# List of Publications

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| 1. | Tej Parsania, Maulik Thakkar, Akshay More, Devang Mahant, Vandana Rao | Study on Modified Heat Treatment of Direct Chill Cast 7075 Aluminum Alloy | International Journal of Emerging Technology and Advanced Engineering (IJETAE) | ISSN: 2250-2459; Vol - 5, Issue 11, Nov 2015 | --- | Published |
| 2. | Devang Mahant, Vandana Rao | Mechanical Property and Microstructural Comparison of Wrought and Cast 7075 Aluminium Alloy | Proceedings of International Conference on Recent Advances in Metallurgy for Sustainable Development | ISBN: 978-93-88879-64-4 pp. 373-375 Year: 2018 | New Delhi Publisher | Paper presented on 1-3 Feb 2018 and published |
| .3 | Devang Mahant, Vandana Rao | Investigation of microstructure and mechanical properties of $ZrO_2$, $TiO_2$, and $ZrTiO_4$ added cast Al7075 alloy. | Indian Foundry Journal (IFJ) | ISSN: 0379-5446, Vol.69, Issue II, Feb 2023 | The Indian Institute of Foundrymen | Published in Feb 2023 issue. |
| 4. | Devang Mahant, Vandana Rao | Intermediate Phase Analysis of Cast Al7075 after the Addition of High-Temperature Oxides | International Conference on Advanced Technologies in Chemical, Construction, and Mechanical Sciences (iCATCHCOME 2023 | Materials Today Proceedings, Feb 2023 | KPR Institute of Engg. and Tech. Coimbatore, Tamil Nadu. | Presented on 9th Feb 2023. |
| 5 | Devang Mahant, Vandana Rao | Intermediate phase analysis of cast Al7075 after the addition of high-temperature oxides | Materials Today: Proceedings | 2214-7853 | Elsevier, Science Direct | 8th August 2023 |
| 6. | Devang Mahant, Rahul Yadav, Vandana Rao | Comparison of Wear Behaviour of Cast 7075 Aluminum by Oxide Addition | -- | -- | -- | In the process of the journal publication |

**Publication 1**

International Journal of Emerging Technology and Advanced Engineering
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# Study on Modified heat treatment of Direct Chill Cast 7075 Aluminum Alloy.

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***Abstract*— The effect of heat treatment on microstructure, hardness and tensile properties of the direct chill cast Al-Zn-Mg-Cu (7075) alloy has been evaluated in this research work. To achieve the properties of cast 7075 alloy, comparable to that of wrought, it was subjected to conventional T6 heat treatment as well as modified T6 heat treatment cycle. Higher quenching rate and 2 stage ageing cycle of modified T6 heat treatment cycle, improves the mechanical properties of as cast alloy like Hardness (90 BHN to 140 BHN) and Tensile strength (221 Mpa to 464 MPa).**

***Keywords*— Cast 7075 alloy, Conventional T6 heat treatment, Double step ageing, Modified T6 heat treatment, Microstructure, Tensile strength**

## I. Introduction

The Al-Zn-Mg-Cu (7XXXseries) alloys have been widely used in aerospace industry due to their desirable specific mechanical properties.[1-4] 7XXX alloys are generally used in wrought conditions and they can be artificially aged to achieve high strength and hardness which is mainly attributed to the formation of η ($MgZn_2$) or T' ($Mg_3Zn_3Al_2$) phases which precipitates during ageing treatment depending on the ratio of Zn:Mg present (η for high ratio and T' for low ratio) in the system.[5-9] As cast 7XXX alloys has a cored dendritic microstructure with an inter-dendritic distribution of second phase particles or eutectics. The inter-granular or inter-dendritic networks of these second phase particles results in inferior mechanical properties of as cast alloys as compared to that of wrought alloys. Efforts are made to optimize the properties of as cast Al-Zn-Mg-Cu alloys [10-12]. The effect of addition of Sc, Zr etc is evaluated on cast ingots.[11] Jie Dong et al [12] worked on low frequency electromagnetic casting techniques to reduce the average grain size to improve the mechanical properties. All these techniques however focuses on rapid solidification techniques to reduce the grain size and to minimize the macro-segregation of second phases which are not only expensive but also limits their application in manufacturing products from these alloys.

Cast alloys as well as wrought alloys are both usually subjected to T6 thermal treatment to attain peak strength. Conventional T6 treatment cycle consists of solutionizing at 475 $^0$C for 3 hours to get supersaturated solid solution followed by quenching in water and then artificially aging for 24 hours at 120 $^0$C. One of the most important parameter in this treatment is the rate of quenching which must be sufficiently high enough to retard heterogeneous segregation of second phases at the high angle grain boundaries and to maintain a certain number of vacant lattice sites required for precipitates to form during aging which contributes to the strength of the alloy [13]. Another important factor to be considered is the time of exposure at the room temperature before the start of precipitation treatment which is detrimental as GP zones formed from supersaturated solid solution at this temperature are not stable during aging treatment and GP zone reversion takes place at higher temperatures. In order to overcome this, two stage aging cycle is performed which consists of pre-aging the alloy at lower temperature to form GP zones which are stable when temperature is raised to final aging temperature [13]. In this study, idea is to cast 7075 (a very popular alloy of 7XXX family used widely in aerospace industry) using simple gravity die casting process and then subject it to the modified T6 thermal treatment using two step aging cycles. An attempt has been made here to optimize the microstructure of as cast alloy using modified T6 thermal treatment to attain its mechanical properties comparable to that of wrought alloy system.

## II. Experimental Procedure

The 7075-T6 wrought alloy is first melted in a resistance heating furnace at the temperature of 635 $^0$C. Superheating at temperature 40 $^0$C -50 $^0$C above the melting range is done to ensure complete melting of the charge. After degassing and slag removal operations on the melt, it is poured into metallic dies to get cylindrical specimens which were then subjected to conventional T6 as well as modified T6 heat treatment cycles as shown below.

## Publication 2

# Mechanical Property and Microstructural Comparison of Wrought and Cast 7075 Aluminium Alloy

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**Abstract**

This paper reports the comparison between wrought and cast conditions of 7075 aluminium alloy by its mechanical properties and microstructural observation. The material was as received in wrought 7075-T6 condition and the same material was cast in the form of cylindrical rods by gravity die casting route. The sampling was done to perform mechanical properties and micro-structural study by optical microscopy. The main aim of study is to usage the cast 7075 instead of wrought 7075 where processing cost of wrought 7075 can be reduced. Moreover, machining cost of the component is an add-on factor which increase cost per unit. The result of hardness and tensile testing of cast 7075 was slighter than wrought 7075 however there is a scope of increase in properties by thermal treatment of the cast 7075 as it is heat treatable alloy. It was also found out by microstructure that rapid solidification of as cast 7075 also improves the mechanical properties by avoiding micro-segregations.

**Keywords:** Wrought 7075 Aluminium alloy, Cast 7075, Mechanical property, Microstructure, Rapid solidification, Micro-segregation

## 1. INTRODUCTION

The aluminium 7075 is Al-Zn-Mg-Cu alloy as this alloy is widely used in the form of wrought condition due to its higher strength in wrought condition. The casting of this alloy is very crucial due to macro and micro segregation of alloying elements on different length scale. It is well known that the solidification of alloys is accompanied by a certain degree of micro segregation of alloying elements due to their partitioning between liquid and solid phases during solidification, and due to the non-equilibrium nature of solidification. If, subsequently, gross relative movement between the liquid and the solid occurs, the segregation can appear on a macro-scale, which is called macro segregation [1]. The degree of macro segregation in an alloy is influenced to a large extent by ingot dimensions, type and amount of alloying elements and the casting process used. Continuous or semi-continuous casting routes are commonly used to produce ingots of wrought alloy compositions, which are intended for subsequent processing [2-6]. To avoid such macro and micro segregation of alloying elements it is necessary to rapidly cool the casting and check the final properties of the alloy. The main aim of the study was to use the cast 7075 in conventional use instead of wrought condition moreover the extrusion of this alloy is quite difficult. By the use of cast 7075, the economic factor greatly influence as that was much higher in wrought condition.

## 2. EXPERIMENTAL

The as received 7075-T6 wrought aluminium alloy was melted in a resistance heating furnace at the temperature of 730 °C. Superheating was done to ensure proper melting of alloy. After that degassing and slag removal was done on melt and it was poured in the cylindrical rod diameter of Ø 20 mm which was made from S. G. Iron die. The cast alloy was removed from die and sampling was done for mechanical and microstructural characterization. As received 7075 Al alloy was cut to test the micro and mechanical properties. After that the comparison was done.

The micrographs were taken on optical microscope and for tensile testing an Average of four values was taken. Tensile test was performed using a Monsanto 20 tensile testing machine while maintaining a constant crosshead speed of 0.5 mm per minute. The ultimate tensile strength and % elongation was determined in each case and an average of 4 values was taken into consideration. The Brinell hardness was done as an average of 6 values.

## 3. RESULTS AND DISCUSSION

The chemical composition of as received 7075 T-6 was done by bulk spectroscopy. The material specification was conformed though EN-573-3 AW-7075 EN AW-AL. The result was as below:

Publication 3

TECHNICAL PAPER

# Investigation of Microstructure and Mechanical Properties of $ZrO_2$, $TiO_2$ and $ZrTiO_4$ Added Cast Al7075 Alloy


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## Abstract

Wrought Al7075 alloy is well-known in the area of aerospace industry and automobile sectors. Such materials reduce the problem of $CO_2$ emission due to high-strength and low-weight ratios. Instead of heavy-weight ferrous-based material used, nonferrous alloys become environment friendly. But, the cast properties of such nonferrous alloys do not match the wrought properties of the same. Cast products have problems with porosities, segregation, and grain size, which reduces the mechanical properties. Out of all, solute segregation at the grain boundary is the main problem with Al7075 casting. A few methodologies are employed to avoid solute segregation, like mould vibration, heat treatment cycles, and the addition of chemicals to control nucleation and growth. In this research, chemical treatment with the oxide addition generates more nuclei for a uniform distributed segregated phase. It is analogous to a change in the microstructure of liquid melt by adding inoculants. The 2.5 wt. % $ZrO_2$, $TiO_2$, and $ZrTiO_4$ were added to Al7075 to study microstructure and mechanical properties. Mechanical characteristics, microstructural analysis, SEM-EDS, and XRD were used to characterize the samples. The oxide addition increases the nucleation site by inhibiting grain growth resulting in improved mechanical properties. The distribution of the eutectic phase during solidification is at the grain boundary and inter-dendritic regions. The microscopy and mechanical property results of $ZrO_2$ oxide addition were excellent compared to as-cast Al7075. The microstructural examination showed the second phase distribution within the α-Al matrix. The XRD analysis confirms the presence of eutectic phases η(Mg(AlCuZn)$_2$). The Fractography analysis was performed to determine the failure mechanism using tensile specimens.



**Keywords:** 7075 aluminium alloy; oxide addition; Microstructure; Mechanical properties; SEM-EDS


## Introduction

T6 heat-treated 7075 alloys have vast potential in automobiles due to their best mechanical properties. A lightweight-to-high strength ratio is essential to increase vehicle performance and reduce fuel consumption[1]. Many techniques are studied to improve the cast properties of 7075 alloys. It is categorized into three major areas; the addition of oxides, modification of the heat treatment cycle, and the micro-alloying effect[2,3]. Many researchers studied the addition of oxides, carbides, and nitrides in aluminium alloys to improve the structure-property relationship. The addition of $Al_2O_3$, $TiO_2$, TiC, SiC, AlN, and numerous other additives is investigated in Al alloys, including Al7075[4-9]. The other technique includes a heat treatment cycle named the diffusion-

## Publication 4


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Certificate

This certificate is presented to

**Devang Mahant**

Ph.D. Scholar, Department of Metallurgical & Materials Engineering,
Faculty of Technology and Engineering,
The M. S. University of Baroda Vadodara, 390001, India.

for presenting the research paper entitled "Intermediate Phase Analysis of Cast Al7075 after the Addition of High-Temperature Oxides" in the 2023 International Conference on Advanced Technologies in Chemical, Construction and Mechanical Sciences (ICATCHCOME 2023) held at KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India during 09 - 10, February 2023. The Conference has been organized by the Center for Research and Development (CfRD), KPR Institute of Engineering & Technology.

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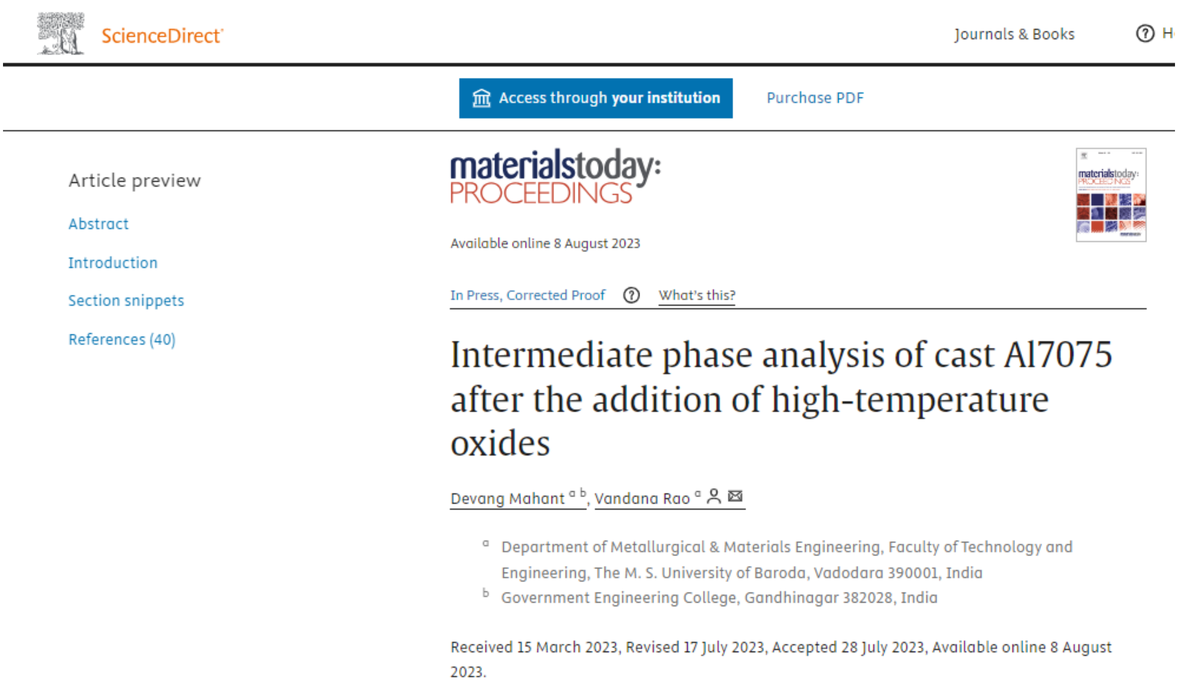
## Publication 5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# Intermediate phase analysis of cast Al7075 after the addition of high-temperature oxides

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