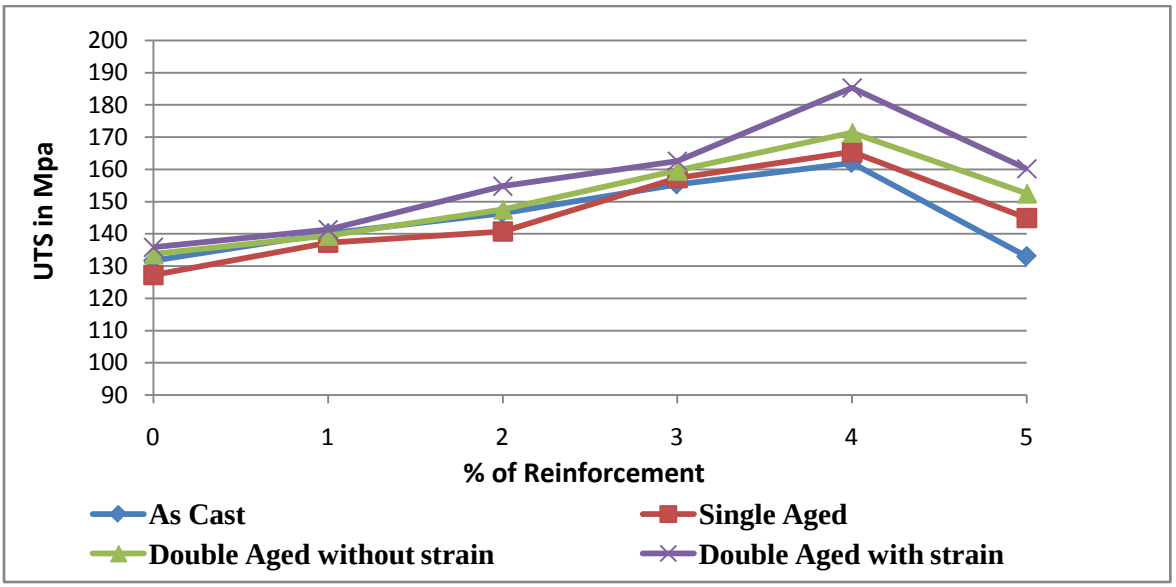



**Fig -4:** Microstructure of Double aged with strain A356 composite (4%RHA and 4% $Al_2O_3$**)**

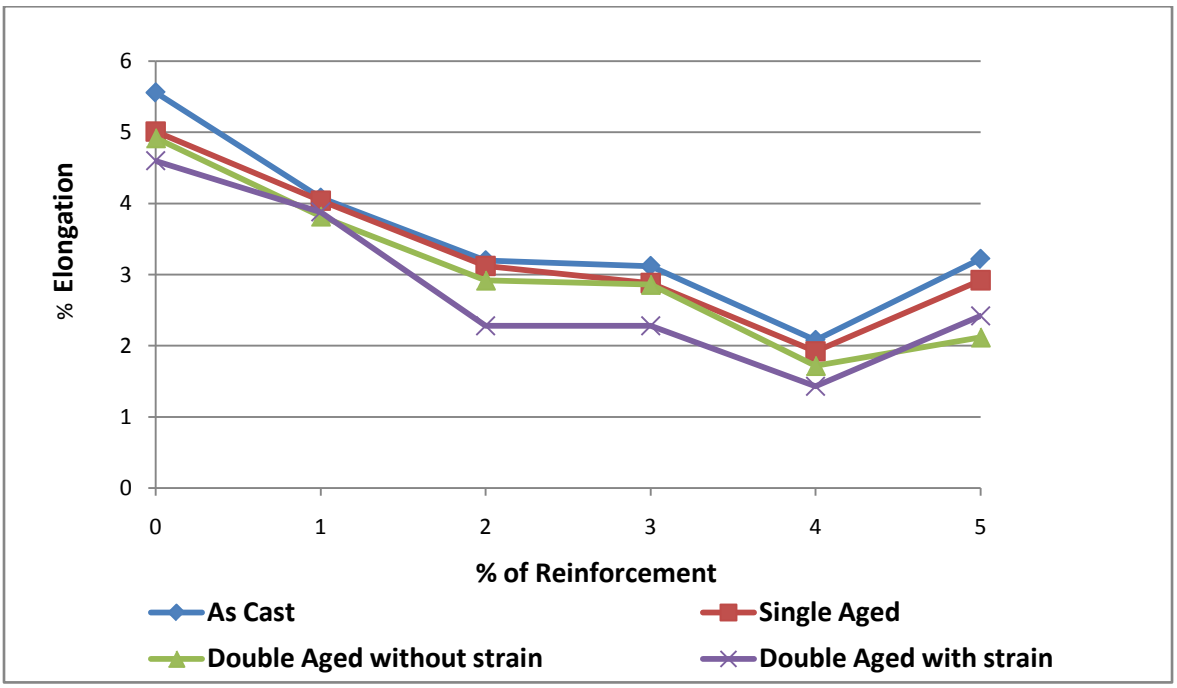
The figure 1 to 4 shows the microstructure of as cast alloy and aged conditions of hybrid composites. A closure inspection of the microstructures demonstrated more uniform and improved distribution of spherodized silicon particle in double aged with strain condition compared to dendrite structure observed in as –cast, Single aged and Double aged with strain conditions.

## Tensile test

The set of specimens were loaded in uni-axial tensile testing machine as per ASTM E8 standards and loaded until the failure of the specimen occurs. Tensile tests were conducted of different compositions of RHA and $Al_2O_3$ particulates reinforcing materials and aging conditions.UTS (Ultimate tensile strength) and % elongation were measured.




**Graph -1:** Evaluation of UTS for samples with various RHA and $Al_2O_3$ Compositions and Aging conditions



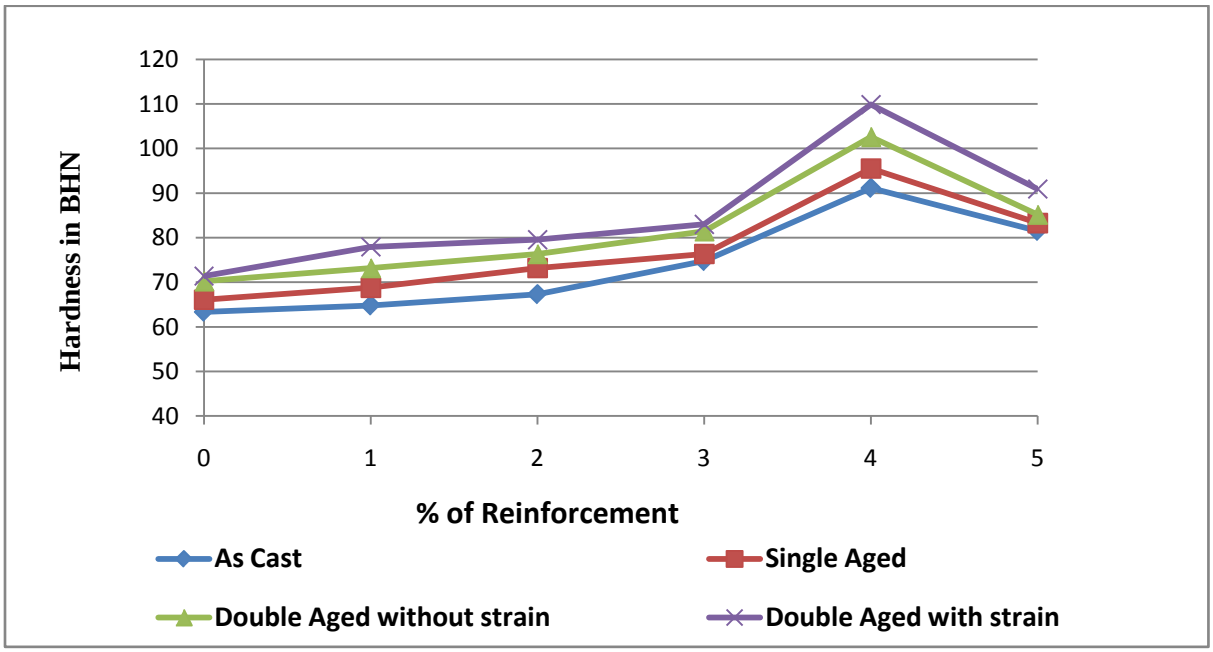

**Graph -2:** Percentage Elongation for samples with various RHA and $Al_2O_3$ Compositions and Aging conditions

It is noticeable from Graph 1and 2 the ultimate tensile strength( UTS )gradually increases with increase in weight % of RHA and $Al_2O_3$ reinforcement particles and % elongation decreases with the increase in weight % of RHA and $Al_2O_3$ reinforcement content. This is due to the resistance to dislocations and hence, strength increases with the weight percent. An effective bonding between reinforcements and matrix favors an improvement of the tensile strength.

**Hardness test**

The Binell hardness tester was used to carry out the hardness tests. The test specimens of 20mm thickness were machined from As-cast, aging at lower and higher temperature with the use of various composite specified. The steel ball with a diameter of 2.5mm and 60 Kgf of the load was adopted. The average value of the tests done at three different locations was considered as the hardness value of the composite specimens. The outcomes appear as underneath.

From the Graph -3, it is noticeable that the hardness of the composite material obtained in this experiment is higher enough than parent metal from which it is derived. It is likewise presented that increase in the weight fraction percentage of reinforcement materials, hardness of the composite material increases. As the content of silica substance increases, the result of the addition of reinforcement makes the A356 composite into more brittle and hard. Furthermore the heat treatment and aging results in the production of intermetallic precipitates. At the point when the specimens are subjected to double aging with strain, the resulting grains have obtained much more uniform and closer structure and this prompts to improve hardness which is found in the Graph -3.




**Graph -3:** Evaluation of Hardness for samples with various RHA and $Al_2O_3$ Compositions and Aging conditions.

## VI. CONCLUSION

The A356 based Hybrid composites were successfully produced by stir casting method with different weight percentage of RHA and $Al_2O_3$ particulate reinforcements with A356 as matrix material. Within purview of the study following conclusions have been drawn.

- By making use of stir casting method, RHA and $Al_2O_3$ particulates can be successfully introduced in the A356 matrix alloy material to fabricate hybrid composite materials.
- From the microstructure analysis, it is noticeable that reinforcement in the fabricated composite material is distributed inadequately even manner.

- The grain structure of the specimens which are treated with Double aging with strain have denser structure when compared to other samples, because of nucleation of precipitates and the reinforcement material is well bonded with the matrix material.
- When the percentage of RHA and $Al_2O_3$ increases in the composite, the UTS of that of composite also increases. UTS is significantly affected by the heat treatment procedure and aging procedure and results obtained for specimens which undergo double aging with strain has peak values.
- If the reinforcement content in the composite increases, then the hardness of the specimens also increases. Peak values have been shown up for Hardness of material and specimens after double aging with strain and they are noticeably affected by the Heat treatment and aging procedures.
- However, beyond four percentages of reinforcement, loss of reinforcements has started taking place due to floatation of the reinforcements in particular RHA. Further, it was difficult to stir and mix them in the molten metal uniformly due to increase in volume.
- The outcomes obtained clearly demonstrate that the double aged with strain specimens shown improved tensile strength and hardness in comparison with the single aging and as cast specimens.

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## REFERENCES

[1] D.Shiva prasad , Dr.A.Rama Krishna, 2011"Production and mechanical properties of A356.2/RHA composites", International journal of advanced science and technology, vol33, pp51-57.

[2] V.Auradi et al, 2014, "Processing of $B_4C$ particulate Reinforced 6061 Aluminium Matrix composites by melt stirring involving two-step addition",ELSEVIER,pp1068-1076.

[3] Praveen.G et al, synthesis, 2014 "Characterization and mechanical properties of A356.1 aluminium allo matrix composite reinforced with Mgo Nano particles", International journal of engineering science invention, vol-3, pp53-59

[4] MAO wei-min et al, 2012, "Rheo-squeeze casting of semi-sold A356 aluminium alloy slurry", ELSEVIER, pp 1769-1773

[5] Ramesh D et al. 2010, "Effect of weigth percentage on mechanical properties of frit particulate reinforced Al6061 composite",ARPN journal of engineering and applied sciences,Vol 5,pp32-36.

[6] Ranganath S et al, 2013, "Evaluation of mechancal and wear properties of hybrid aluminium matrix composites",Transactions of Nonferrous metals society of china 23, pp 2509-2517.

[7] Nalla Ramanaiah et al, 2014, ''Investigation on mechanical properties of aluminium hybrid composites'', journal of materials research and technology(jmr&t), Vol 3, pp 79-85.

[8] Zagade et al,2015, "Study of mechanical behaviour of Aluminium matrix composite by analytical and experimental approach", Issue 2,pp1150-1154

[9] Honnaiah C et al, 2014, "Effect of particle size on dry sliding wear of cast A356-$Al_2O_3$ Metal matrix composites", International journal of engineering trends and Technology", Vol 12, pp 438-445

[10] Shenoy G et al ,2013 "Evaluation of ultimate tensile strength and corrosion resistance of Al-Mg-Si based hybrid composite in different ageing condition", International Journal of material science, Vol 8, pp 29-37

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