ERGONOMIC DESIGN OF THE INTERIOR PACKAGING OF OFF-TRACK RACING VEHICLE- BAJA SAE

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Abstract

As the physical as well as mental health of the user of the vehicle is deeply impacted by its interiors, the ergonomic design of the occupant position relative to occupant packaging in the vehicle has to be considered. The primary focus of the paper is ergonomically design every component of interior packaging of the Off-track vehicle fulfilling standards of safety, comfort, ease to use and productivity for the user of the vehicle.

Introduction

In a surface vehicle, ergonomics comes into picture with 5 aspects that are to be concentrated upon:

1. Safety
2. Comfort
3. Ease of use
4. Productivity
5. Aesthetics

It is important that the driver be comfortable for the endurance race in which he is to drive the vehicle for a time length of continuous 4 hours and thus from this point of consideration for ATV of JAJA SAE, the comfort and safety of the driver are vital in order to reduce the fatigue of the driver and hence increase his efficiency.

The design is to be finalized taking into consideration the anthropometric, biomechanical and psychological elements of the driver and the interior packaging with which he interacts.

The specifications to be worked upon and scope of improvement from the vehicle of our last race are driver's seat shape and size, interior package dimensions with respect to H-point of driver, positioning of kill switch and Driver's Visibility.

Driver's Seat

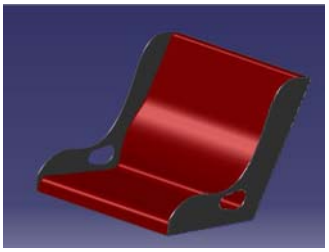
The seat is designed to:

1. Keep the correct curvature in the spine by lumbar support .Stop the pelvis tilting backward.
2. Minimize pressure under the coccyx (tail) and buttocks. Manage high pressure under the pelvis (ischial tuberosities).
3. Limit pressure under the hamstring muscles.
4. Provide good support under the pelvis and feet.
5. Keeping the head erect for best visibility.
6. Provide support to the thigh with enough knee clearance.
7. To achieve this, the seat dimensions, shape, geometry and cushioning are to be according to ergonomics specification.

DESCRIPTION	VALUE(mm)
Seat height	450
Lumbar support is provided	
Seat height till lumbar support	235
Seat back thickness (min.)	35
Seat back thickness (max.)	67
Cushion pan thickness (min.)	30
Cushion pan thickness (max.)	49
Cushion pan width at H-point (max)	400
Cushion pan width (min.)	360
Back pan width max at H-point	400
Back pan width min at lumbar region	
Back pan width at shoulder	367
H-point height above seat bottom	98+(-)2

The seat is designed by optimizing the standards given by SAE J4002-2010, anthropometric data of Indian, considering our driver's anthropometry and constraints on our car regarding weight of ATV and space in cockpit. The contouring along the side of seat and head rest still left are to be provided. The seat is attached to the firewall. The required distance between AHP and H-point is achieved by eliminating the space between seat back and firewall.

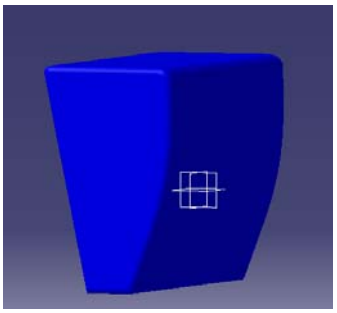
The seat dimensions and angles are:



Description	Angle
Seat back angle	20˚
Cushion pan angle	5˚

Headrest

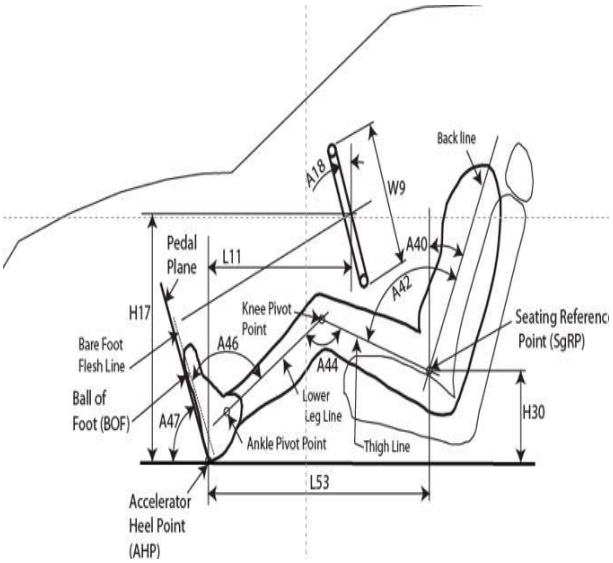
Description	Dimension (mm)
Width of Headrest	180
Height of Headrest	180
Thickness of Headrest	35-90



Designed to keep the head of the driver erect for the better visibility and preventing injuries to head and neck in case of accident.

Interior Packaging Dimension

Steering and pedal dimension and orientation with respect to driver and driver seating position is defined by SAE J4002-2010 in the following figure



Taking SAE standard of J4002-2010, driver anthropometric data and limited space above belly pan, pedal was designed with following dimensions:

Description	Value(mm)
AHP to BOF	170
Size of pedal	70x50
Shoe length	260

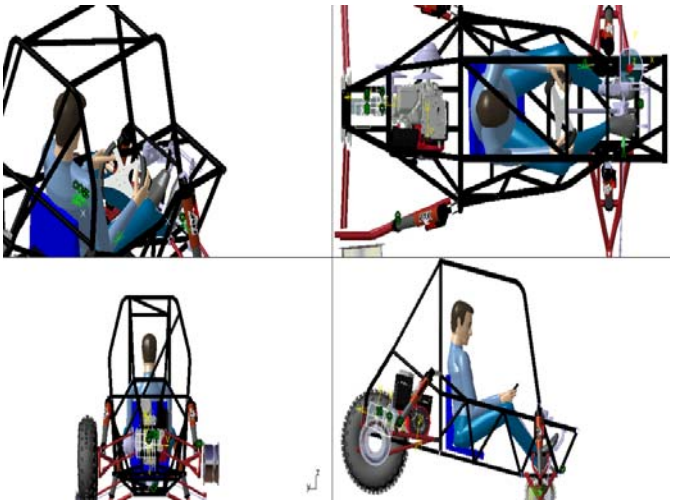
Description	Value(mm)
Pedal angle	56
Pedal travel	25

There is sufficient distance between brake pedal and accelerator for comfortable positioning of both shoe on pedal. There is bracing provided as a support to change position while sitting and prevention from fatigue due to constraint. The pedal is up-mounted to remove the reverse floor plane angle which is not recommended for such vehicle and bring AHP below H-point. This remove AHP just above master cylinder which was a mistake in old car. Using an OEM master cylinder the resistance provided by the pedal is within the allowed range and comfortable to use without causing fatigue to ankle and thigh muscle.

Calculation of position of BOF, AHP, knee angle (A44), ankle angle (A46), A42 was done and was compared with the comfort angles.

Description	Comfort angles
Knee angle	110-120
Ankle angle	90-100
A42	95-100

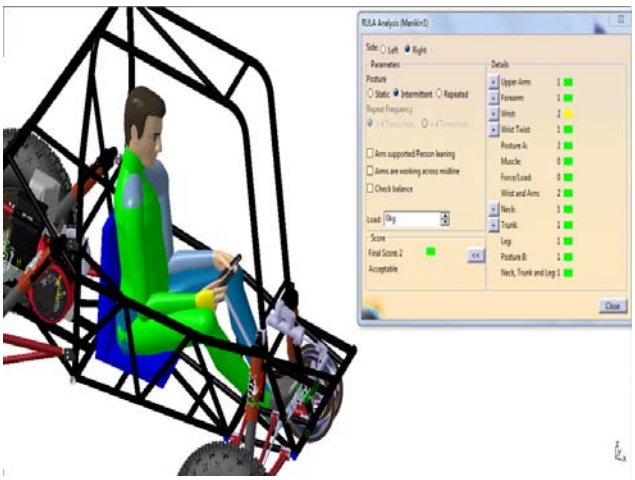
The manikin in Catia was built having anthropometry of nearly 95th percentile of Indians. There was no Indian manikin present in Catia so Japanese 92nd percentile was nearly same after correcting certain parts of the constructed manikin. The manikin was most comfortably placed and different clearances from manikin, its visibility, knee pivot and ankle angle was measured and RULA analysis was conducted. There was enough knee and thigh clearance because of ample space created because attaching the seat mounting to the firewall and giving a bend in chassis where the knee may come. There was about 192mm distance head clearance. The legs was comfortably balanced with knee near about 110° and ankle angle about 82° which goes well with the comfort zone as specified in SAE J4002-2010. The L53 length which the distance between the H-point and AHP is more than 720mm.



The visibility of manikin after placing comfortably on the seat was checked. The kill switch is in the visibility of the driver.

RULA Analysis

The RULA analysis was conducted. We obtained RULA score=2 on the driver which says acceptable.



Steering Wheel

The steering wheel angle to the horizontal is 35° which sets the angle of upper arm to the horizontal be at about 10° to the horizontal. Thus there is no fatigue generated on the arm. The centre distance of steering wheel from the belly pan is 600mm. Thus there is enough knee as well thigh clearance and prevents injury of the driver's leg in case of any accident. The minimum distance of the steering wheel should be more than 30mm from driver's chest bone. This has been taken care of to prevent any injury to the driver in case of jerk. A bend in the chassis is provided at a point where knee is positioned while sitting. It creates adequate space in the cockpit for the driver to sit comfortably and also increase the knee clearance.

	Old Design	Proposed Design
Seat	• Seat back angle(A40)=30˚ • Lumbar support absent • Seat contouring absent • Cushion support to thigh absent • L53=660mm	• Seat back angle(A40)=20˚ • Lumbar support present • Seat contouring present • Cushion pan angle=5˚ to support thigh • L53=720mm
Pedal	• Pedal angle(A47)=85˚ • AHP to BOF distance=160mm • Pedal travel>50˚ for accelerator pedal • High Brake Pedal resistance • Floor-mounted pedal • Knee and ankle angle not under comfort zone	• Pedal angle(A47)=55˚ • AHP to BOF distance=170mm • Pedal travel=25˚ • Brake Pedal resistance under allowed range using OEM master cylinder • Up-mounted pedal bringing AHP below H-point • Knee angle(A44)=110˚ • Ankle angle(A46)=82˚
Steering	• Steering wheel angle=60˚ to horizontal • Wrist under stress • Not enough knee and thigh clearance • Steering wheel close to breast bone of driver	• Steering wheel angle=35˚ to horizontal • Steering wheel 600mm above belly pan • Knee and thigh clearance>20mm • Steering wheel distance from breast bone>300mm
Chassis	• No bend provided in SIM • Kill switch not in the visibility of driver • Seat mounting and firewall distance=20mm	• Bend in SIM at knee position • Kill switch on steering wheel • Seat mounting attached to

		firewall creating space for driver
RULA Analysis	• RULA Analysis was not conducted	• RULA Analysis was conducted • RULA Score=2

References:

[1]SAE J4002:2010 H-point Machine (hpm-2) Specifications And Procedure For H-point Determination-Auditing Vehicle Seats.

[2]SAE J4003-2008 H-point Machine (hpm-2)-Procedure For H-point Determination-Benchmarking Vehicle Seats.

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[4] Reed, M.P., Manary, M.A., and Schneider, L.W. (1999a). Automobile occupant posture prediction for use with human models. Technical Paper 990966. Warrendale, PA: Society of Automotive Engineers, Inc.