

DESIGN AND ANALYSIS OF CONNECTING ROD MATERIAL MADE BY B₄C REINFORCED AL7075 ALLOY HEAT TREATED COMPOSITES

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ABSTRACT

Connecting rods are highly stressed members in engines; connecting rods are also called as CON rods are subjected to alternative tensile and compressive loads with inertia loads. Inertia plays a major role in high speed engines due to the fact that the higher inertia and it is neither easy to start and stop the engines. Hence the weight of connecting rod plays a major role in the high-speed engines, here an attempt is made to reduce the weight of the connecting rod by using B₄C reinforced AL7075 composite material without compromising the stiffness, and also it is found that aluminum has better damping and Vibrations absorbing capabilities. The mechanical characterization of cast AL7075 composite is conducted by subjecting it to Mechanical characterization such as SEM, compression, and tensile test, and wear test and hardness test. It is found that heat treated (T6) Al7075 composite with 9% wt B₄C has the high tensile strength of 271.4 MPa, compression strength of 854.1 MPa, hardness BHN- 86.8, and low wear rate of $2.3 \times 10^{-4} \text{ mm}^3$.

The connecting rods are subjected to alternative axial tensile and compressive loads since compressive loads are higher than tensile loads here the connecting rod is designed as a strut to withstand buckling load, and magnitude of critical buckling load for a high speed four stroke two wheeler considered here is found to be, 389130.23 N. Using Rankine's Theory, length, width, thickness of the rod and diameter of bolts connecting end caps are evaluated in the design phase by considering the connecting rod as a strut to withstand buckling loads. The model of the Connecting rod is developed in Solid edge and Finite element analysis is carried out using Ansys Workbench. A comparison is done between the conventional connecting rod and Al7075 composite material connecting rod and found that the weight, stress, strain and deformation induced in the composite connecting rod is less compared to forged steel connecting rod.

KEYWORDS : Heat Treatment, SEM & BHN

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1. INTRODUCTION

Aluminum and its alloys possess low density, high thermal conductivity and high resistance to corrosion. These material have low melting point and high ductility. The mechanical properties can be enhanced by alloying and cold working. The major alloying elements are: magnesium, silicon, copper, zinc [1]. Recent attention has given to alloys of aluminum and other low density materials as engineering materials for applications in aerospace, automobile and defense etc. Here AL7075 aluminum alloy [2] with major constituent as zinc is considered for design and analysis of connecting rod, because of its high strength corrosion and wear resistance properties.

Table 1: Chemical Composition of Al7075 Alloy

Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn	Al
0.18-0.28	1.2-2.0	0.50	2.1-2.9	0.30	0.40	0.20	5.1-6.1	Balance

Generally, SiC, Al₂O₃, TiC, TiO₂, TiB₂, MgO and BN [3] are reinforced to aluminum matrix and widespread in literature. The reinforcement of B₄C increases the hardness, wear resistance, strength properties. Boron carbide (B₄C) has high hardness, thermal, strength properties making it suitable for Aluminum metal composites (AMC). Studies shows that B₄C reinforced AMCs possess superior mechanical properties compared to unreinforced alloys.

Generally the heat treatment follows this basic 3 steps.

Stage 1: The metal is heated to attain the uniform temperature.

Stage 2: Soak and hold the metal at required temperature and time.

Stage 3: Cool the metal to room temperature.

The T6 heat treatment of Al7075 composites is adapted to enhance the mechanical and tribological properties [4], and it is found from the literature that the strength, wear and hardness properties can be enhanced by reinforcing ceramic particulates to heat treated Al7075 base metal.

The connecting rod acts as an intermediate link to transmit reciprocating motion of the piston to rotary motion of the crank shaft. The main parts of the connecting rod are the shank, the crank end with two halves, the piston end, the two bolts, nuts and washers. The piston end (small end) is connected to piston and crank end (big end) to the crank, the motion of the connecting rod is a combination of translation and rotation [5]. The connecting rods should be of light weight and possess higher strength to ease the acceleration and de-acceleration and to transfer forces of high magnitude. It is found from the Literature that the Suitable Cross Section For The Connecting Rod Is I Section [6]. The Connecting Rod Is Subjected To high forces transmitted from piston directly to the connecting rod during power stroke, and inertia forces due to mass of reciprocating parts and its angular acceleration. The inertia [7] force acts transversely on connecting rod causing bending moment on it. The angular acceleration varies from zero at piston end to maximum at the crank end. The connecting rod, can be treated as a column with pin ends and Rankine's theory is used to evaluate the buckling load, maximum stresses and maximum deformation induced in the connecting rod.

2. METHODOLOGY

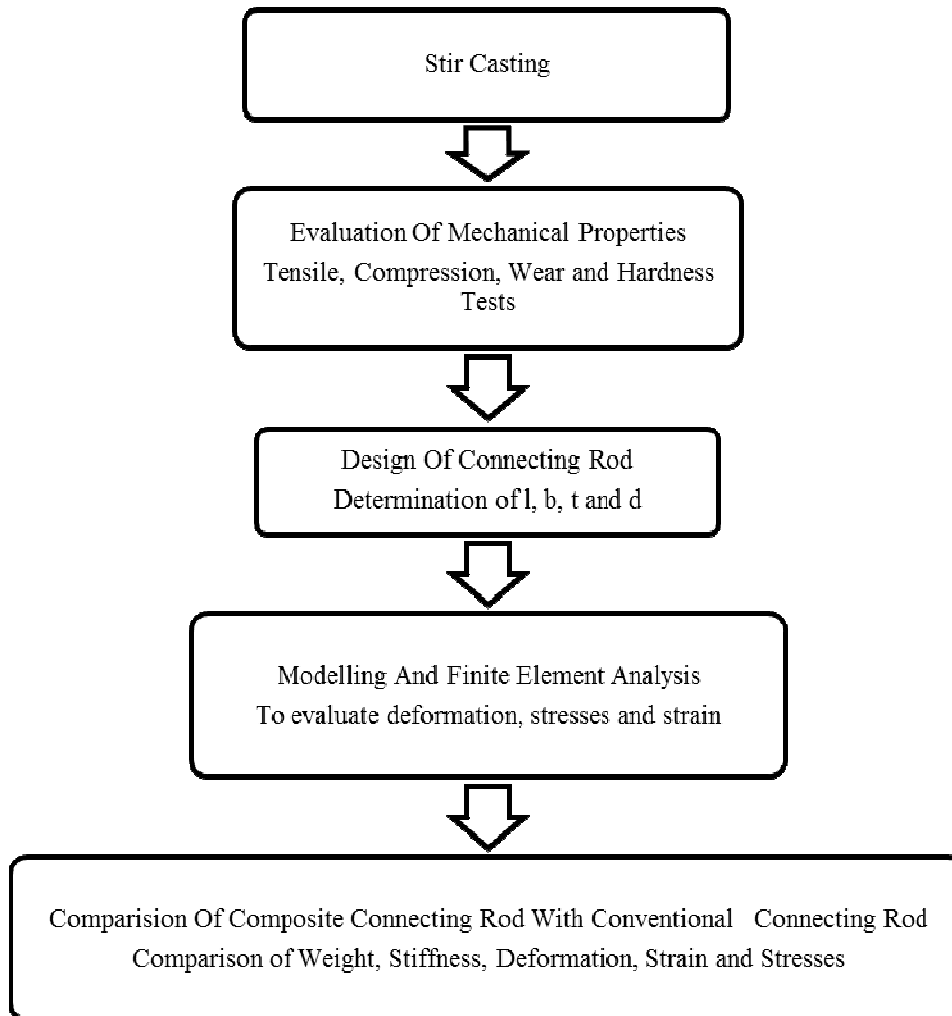


Figure 1

The ingots are subjected to T6 Heat treatment process to increase the strength, hardness and wear properties. The test specimens will be prepared from these ingots. The composites having 3, 6 & 9 wt. % of B₄C separately and in combination will be made by the same procedure [8]. Prepared samples will be machined as per ASTM standards to conduct the tensile, compression and wear tests to know the effect of B₄C particulates on properties of Al7075 alloy. An high speed motor bike engine connecting rod is considered for design by knowing the specifications of the engine, the pressure acting on the piston is calculated and by neglecting the thrust force the same force is transmitted to connecting rod. The connecting rods is subjected to alternative axial tensile and compressive loads since compressive loads are higher than tensile loads the connecting rod is designed as a strut to withstand buckling loads. The design of connecting rod is carried out to evaluate design parameters like length, width, thickness of the rod and diameter of bolts connecting end caps. The model of the Connecting rod is developed in Solid Edge and Finite element analysis is carried out using Ansys Workbench. A comparison is done between the conventional forged steel connecting rod and the AL7075 composite connecting rod for the parameters such as weight, stiffness, maximum stress, maximum strain and maximum deformation induced.

3. STIR CASTING AND SEM RESULTS

3.1 Stir Casting

The characteristics of Aluminum alloy is in its high specific strength and damping capacities. The stir casting technique will be adopted to prepare the cast composites. The known quantity of Al7075 will be melted at 750 °C in a graphite crucible using resistance furnace. The melted liquid will be agitated with the help of stirrer to form a fine vortex. 3g of degassing tablet (C_6Cl_6 -solid hexa chloroethane) [9] will be added to the vortex and the slag will be removed from the molten metal. B_4C particles will be preheated at around 300 °C for 3 hrs to make their surfaces oxidized [14]. The preheated B_4C particles will then be added into the vortex and stirred mechanically at 300 rpm for 5 minutes. Before pouring the molten metal to mould, 2g of cover flux (NaCl 45 % + KCl 45 % + NaF 10 %) [15] will be added to the molten metal to reduce the atmospheric contamination. The molten metal at a temperature of 730 °C will then be poured into the mould preheated at 300 °C [10] and will be allowed to solidify to obtain ingots.

3.2 SEM Results of Heat Treated B_4C Reinforced Al7075 Composites

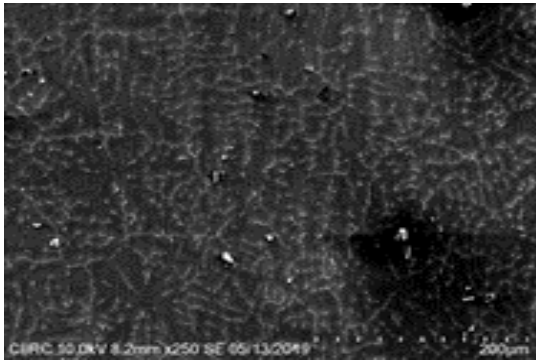


Figure 2: Base Metal

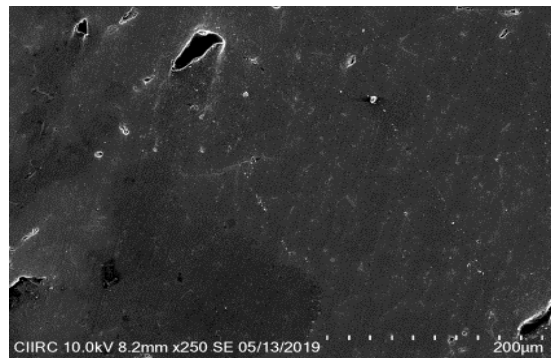


Figure 3: Al7075+ 3% B_4C

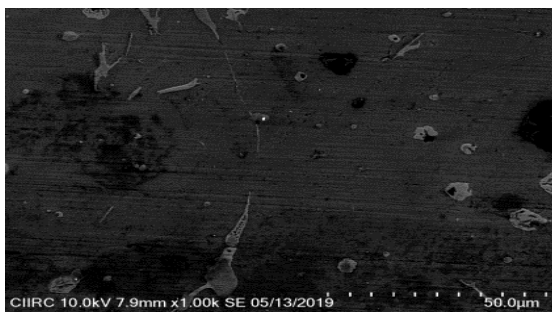


Figure 4: Al7075+ 6% B_4C

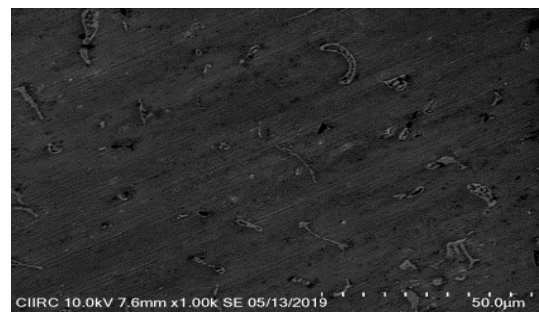


Figure 5: Al7075+9% B_4C

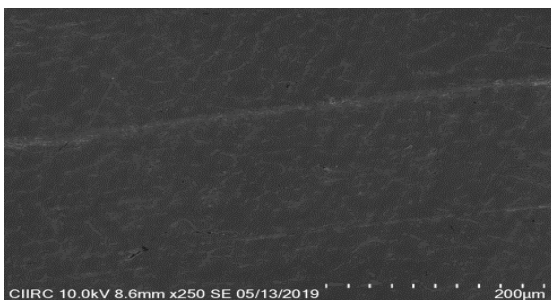


Figure 6: Base Metal

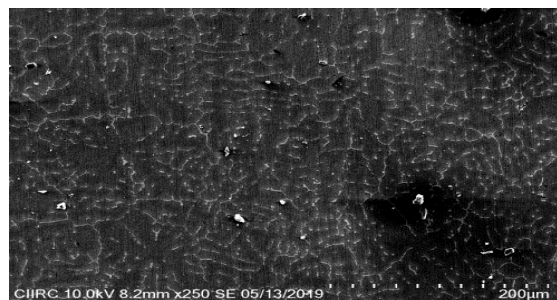


Figure 7: Al7075+ 3% B_4C

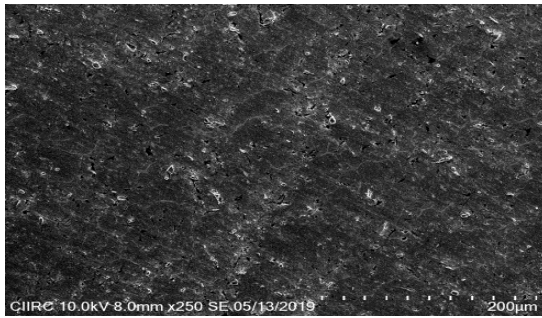


Figure 8: Al7075+ 6% B₄C

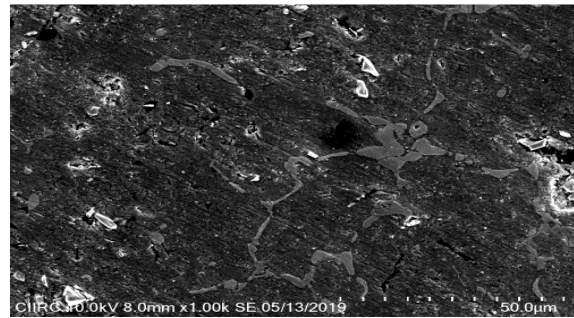


Figure 9: Al7075+ 9% B₄C

3.4 Microstructural Analysis

From the microstructure observation the casted composites were grounded using different grit size silicon carbide papers. Once the polish is done the specimens are washed thoroughly and then allowed to drying and then wiped with velvet cloth. This specimen with suitable etchant undergoes electro etching the process is called Keller's reagent. The polished specimens are observed in scanning electron microscope to get the microstructure of composites. The stirring process breaks the dendrite structure into equal forms; it also helps to improve the wett ability and improves the incorporation of particles uniformly dispersed in matrix. Microstructure shows uniform distribution of boron carbide particulates and very segregation, agglomeration of particles and porosity at few places.

4. DETERMINATION OF DENSITY AND POISSON'S RATIO BY RULE OF MIXTURES

Table 2: Determination of Density of the Composites Using Rule of Mixtures

Heat Treated Al7075 Composites	Volume Fraction (V_f)	Density of the Composite (ρ) (kg/m ³)
	$V_f = \left\{ \frac{\frac{M_f}{\rho_f}}{\frac{M_f}{\rho_f} + \frac{M_c - M_f}{\rho_m}} \right\}$	$\rho = \rho_f V_f + (1 - V_f) \rho_m$ (kg/m ³)
3% (60g B ₄ c) (2kg - Al7075)	0.03236	2800
6% (120g B ₄ c) (2kg - Al7075)	0.06270	2791
9% (180g B ₄ c) (2kg - Al7075)	0.0912	2783

4.1 Determination of Poisson's Ratio of the Composites using Rule of Mixtures

$$v = v_f V_f + (1 - V_f) v_m = 0.3192$$

The density of Al7075 composite and Poisson's ratio are evaluated from the Rule of Mixtures, it is found that the density of 9% B₄C reinforced heat treated Al7075 composites is 2783 kg/m³ which is much lesser than the forged steel having a density of 7800 kg/m³. Due to decrease in density, the mass of the cast Al7075 composite connecting rod is lesser and hence it is easy to accelerate and de-accelerate the engine which is much essential in high speed racing engines.

5. MECHANICAL CHARACTERISATION OF HEAT TREATED AND UNHEAT TREATED COMPOSITES

5.1 Mechanical Properties of Heat Treated Composites

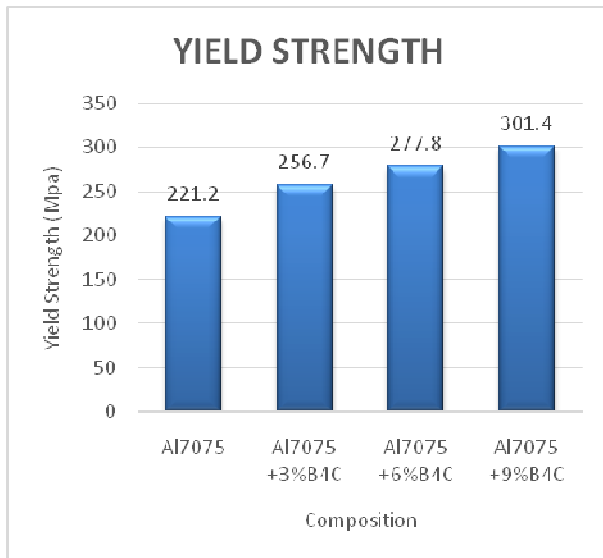


Figure 10: Yield Strength

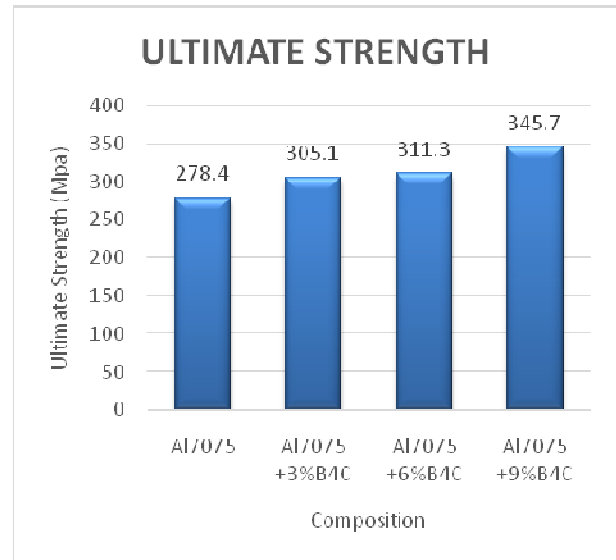


Figure 11: Ultimate Tensile Strength

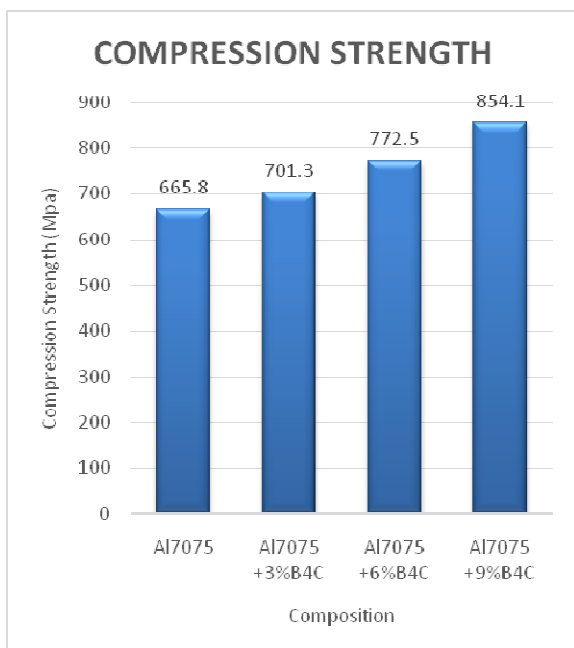


Figure 12: Compression Strength

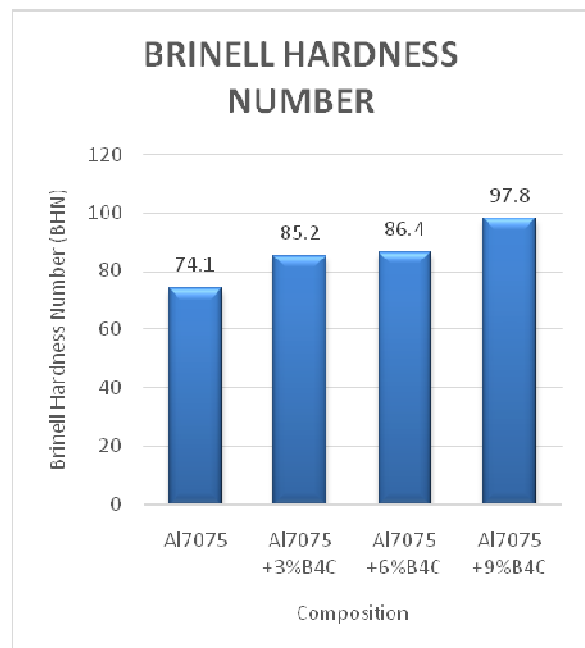


Figure 13: Hardness Number

5.2 Mechanical Properties of Un-Heat Treated Composites

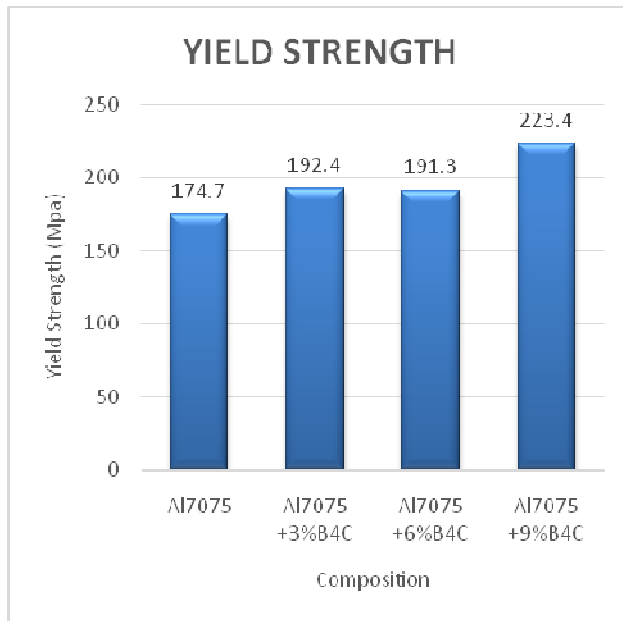


Figure 14: Yield Strength

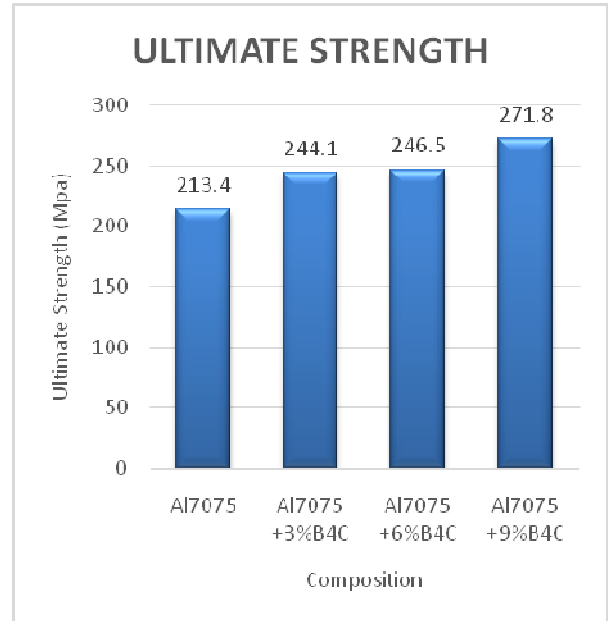


Figure 15: Ultimate Tensile Strength

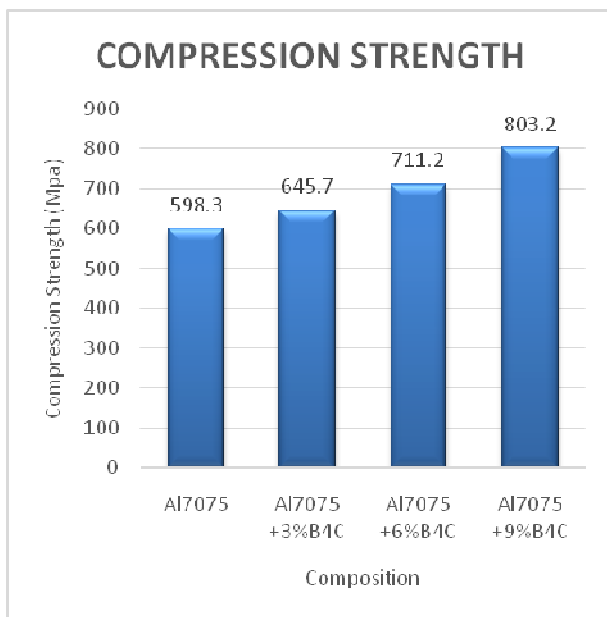


Figure 16: Compression Strength

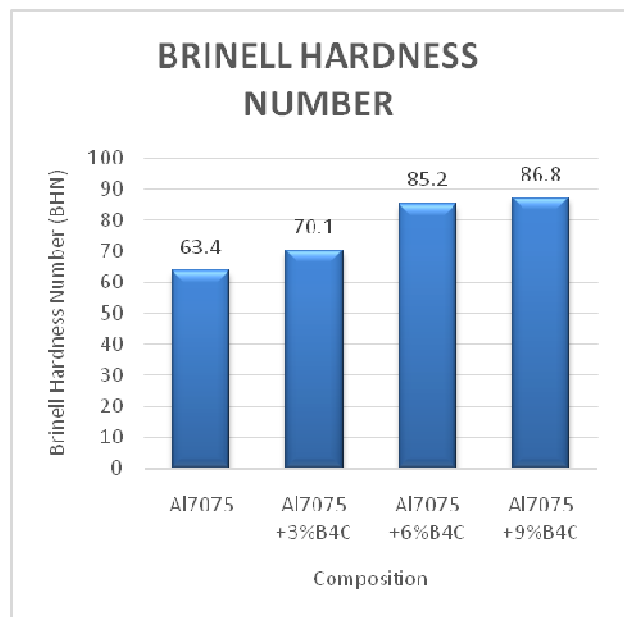


Figure 17: Hardness Number

Table 3: Strength and Hardness Properties of Heat Treated B₄C Reinforced Al7075 Composites

Sl. No	Composition	Yield Strength (MPa)	UTS (MPa)	Compression Strength(MPa)	Hardness (BHN)
1	Al7075	221.2	278.4	665.8	74.1
2	Al7075 + 3% B ₄ C	256.7	294.1	701.3	79.2
3	Al7075 + 6% B ₄ C	277.8	311.3	772.5	86.4
4	Al7075 + 9% B ₄ C	301.4	345.7	854.1	97.8

Table 4: Strength and Hardness Properties of un-Heat Treated B₄C Reinforced Al7075 Composites

Sl. No	Composition	Yield Strength (Mpa)	UTS (Mpa)	Compression Strength (Mpa)	(Hardness BHN)
1	Al7075	174.7	213.4	598.3	63.4
2	Al7075 + 3% B ₄ C	186.9	234.1	645.7	70.1
3	Al7075 + 6% B ₄ C	191.3	246.5	711.2	75.2
4	Al7075 + 9% B ₄ C	223.4	271.8	803.2	86.8

5.3 Wear Test Results and Stress- Strain Curve For 9% B₄c Reinforced Al7075 Composites

Tensile test and compression tests are conducted from ASTM [11] standard specimens at room temperature in universal testing machine (UTM), the test was conducted for 2 specimens and the average is taken for each compositions. The ultimate strength and yield strength is investigated using stress strain curves of tensile test, and compressive yield strength was obtained from compression test. The hardness was evaluated from Brinell Hard Ness test (BHN). The results are tabulated in Table 3 and Table 4. It is evident from the Table 3 and 4 that the yield strength, ultimate strength, compression strength and hardness of 9% B₄C reinforced heat treated composites are higher than other compositions and un-heat treated composites, this is because due to the increase in bonding strength between the reinforcement and matrix which exists up to 15% addition of B₄C, it is found from the literature that bonding strength can increase up to 15%, but there is a decrease in wear properties due to the formation of agglomerates if the addition of reinforcement exceeds 9%. The strength properties and wear properties of 9% B₄C reinforced heat treated composites is much higher than other composition and the stress versus strain curve is plotted for this composition and found from the trend line of the plot the Young’s modulus of the composite is 124 GPa (as shown in Figure 19).

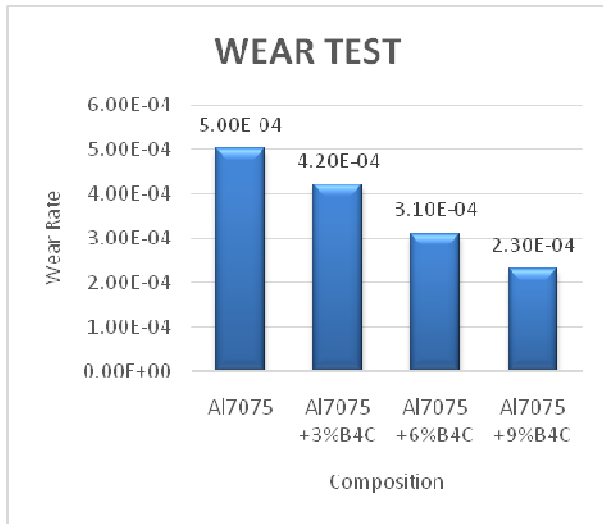


Figure 18: Wear Rate

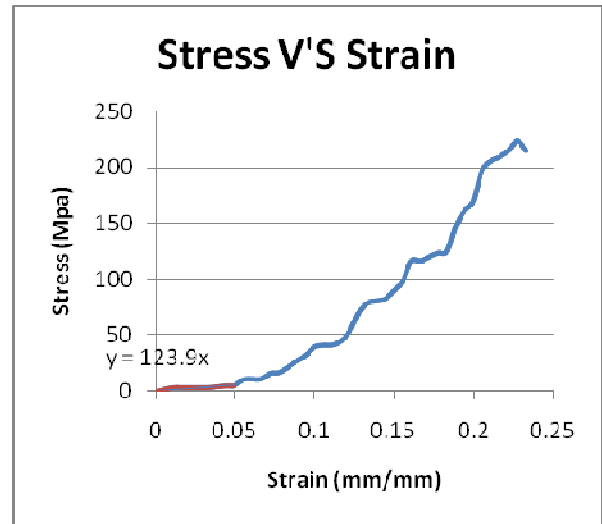


Figure 19: Stress Strain Curve for 9% B₄C Reinforced Al7075 Composites

6. DESIGN OF COMPOSITE CONNECTING ROD

6.1 Engine Specification of a High Speed Race Bike

Bore*Stroke = 80mm*62.1mm

Compression ratio = 10.9:1

- Maximum Power = 34Ps@9700rpm
- Maximum Torque = 27.3N-m@7700rpm
- Displacement = 312.2cc
- Pressure calculations
- Density of petrol = 737.22kg/m³
- Temperature 60F = 288.855K
- Mass of Petrol = Density*Volume
= 737.22*10⁻⁹*312.210⁻³=0.23kg

Molecular weight of Petrol=114.228g/mole

Gas Equation, PV=mRT

$$P = ((0.23*72.786*288.55)/312.2)$$

Pressure P=15.483 MPa

The pressure P = 15. 483 MPa acts on the piston and neglecting the side thrust the same force of magnitude 77826.46 N is assumed to be transmitted to the connecting rod. The compressive yield strength obtained from testing of the heat treated B₄C reinforced Al7075 alloy composite is used for design and analysis, and found to be 854.1 MPa. The connecting rod is designed as a Strut to withstand buckling load, and by adapting Rankine’s theory [12] and a FOS of 5 the critical buckling load is evaluated. The I- Section having I_{xx} = 3.2 I_{yy}, has the equal strength to resist buckling loads about both the axes.

6.2 Design of Composite Connecting Rod

6.2.1 Design of Cross-Section

Thickness of flange & web of the section = t

Width of section B= 4t

The standard dimension of I – section

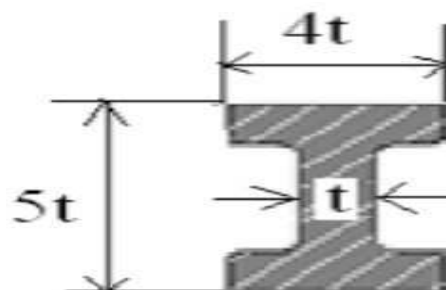


Figure 20

I- cross section

Height of section H = 5t

Area of section, $A = 2(4t \times t) + 3t \times t$

$$A = 11t^2$$

M.O.I of section about x axis: $I_{xx} = 1/12 [4t \{5t\}^3 - 3t \{3t\}^3] = 419/12[t^4]$

MI of section about y axis: $I_{yy} = 2 \times 1/12 [t \times \{4t\}^3 + 1/12 \{3t\}t^3] = 131/12[t^4]$

$$I_{xx} / I_{yy} = 3.2$$

Length of connecting rod (L) = 2 times the stroke length

$$L = 2 \times 62.1 = 124.2 \text{ mm}$$

$$P = 15.483 \text{ MPa}$$

σ_c = compressive yield stress = 854.12 N/mm^2

Buckling load $W_B = \text{maximum gas force} \times \text{F.O.S}$

$$F_c = ((\pi D^2)/4)P = (\pi \times (80 \times [10]^{-3})^2)/4 \times 15.483 \times [10]^6 = 77826.046 \text{ N}$$

$$W_B = F_c \times \text{FOS} = 77826.496 \times 5 = 389132.23 \text{ N}$$

$$W_B = (\sigma_c A) / (1 + a(L/K_{xx})^2)$$

Radius of crank, $r = \text{stroke length}/2 = 62.1/2 = 31.05 \text{ mm}$

$$K_{xx} = I_{xx} / A, K_{xx} = 1.78t$$

The heat treated 9% B_4C reinforced Al7075 composites have high yield strength, ultimate strength and compressive yield strength hence this material having maximum compressive yield strength of 854.1 MPa is considered for design

$$F_c = ((\pi D^2)/4)P = (\pi \times (80 \times [10]^{-3})^2)/4 \times 15.483 \times [10]^6 = 77826.046 \text{ N}$$

By substituting σ_c , A , a , L , K_{xx} on W_B then

$$t^2 = 44.823, t = 6.695 \text{ mm}, t = 6.7 \text{ mm}$$

Width of section $B = 4t = 4 \times 6.7 = 26.8 \text{ mm}$

Height of section $H = 5t = 5 \times 6.7 = 33.5 \text{ mm}$

$$\text{Area } A = 11t^2 = 11 \times 6.7 \times 6.7 = 493.79 \text{ mm}^2$$

Height at the big end (crank end) = $H_2 = 1.1H$ to $1.25H$

$$= 1.1 \times 33.5 \text{ mm} = 36.85 \text{ mm}$$

Height at the middle, $H = 5 \times 6.7 = 33.5 \text{ mm}$

Height at the small end (piston end) = $0.9H$ to $0.75H = 0.9 \times 33.5$

$$H_1 = 30.15 \text{ mm}$$

6.2.2 Dimensions of Big and Small End Bearings

$$P_c = \left(\frac{\pi D^2}{4}\right) P_{max}$$

$$P_c = \left(\frac{\pi(80 \times 10^{-3})^2}{4}\right) 15.483 \times 10^6$$

$$P_c = 77826.046 \text{ N}$$

$$P_c = d_p l_p (P_b)_p$$

d_p = diameter of the piston pin; l_p = length of the piston pin

$(P_b)_p$ ranges from 10 to 12.5 MPa

$$\left(\frac{l_p}{d_p}\right) = 1.5 \text{ to } 2$$

Let $(P_b)_p = 12.5$ and let $\left(\frac{l_p}{d_p}\right) = 1.5$

$$d_p = 65.7 \text{ mm}; l_p = 98.61 \text{ mm}$$

$$P_c = d_c l_c (P_b)_c$$

d_c = diameter of crank pin; l_c = length of crank pin

$(P_b)_c$ ranges from 5 to 10 MPa

$$\left(\frac{l_c}{d_c}\right) = 1.25 \text{ to } 1.5$$

Let $(P_b)_c = 6.5 \text{ N/mm}^2$ and let $\left(\frac{l_c}{d_c}\right) = 1.3$

$$d_c = 89.1 \text{ mm}; l_c = 124.7 \text{ mm}$$

6.2.3 Determination of Diameter of Blots

$$P_{i_{max}} = m_r \omega^2 r \left[\cos\theta + \frac{\cos 2\theta}{n_1} \right]$$

$$\omega = \left(\frac{2\pi N}{60}\right) = \frac{2\pi \times 7700}{60} = 806.34 \text{ rad/s}$$

$$\text{Crank radius, } r = \left(\frac{l}{2}\right) = \frac{124.2}{31.05} = 4$$

$$m_r = 2 + 0.18 = 2.18 \text{ kg}$$

$$P_{i_{max}} = 2.18 \times (806.34)^2 \times 31.05 \times 10^{-3} \left[1 + \frac{1}{4} \right]$$

$$P_{i_{max}} = 55012.9 \text{ N}$$

$$P_{i_{max}} = 2 \left(\frac{\pi d_c^2}{4}\right) \sigma_t$$

$$\text{Let } \sigma_t = 80 \text{ N/mm}^2$$

$$55012.9 = 2 \times \frac{\pi d_c^2}{4} \times 80 \times 10^6$$

$$d_c = 20.923 \text{ mm}$$

$$d = \frac{d_c}{0.8} = 26.153 \text{ mm}$$

6.2.4 Determination of Thickness of Big End Cap

$$M_b = \left(\frac{P_{i_{max}} \times l}{6} \right)$$

l = diameter of crank pin + 2 × 3(thickness of bush) + nominal dia of bolt + 3(clearance)

$$l = 89.114 + (2 \times 3) + 26.153 + 3$$

$$l = 141.014 \text{ mm}$$

$$M_b = \left(\frac{55012.9 \times 141.014 \times 10^{-3}}{6} \right) = 1293.169 \text{ Nm}$$

$$\sigma_b = \frac{M_b Y}{I} = 90 \times 10^6 \text{ N/m}^2$$

$$Y = \frac{t_c}{2} \text{ (} t_c \text{ is the thickness of big end cap)}$$

$$I = \frac{b_c t_c^3}{12} \text{ (} b_c \text{ is the length of crank pin} = 124.76 \text{ mm)}$$

$$I = \frac{124.76 \times t_c^3}{12} = 10.396 \times 10^{-3} \times t_c^3$$

$$\sigma_b = \frac{1293.169 \times t_c}{2 \times 10.396 \times 10^{-3} \times t_c^3}$$

$$t_c^2 = \frac{1293.169}{90 \times 10^6 \times 10.396 \times 10^{-3} \times 2}$$

$$t_c = 26.288 \text{ mm}$$

Table 5: Tabulation of Connecting Rod Dimensions

Sl.No	Design Parameters	Dimension (In Mm)
1.	Thickness of connecting rod (t)	6.7
2.	Height of section (H = 5t)	33.5
3.	Width of section (B = 4t)	26.8
4.	Height at big end (H2 = 1.1H)	36.85
5.	Height at small end (H1 = 0.9H)	30.15
6.	Inner diameter of small end	65.7
7.	Outer diameter of small end	92
8.	Inner diameter of big end	89.1
9.	Outer diameter of big end	115.38

7. FINITE ELEMENT ANALYSIS

The analysis of connecting rod is done using ANSYS software. Initially the 3D CAD model is prepared in the Solid Edge software and exported to ANSYS Workbench in Para solid format. The exported connecting rod is considered as isotropic homogeneous material with Young's modulus, $E = 124 \text{ GPa}$, and Poisson's ratio $\nu = 0.31$, which are evaluated

from the mechanical tests, and density $\rho = 2800 \text{ kg/m}^3$ found from the rule of Mixtures. The connecting rod is designed as a strut to withstand buckling load and inertia load. A compressive load of Maximum magnitude 132839.36 N [13] acts on the small end of the connecting rod during compression stroke and the crank end is fixed. A fine mesh with tetra hedra element size of 3mm is used for discretization, the numbers of nodes were found to be 2, 30,678 and the numbers of elements are 1, 34,522.

7.1 Analysis Results of 9%B₄C Reinforced Heat Treated Al7075 Composites

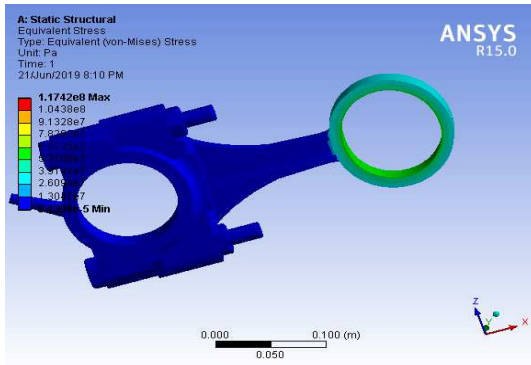


Figure 21: Equivalent Vonnises Stress

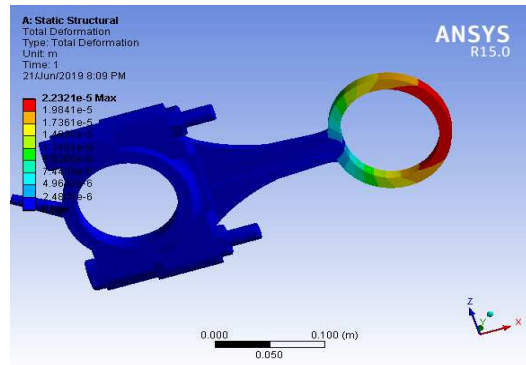


Figure 22: Total Deformation

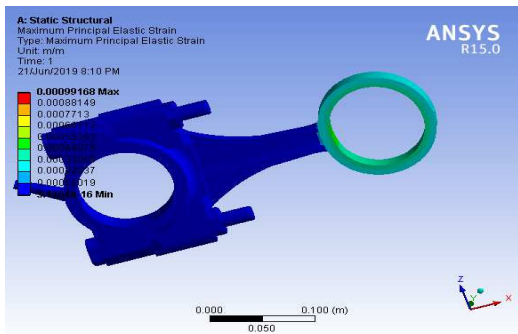


Figure 23: Maximum Principal Elastic Strain

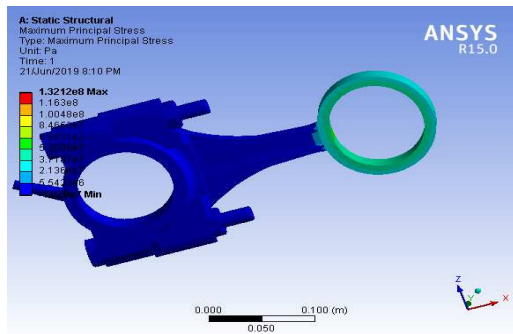


Figure 24: Maximum Principal Stress

7.2 Analysis Results of Forged Steel Connecting Rod

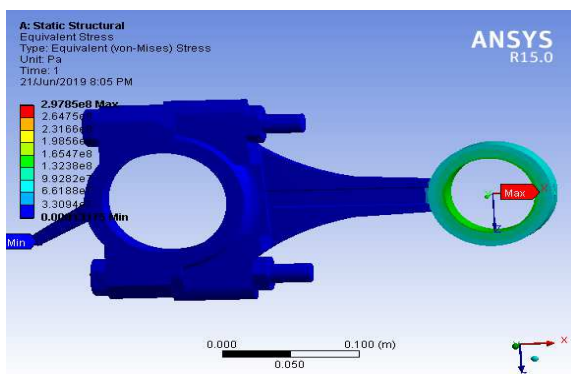


Figure 25: Equivalent Vonnises Stress

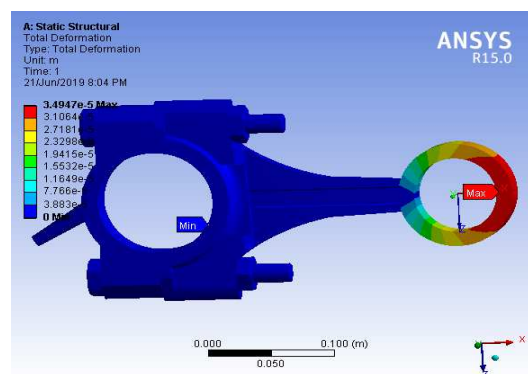


Figure 26: Total Deformation

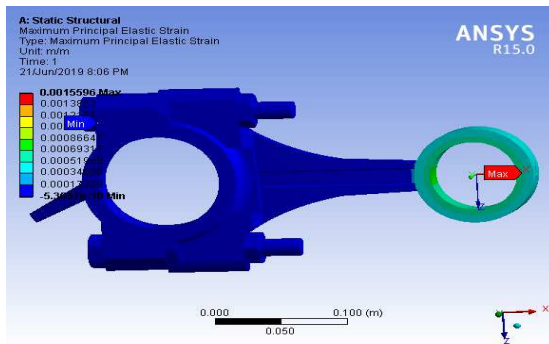


Figure 27: Maximum Principal Elastic Strain

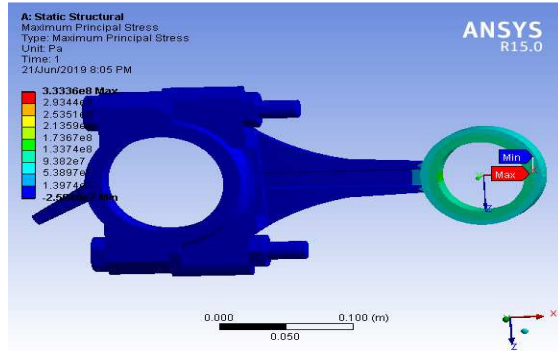


Figure 28: Maximum Principal Stress

8. RESULTS AND DISCUSSIONS

Table 6: Analysis Results of Forged Steel Connecting Rod

Design Parameters	Maximum	Minimum	Mass
Equivalent Vonmises Stress	297.85 MPa	3.39 MPa	4.08 kg
Maximum Principal Elastic Strain	1.59 mm/mm	0.1mm/mm	
Maximum Pricipal Stress	333.33 MPa	139.74 MPa (Compression)	
Total Deformation	0.0349 mm	0.003 mm	

Table 7: Analysis Results Of 9% B₄C Reinforced Heat Treated Al7075 Composites

Design Parameters	Maximum	Minimum	Mass
Equivalent Vonmises Stress	117.42 MPa	13.70 MPa	1.4158 kg
Maximum Principal Elastic Strain	0.919 mm/mm	0.1 mm/mm	
Maximum Principal Stress	132.4 MPa	5.52 MPa (Compression)	
Total Deformation	0.02 mm	0.023 mm	

It is evident from Table 6 & 7 the stress, strain, deformation and mass of 9%B₄Creinforced heat treated Al7075 composite connecting rod is less compared to its counterpart forged steel connecting rod, andin high speed engines inertia (mass) plays an important role, due to lesser mass the connecting rod made from these material can be an ideal choice. Due to inherent property of damping in Al7075 composites the material can absorb higher shocks and vibrations compared to forged steel connecting rod.

9. CONCLUSIONS

- From the Mechanical Tests it is observed that that the yield strength, ultimate tensile strength, compression strength of the heat treated Al7075 composites is much higher than un-heatreated Al7075 composites.
- The loss of material due to wear in the composites is less and suitable for connecting rod where high wear rates are involved. Since the aluminum possess good damping characteristics it can act as a good vibration and shocks absorber.
- Inertia plays a major role in high speed engines and hence an attempt is made to reduce the weight of the connecting rod without compromising the stiffness, it is found that the Mass of 9% B₄C reinforced heat treated Al7075 Composite connecting rod is 1.4185 kg and deformation is 0.02 mm, compared to forged steel connecting rod of 4.08 kg and deformation 0.0349 mm.

- From the analysis it is found that the equivalent Vonmises stress, maximum principal elastic strain, maximum principal stress and total deformation in the 9% B₄C reinforced Al7075 Composite connecting rod material is less when compared to forged steel connecting rod.
- The equivalent Vonmises stress in the 9% B₄C reinforced heat treated Al7075 composite connecting rod is 117.42 MPa which is much lesser than the equivalent Vonmises induced in the forged steel connecting rod 297.85 MPa, hence the connecting rod made of this material can withstand high buckling loads without failure, and can be a suitable material for connecting rod.

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