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A Study on the Analysis and Optimization of Vehicle Chassis

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ABSTRACT

In this paper, study of various Go-Karts has been summarized with its design and simulation for different impact tests like front, rear and side impact for multiple materials. This paper includes analysis of go-kart chassis done by some researchers and gives conclusion about different analysis done. Researchers used some software's for design and analysis of go-kart chassis like CAD, SOLIDWORKS, ANSYS, and CATIA. The researchers also observed the collision test on go-kart chassis by applying suitable force. Some papers compared materials and design on chassis frame. They discuss on the fabrication using different manufacturing process of the go-kart chassis in the workshop. Some paper also focused on better flexibility of chassis and better driver ergonomics. They also did analysis and simulation on existing cars chassis and heavy vehicle chassis like bus. This paper tells us about designing and failure standard. The intention of the present examination aims to look for the ideal material for the chassis design by looking at the work done by various researchers. Analysis has been done on Carbon and Aluminium chassis. So, this paper presents a study and analysis on different material chassis with impacts on front, rear and side.

Keywords: *Chassis; Analysis; Design; Go-Kart; Frame.*

1.0 Introduction

In automobiles, chassis is defined as the frame which gives support to different vehicle component. The wheels are ascending on the chassis with the assist of king pin and sprockets. Other parts of the vehicle likewise mounted with bolts and welding bonds. Framework need to be strong enough to take all the stresses and Bending or Torsion. To make certain the protection of the driver and passengers the skeleton ought to have a perfect design to ensure the basic safety rules and also fulfil its purpose. Go-kart is aneasy manageable, flimsy and close-packed vehicle with easy functioning. On account ofit's very low ground clearance, it is mainly used in the racing fields. The frame structure of go-kart is fabricated withvoid pipes frame having different cross sections. It must have high stability with high torsional rigidity and also have high flexibility as they do not have any suspension to absorb road shocks. So, it should be designed as thus and so it can offer sufficient firmness to hold out againstthe load furthermore other mountings. Hence, the main factor in designing chassis is its ergonomics. Chassis must be designed to ensure the safe ride and to distribute the load evenly so that it does not cause any structural changes in the chassis. Chassis are generally constructed of typically GI material having different grades. Chassis gives support to different power unit and various running systems etc. Go-kart chassis

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frame is generally categorized into four kinds. These are open, caged, straight or offset. Open karts lack chassis. Caged kart chassis only covers the driver and has a roll cage, commonly exploited in cinder tracks. Straight chassis are the widely appliedchassis, in this the driver seat is placed at the core and is used in sprint racing.

Go-karts may appear like a small car with no suspension system. The differential system and rest of the systems are same as the other automobiles. Typically, a kart has brakes on the rear and nothing on the front, and the brake pedal is setup at the front on one side of the kart, with the accelerator pedal on the right. In the left side, the clutch is arranged which is available at driver foot to operate the pedals. Perfectly fitted seat for the driver is setup at the centre of kart.

The main components of Go-kart are the chassis, axle, steering, engine, wheels, bumpers and tires. Its engine motor could be used each of two 2-stroke or 4-stroke. Chassis is the frame of aautomobile as the total weight of the vehicle need be withstand by it. By cause of this, the casing ought to have strength, flexibility and solidity. Go-kart cannot be used in off-road because it does not have suspension system and big tires. The bodywork is designed in kind a way that it needed less members and potential to bear loads put on it.

Chassis are the principal base formation of the vehicle which is referred to as frame. It consists of engine, transmission system, suspension system, steering system, wheels etc. it bears load of the components and load caused by external forces. There are types of chassis as-

- Ladder frame
- Tubular frame
- Monocoque frame

This paper presents the work done by various researchers on Go-Kart chassis with their design and simulation aspects.

2.0 Literature Review

Himanshu et al. [1] reviewed the different chassis systems and analysed them. The properties of various alternate materials like carbon fibre, aluminium alloy, titanium have been studied and been compared with conventional mild steel and they concluded that sufficient studies have not conducted on variable section concept and chassis.

Syed Azam Pasha Quadr et al. [2] provided a direct perception in design and analysis of the automobile by placing nodes where tubes of frame join. Their design depends on main factors like safety of driver and kart. Barve et al. [3] gave detailed outline calculation and inspection of go-kart chassis and concluded that AISI 4130 is finer substance with regard to strength, trustworthiness and function when differentiate with AISI 1018.

Anjul Chauhan et al. [4] analysed that material which has easy to be machined and cost efficiency is AISI 1018, hence was a great choice. Its major aim is to decrease complexity of the entire design process to reduce the weight without sacrificing durability and Performance. Kiral et al. [5] applied the finite substance for the judgment, forming and moderation of the best vehicle design. The material cast-off for the chassis is AISI 1080 mild /low carbon steel as itstands low cost and provides adequate safety to the driver. Shaik Himam Saheb et al. [6] discussed on the way go-kart should be and designed a safe and operationnal vehicle form on stiff and torsion free frames. The design was picked in such manner that the goKart is effortless to manufacture in all aspects.

Anbuselvi S et al [7] applied the finite substance for the judgment, forming and moderation of the best vehicle design. The material cast-off for the chassis is AISI 1080 mild /low carbon steel as itstands low cost and provides adequate safety to the driver. D.Raghunandan et al. [8] made chassis in a way that it needs small amount material and able to bear loads applied on it and concluded that outlining of the skeleton for Go-Kart assists in identifycation of weakness and strengths of the design. With the aid of this study, it would be not difficult to alter the chassis to have enough strength in it with small modifications. And rectify the weak points.

Bala Subramanyam et al. [9] has studied the Wagon R car chassis to understand the vibration characteristics. The chassis material was assigned as structural steel. 10 node tetrahedral solid elements were used for meshing in ANSYS software. In order to reduce the errors 70000 elements were used. Free-Free state modal analysis was performed with no constraints to study the natural frequencies and mode shapes. Initial 15 modes results were plotted for study out of which first 6 modes were zero. The results revealed that the first available 6 modes frequencies were less than 80Hz. Comparing the low idle engine vibrations with road excitation, the later have more impact in dynamic vehicle condition.

Prashant Thakareet al. [10] studied the alternate material for regular structural steel of a TATA 407 fire truck chassis. The ultra light weight carbon fibre material has been taken for comparative study. The Linear structural analysis and modal analysis were carried out separately with steel and carbon fibre materials. The analysis results revealed that the carbon fibre chassis have higher excitation frequency and less weight compared with the steel chassis. The Stress values were within the yield limit through comparatively higher in the carbon fibre.

Abdullahet al. [11] studied the bus chassis with different cross sections. C-section along with I-section and hollow rectangular sections for comparison study. The software model of the chassis was designed in Pro-E software and static analysis was performed in hyper mesh software. They analyzed calculation and FEA in software given that the hollow rectangular section has better result in stress and movement compared with I-section and C-section.

Karan Pariharet al. [12] researched and examined of the chassis of Hyundai Cruz Minibus. ABAQUS Software was utilized for designing and analysis. Own-weight of the frame is mentioned for stableinvestigation and acceleration, stopping test and roughness of road are taken for active dynamic analysis. It gives result such the stress on the chassis coming by braking was greater than comparison with acceleration.

Manjinderet al. [13] designed a chassis with Aluminum material. The selected aluminum for the chassis is 6061-T6 as Aluminum gives an edge of mass depletion. They concluded that aluminum chassis fulfill the aimed weight reduction, rigidity and strength.

Vigneshwaran. et al. [14] performed an analytical study on chassis fatigue life which utilized historical results from proving grounds and computational methods. The result of the study was two-folded. One was that a comprehensive dynamic of the vehicle is modeled which gives the force vectors acting on the chassis components which results in the improvement of stress evaluation procedure. This study has developed a comprehensive technique which combines models of vehicle dynamics, numerical simulation and real-world data for fatigue analysis.

Abhishek Singhet al. [15] develops Aluminum chassis. The aluminum selected for the chassis is 6061-T6 due to its low weight. As per them, aluminum chassis coincide with aimed of less weight, strength and rigidity. Balasubramanyam et al. [16] designed a chassis with reliability and safety. In order to increase the reliability, thickness of the chassis members is increased. Linear static analysis was carried out for three different thicknesses of chassis i.e. 4mm, 5mm and 6mm with a constant distributed load. The study revealed that the 4mm thickness can be replaced in place of 6mm thickness chassis cross members without affecting safety.

Chetan Mahatmeet al. [17] studied for the different material for frame. S-glass/Epoxy, Carbon/Epoxy and E-glass/Epoxy were taken as material for frame in three different cross sections like C-Section, I-Section and Box Section. Analysis was done for TATA EX chassis. 3D designing and FEA was done in Pro-E and ANSYS software respectively. Their research explained that the Carbon/Epoxy I-type section has great mechanical advantages like stiffness, strength and weight respective to remaining materials and structures.

Hajare Ket al. [18] implemented the design and analysis of a composite go-kart based on the combination of bio-fuels and efficient electric drive system. They used finite element analysis (FEA) by using COSMOS work. Finite element analysis method is used for Static Analysis in improving performance of racing go-kart successfully carried out with the chassis. The maximum deflection was successfully identified.

Kelkar Ket al. [19] analyzed that the modeling of chassis acts as an vital role and it can evolve many expertise in designing software like FUSION 360. From this examination, the prophecy of the frame is able to defend the stresses with alteration in frame model. C. Sharmaet al. [20] inspected that the engine and aerodynamic outline effortlessly thrust the speed of a go-kart. Braking system is modeled to compose a crucial role to stop the back-end wheels harmlessly and easily at rapid speed. Steering system designed likewise to give the true turning radius on any terms and gratifies the minimal condition of radius.

U. Kalitaet al. [21] sketched Go-Kart chassis frame and analyzed for various collision examination like rear collision testing, front collision testing and side collision testing for taken materials. Chassis is designed in CAD Software; analysis is done in

ANSYS. They concluded that AISI 4130 has more material performance as it is giving more secure results. Biancolini et al. [22] designed and fabricated go-kart vehicles with enhanced suspension and dynamics. This study is forecast on remodeling and simulation of the frame and the suspension systems of land vehicles made in 2010. Their study targeted to function static and dynamic inspection from analytical method sand conceptual knowledge makes use of software's like solid works and Ansys.

3.0 Analysis of Chassis

For go-kart chassis analysis we use two different materials for the analysis that we are going to compare aluminium alloy 7075 and carbon steel 1023

Table 1: Material Properties, Aluminium Alloy – 7075

Property	Value	Units
Elastic modulus	10442717	psi
Poisson's Ratio	0.33	N/A
Tensile Strength	82671.51096	psi
Yield Strength	73244.05797	psi
Thermal Expansion Coefficient	1.333333333e-05	/ºF
Mass Density	0.101518	lb/in^3
Hardening Factor	0.85	N/A

Figure 1: Graph for Poission Ratio and Mass Density

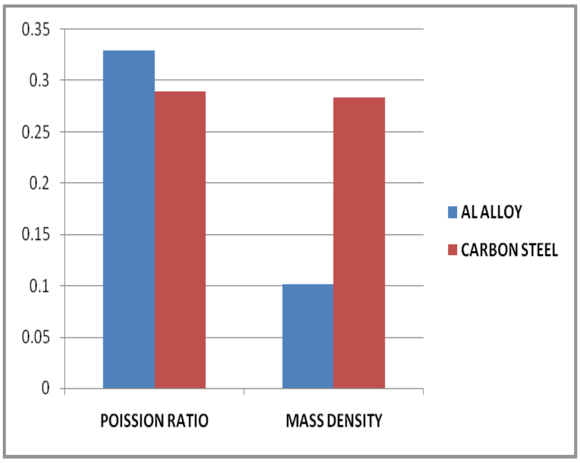


Table 2: Material Properties, Carbon Steel- 1023

Property	Value	Units
Elastic modulus	29732735.99	psi
Poisson's Ratio	0.29	N/A
Tensile Strength	61641.038	psi
Yield Strength	40999.9999	psi
Thermal Expansion Coefficient	6.666666667e-06	/ºF
Mass Density	0.283888	lb/in^3
Hardening Factor	0.85	N/A

3.1 Materieal property comparison

Figure 2: Graph for Tensile and Yield Strength

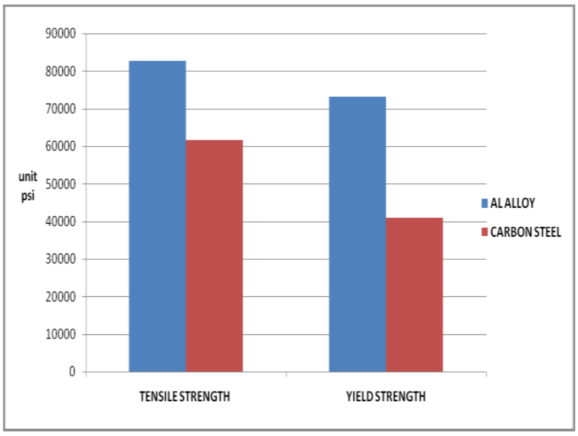
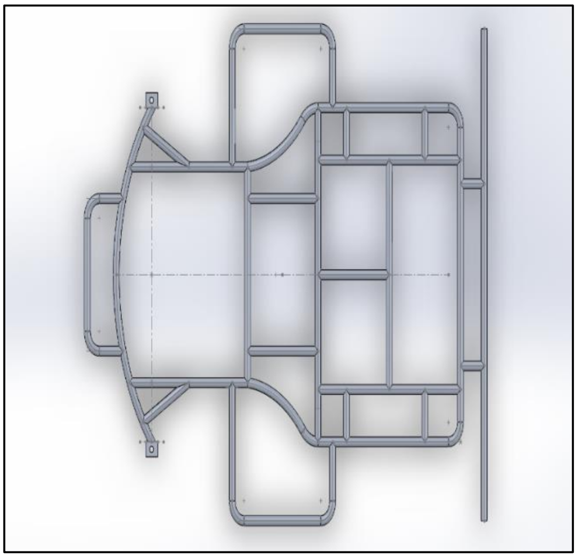


Figure 3: Chassis Model



4.0 Chassis Design

The chassis is the central frame of a vehicle which has to carry the entire component and support all the loads. It plays significant role in weight transfer while cornering the vehicle. It acts as a shock absorber which absorbs various shocks and vibrations from the road to provide maximum comfort to driver. Chassis is a frame hollow pipe. Go-kart chassis model is designed in solidworks software.

Table 3: Chassis Parameter

Parameters	Values
Track width	960mm
Wheel base	1200mm
Total length	1550mm
Total width	1146mm

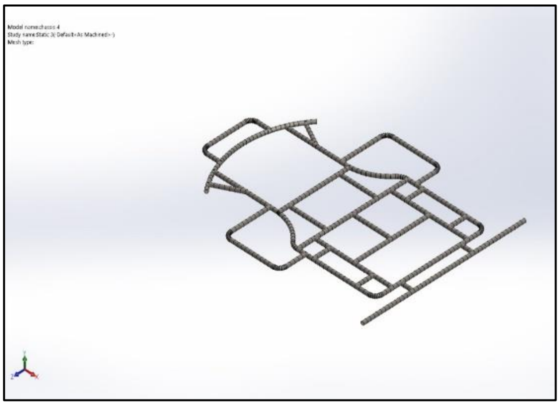
Chassis Design considerations

- Weight of the chassis should be less than 16kg.
- To be flexible enough to absorb road shock.
- To be easy to manufacture.
- To be strong enough to take load.

4.1 Analysis: Finite element analysis

Finite element analysis is a simulation technique for the analysing the different physical effects like stress, deformation and vibrations on the structure on application of forces on it from different directions. This analysis is carried out in solid works software.

Figure 4: Mesh Model



The main criteria of analysis are the stress distribution, displacement of chassis and factor of safety by two materials

- Carbon steel 1023
- Aluminium alloy 7075

Force impact on chassis:

- Front impact
- Rear impact
- Side impact

4.2 Impact considerations and calculation

Weight of the driver assumed to be 60 kg
Weight of the go-kart to be 80 kg
Total mass (m) equal to 120 kg
Speed of the vehicle is up to 55 km/h and velocity (v) is equal to 15.27 m/sec
Time contact during impact is equal 0.8 second
Impact force = (2*m*v)/t = 4581N
Factor of safety= 1.6 and displacement = 6.190 mm

Figure 5: Front impact on Aluminium Alloy Chassis

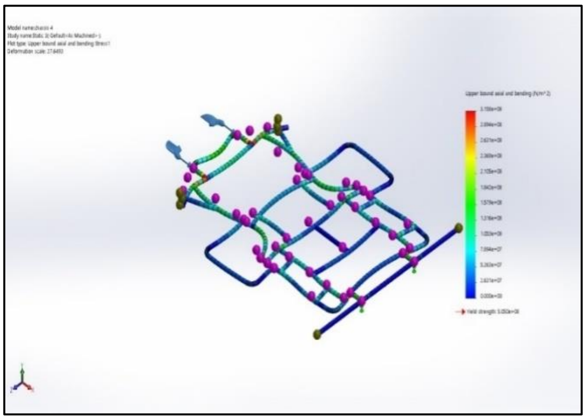


Figure 6: Front Impact on Carbon Steel Chassis With Factor of Safety = 0.91 and Displacement 2.520 mm

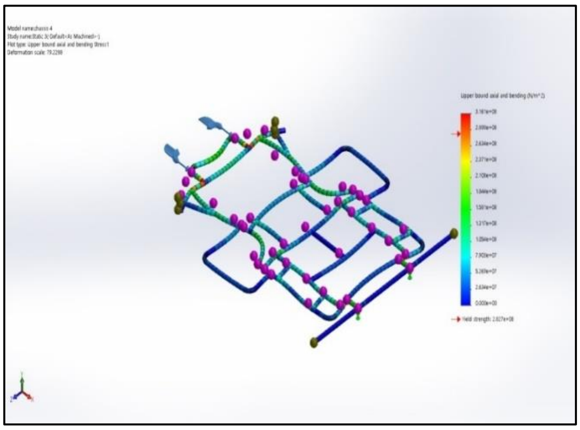


Figure 7: Rear Impact on Aluminium ith Factor of Safety = 0.9 and Maximum Displacement 4.745 mm

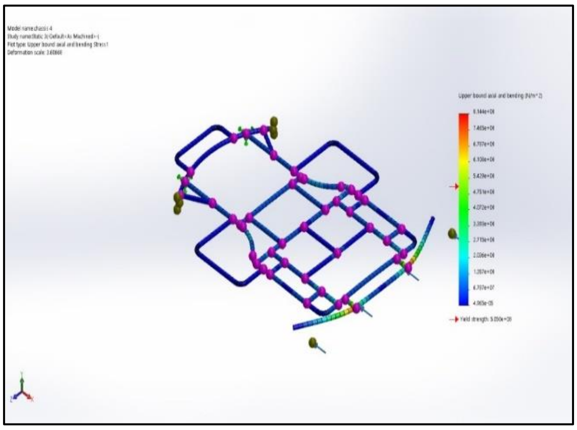


Figure 8: Rear Impact on Carbon Steel with Factor of Safety = 0.35 and Maximum Displacement 1.665 mm

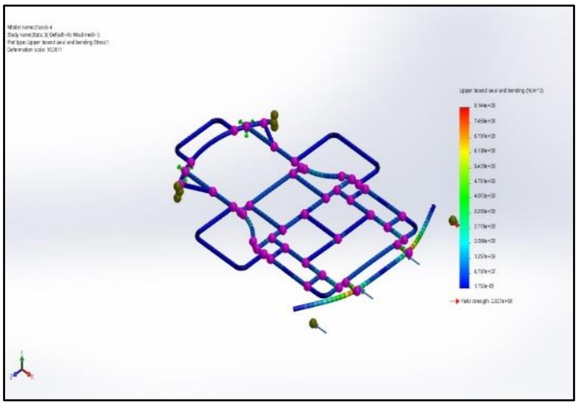


Figure 9: Side Impact on Aluminium Alloy Chassis With Factor of Safety = 1.6 and Maximum Displacement 15.828 mm

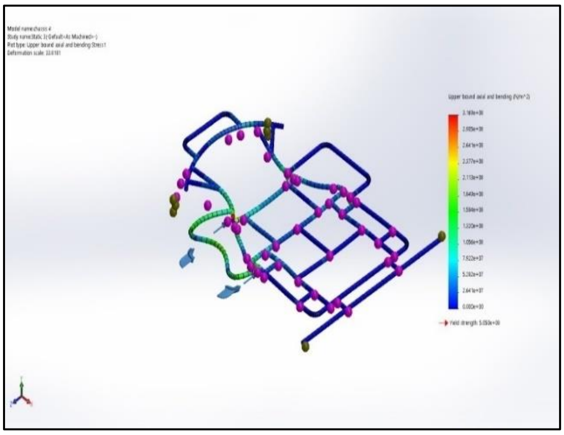
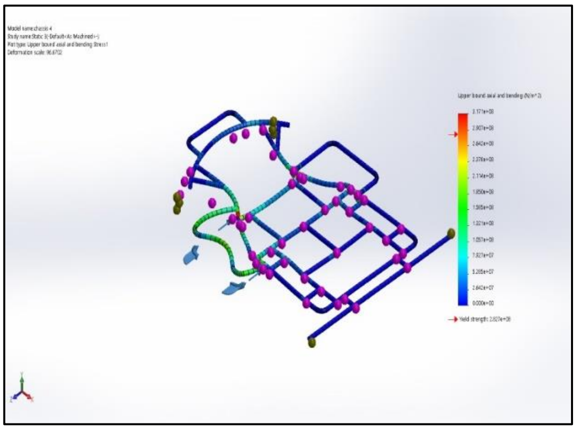


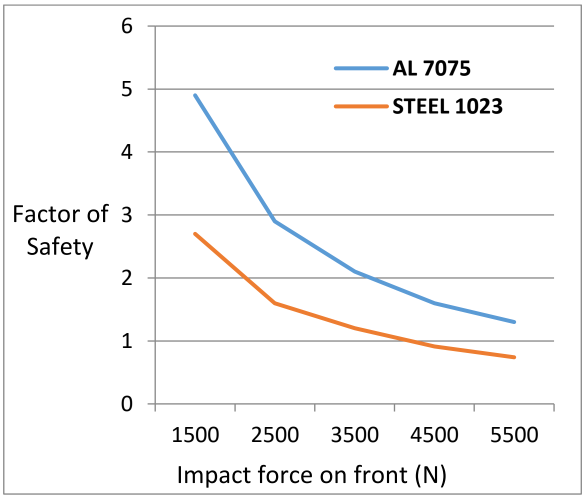
Figure 10: Side Impact on Carbon Steel Chassis With Factor of Safety = 0.89 and Maximum Displacement 2.039mm



4.3 Comparing aluminum alloy 7075 and carbon steel 1023

Graph contains comparison between aluminium alloy 7075 and carbon steel 1023 material on application of forces from 1500N to 5500N on chassis to find out the factor of safety of the both chassis

Figure 11: Graph on Front Impact and Factor of Safety



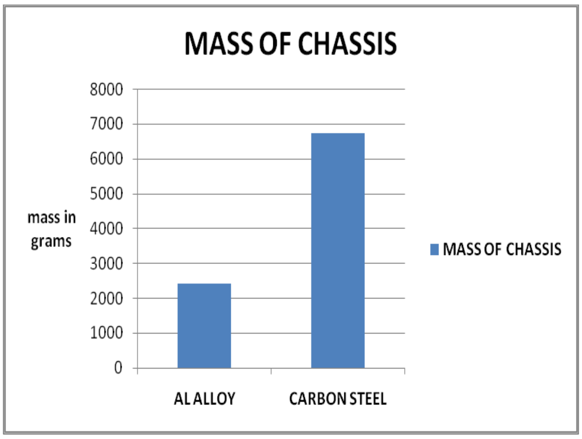
The graph shows the mass of the chassis of aluminium alloy 7075 and carbon steel 1023 materials.

Mass of aluminium alloy chassis is 2404.48

Mass of carbon steel chassis is 6723.99

The mass difference between both chassis is 4319.51

Figure 12: Mass of Chassis



5.0 Conclusions

From front impact, rear impact and side impact force analysis of both chassis are compared respectively.Factor of safety is coming better for aluminium alloy chassis than carbon steel. In the displacement of members carbon steel is giving better results than the aluminium. From the figure 11 we can observe that factor of safety decreases with increase in impact force and we can also observe that aluminium alloy chassis is giving better factor of safety than carbon. From figure 12 we clearly see that aluminium chassis is less weight than carbon steel. Strength and light weight are the basic consideration for choosing the chassis material.As a future scope of study, manufacturing techniques for various chassis could be explored for better quality with less cost.

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