SEAT-BED CABIN MODEL - AN ORIENTATION SUITABLE FOR THE SLEEPER BUS IN VIETNAM'S TRAFFIC EXPLOITATION CONDITIONS

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Abstract - The sleeper bus is considered as a new type of transportation vehicles in Viet Nam. Being manufactured and greatly used for the North-South long distance transportation route (2500 km) of Vietnam, it is much more comfortable than ordinary coaches in the context of the limitations of other means like airplanes and railway trains. The Truong Hai Automotive Joint Stock Company (shortly called Thaco) has recently designed and manufactured this particular type of transportation vehicle based on the Hyundai – Korea's bare chassis. This paper presents the first phases of the research on a seat-bed cabin sleeper bus model which is suitable for both foreign and domestic passengers; also, it puts forward some research aspects in terms of ergonomics, comfort and aesthetic for passengers all the way. The initial results show that the ergonomic dimensions and the comfort level have proved to satisfy passengers. The reverse engineering has been applied to the designing and manufacturing of this vehicle, which helps to upgrade it more and more in the near future.

Key words - seat-bed; sleeper bus; ergonomy; comfort; reverse engineering

1. Introduction

Vietnam is one of the Asian countries that has its major cities locating along geographical coastline from North to South. Thus, all the domestic transport means like road transport, railway transport, and aviation transport following up to develop from North to South.

Transporting passengers mainly occurred by the railway transport with its 1-metre width railway length of 2,249 kilometers and almost all of the locomotives, wagons and rail track systems are considered very old. From 2000 to 2010, the yearly growth rate of passengers reduced by 17.6% by the year of 2000 up until now it dropped by 8.1% in 2010. Its transport capacity only reached to transport roughly 5,400 passengers/day. Although transporting passengers by airplanes has recently developed, the price of airplane tickets is considered to be reasonably high; therefore, it aims to serve the passengers with high incomes and mainly business travelling purposes [5, 9].

National road (No.1, North-South) 2,260 km long, through 31 provinces and cities, if it is mention of the important parts of other national roads which connect other big business centers: Ha Noi – Hai Phong, Ho Chi Minh City – Vung Tau, Ho Chi Minh City – Binh Duong…Viet Nam has got the total of 2,500 km major national roads long with maximum speed is 80 km/h. The numbers of road lanes in one direction are 1-2 lanes, there are rarely road which has 3 lanes, and the majority of roads haven't got hard lane dividers. So, national roads traffic is mainly mixed traffic lanes which have various kinds of means of transportation: truck, coach, passenger car, motorbike, bicycle... the average speed in the whole route is only about 40km/h. It takes 3 days and 2 nights to travel from Ho Chi Minh City to Ha Noi.

Figure 1. *The No.1 national road*

Looking for an alternative mean of transporting passengers from North to South with the main purpose to serve the great number of passengers with the average and low incomes as well as to substitute the railway and airplane transport will be determined as a potential need for Vietnam in the recent time and near future.

2. Sleeper bus demands

2.1. Long distance and transit coach

The need for relaxation rest and sleep of passengers in long distance coach is very necessary. From that point, sleeper bus has presented in Viet Nam from 2007 and is becoming popular for passenger domestic and international transit (Asian transit). Operating sleeper buses mainly produced by Thaco (approximately 95% rate). This sleeper bus will reduce from 3 day & 2 night to 2 days 1 night or more of the North-South travelling.

2.2. Long distance coachs demands

Sleeper bus will be the main force of long distance vehicle for demands as follows [5, 9]:

- Volume of North-South passenger transportation currently has estimated around 70,000 passengers/day & night, this number can be forecasted to reach 120,000 passengers/day & night in 2020 and 156,000 passengers/day & night in 2030. Especially, on occasion of the long vacationr, festivals, Tet holiday… this demand will increase two or three times.

- In cadre of Greater Mekong Subregion (GMS) program that to impulse corporation, develope economic, exchange culture… between countries and territories through which the Mekong river flows, including: Cambodia, Myanmar, Laos, Thai Land, Viet Nam and Van Nam province – China, Viet Nam has got 500km of 4 corridor routes that demand the sleeper bus.

2.3. Coach export

Penetrating Asean and the developing countries coach market of sleeper bus made in Vietnam is a chance and a potential need. The export-sleeper bus in this market have to satisfy two criterions:

- Well adapted with every market on esthetic model, interior/exterior, comfort, habitation, manners and customs, road and traffic conditions.

- Having the particular characteristics and high quality than the coach in these countries.

The initial research shows that: Thaco Sleeper bus satisfies two above criterions.

Table 1. *The need of coach in Viet Nam [9]*

	2015	2020	2025
Total	36.500	69.500	92.000
Bus	30.000	60.000	80.000
Coach	6.000	8.000	10.000
Sleeper bus	3000	7.500	9.000

3. Model of seat - sleeper cabin in sleeper bus

3.1. Main scientific subjects

Thaco sleeper bus has been innovating and improving in a intergrated seat – bed. This seat-bed need the high requirments about demands of different passengers and different conditions of exploitation and traffic, so to be studied methodically, scientifically and suitably:

- Studying Vietnamese, Asean and Asian people egornomic in space and environment of sleeper bus.

- Studying the system of geometrical dimensions and layout standards of seat-sleeper cabin.

- Studying the shape, curve of curshion, back and headrest of sleeper in sitting up, sitting leaning backwards and lying position of passenger relevant to soft and comfort of curshion, back and headrest.

- The vibration of sleeper bus body, seat-sleeper mechanism of the 1st floor and the 2nd floor in cabin correlating with vehicle's movement modes on different types of road.

- Physiology, psychology mechanism of passengers on seat-sleeper, temperature influence and microclimate in cabin of sleeper bus

- Biological imitation about the seat-sleeper model suitable for relaxation need of passengers lying/sitting in seat-sleeper cabin space by day and by night.

- Aestheticism and friendliness of seat-sleeper cabin attract passengers and make comfortable psychology for passengers for long trip by night.

3.2. Seat-bed cabin modelling intent – oriented suitable

Building a seat-sleeper cabin model that satisfies above 7 scientific subjects in section 3.1. is very difficult. It needs to base on some basic theories below:

- Ergonomics theory;

- Physiological and psychological theory;

- Vibration and accommodating theory;

- Passengers' adaptability theory in microclimate environment of sleeper bus in long distance by day and night;

- Aesthetics theory of sleeper;

- Microclimate theory suitable for sleeper bus cabin;

- Temperature distributing model at different positions in sleeper bus cabin;

- Influence of air condition system layout to interior space and seat-sleeper cabin;

- Optimal air condition system suitable for interior space and seat-sleeper cabin;

- Automation control theory about ergonomics, physiological, and microclimate data of seat-sleeper cabin.

The term of "comfort" is commonly used to describe the integration of those 7 scienctific subjects, wich related with human reaction to the environment in seat-sleeper cabin. As psychological constructs, similar to "factigue" or "effort", comfort and discomfort more recently have been suggested to require treatment as different and complementary entities in many human factors, such as: ergonomics, physiology, psychology, oscillation, aesthetic, microclimate, temperature,… Zhang et al. found that sitting comfort and discomfort are orthogonality, not merely the opposite of each other, and therefore should be treated as independent entities. They observed that discomfort is related to biomechanics and factigue factors, whereas comfort is related to a sense of well-being and aesthetics. Similarly. Hancock et al. showed that discomfort relates to a lower-level need (prevention of pain) and comfort, as one of attributes inviting positive affect, relates to a high-level nedd (promotion of pleasure). Figure 2 shows the model of compositions of comfort and discomfort and their possible interactions [3].

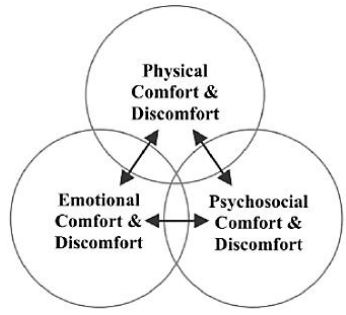

Figure 2. *Comfort and discomfort and their possible interactions*

Human reaction is a system within an environment + this environment potentially affects, or is affected by, people and/or the system. All these factors (ergonomics, heat and cold effects, vibration, noise, light…) on the health, comfort and performance of people, along with spatial factors are determinants of vehicles comfort.

Cobridge classified automotive comfort in 3 domains:

- Dynamic factors: vibration, shocks, acceleration;

- Ambient factors: thermal comfort, air quality, noise, pressure gradients;

- Spatial factors: the ergonomics of passengers' position (postural, physical fit).

Possible factors that can influence sitting comfort and discomfort are shown in Figure 3. [1, 2]

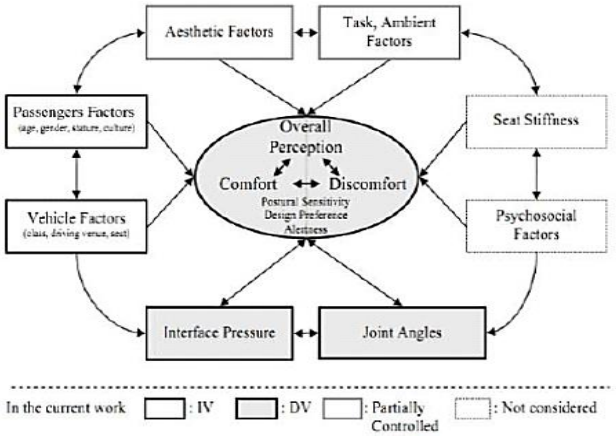

Figure 3. *Factors affecting sitting comfort and discomfort*

We give out the initial intent-oriented model which integrates the scientific subjectives as Figure 4. In this model, 6 satellites elements are ergonomics, physiology, aesthetic, psychology, microclimate and last, phenomenon 'bionics' is considered to design a seat-sleeper cabin that suitable for human biological demand. These 6 satellite elements are turned around the human factors (custom, religion, hobby) and vehicle's operation environment (traffic, road, climate). And more 4 keys factors of passenger's demand (comfort, vibration, easy and friendly).

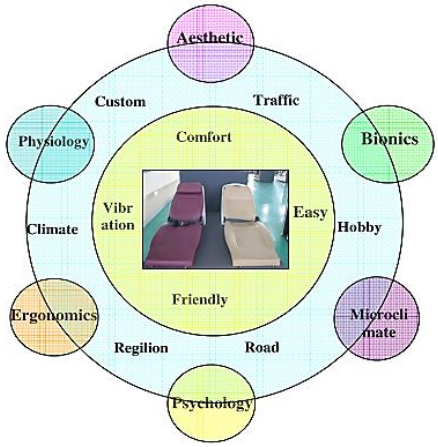

Figure 4. *The modelling intent - oriented suitable for sleeper bus in Asean traffic - exploitation conditions*

4. Initial studies in Thaco

4.1. Sleeper bus specifications

Nowaday, Truong Hai Automotive Joint Stock Company (Thaco) has manufactured sleeper bus which is based on Hyundai's bare chassis, organizing to manufacture body and other parts in Viet Nam (including seat-sleeper cabin). However, this vehicle has been continuousing to advanced technology by Thaco R-D center, including prototype design, exterior-interior design and particularly seat-sleeper cabin for the product quality and high competition to export to Asean market.

There are some images of this sleeper bus, interior, seat-sleeper which have been studying and experimenting at Thaco R-D center. Thaco HB 120SL sleeper bus has some main specifications as below:

Table 2. *Sleeper bus specification*

Specification	Sleeper bus
Bare chassis	THACO HYUNDAI HB120SL
Passenger capacity	38 sleepers + 2 seats
Dimension DxRxC (mm)	12000 x 2500 x 3700
Curb weight (kG)	13590
Gross weight (kG)	16110
Tire	12R22.5
Type of seat	Sleeper on which passenger can sit or lie.
Hygiene Service	Having convenient toilet
Other options	Hard disc + M-Player + 04 LCD + refrigeration + reverse camera + virus treatment light system + Engine firefighting system
Vmax	110 km/h
I_{max}	29,4%
Minimum radius turning (m)	10,4
Fuel consumption 100km	30 lit

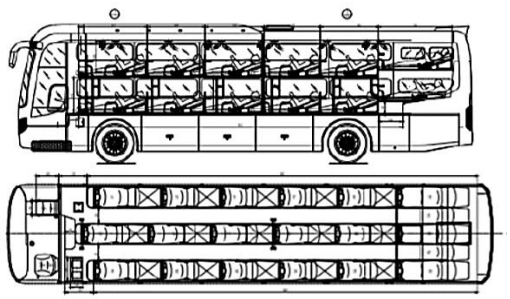

Figure 5. *Sleeper bus layout*

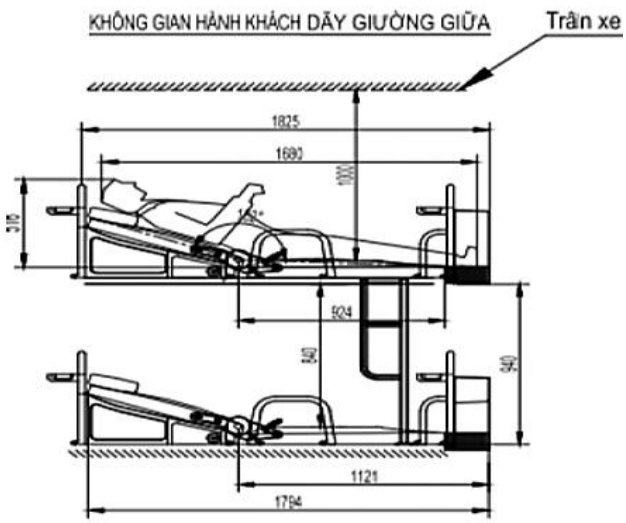

Figure 6. *Seat-sleeper cabin layout.*

4.2. Reverse Engineering application

Reverse Engineering was initially applied for designing sleeper bus interior. Base on real prototypes which are

Figure 7. *Rapid scan laser engineering of GOM*

initially made, we have used "Rapid Scan Laser' engineering of GOM and KREON 3D. From these scan data, transfer to Polygon Mesh data, making Nurbs surface, change to CAD 3D drawing. On this base, analyzing product, smooth test of product… designing die and making CNC program for processing die and parts. This Reverse Engineering are more and more developing and combining with theory studies so that we can give out high quality product.

Figure 8. *Rapid scan laser engineering of KREON*

Figure 9. *Some product pictures*

5. Proposals for the automatic control seats – beds cabin application

As the travel time of passengers is long and it is a non-stop intinerary, it is necessary for the sleeper bus to be regulated automatically the parameters of interior and seats-beds, bringing a high comfort level for passengers. Some suggestions for application of automatic control seats-beds cabin are as follows:

- Control semi-automatically by button-device so passengers can adjust the position of the backrest cushion and headrest cushions to change posture: lying, half lying, sitting as desired in case fatigue;

- Semi-automatic control of ventilation and softness of the seat cushion and back cushion in anthropometry and weight, preferences of the different types of passengers;

- Automatic control of microclimate inside to ensure

clean air for passengers in depending on the number of passengers, length of stay in the sleeper bus;

- Automatic temperature control of cabin passengers depending on the number of passengers, sleeper bus operating time.

These are the content of the research related to automatic control that we will continuously deploy and announce at the next conferences.

6. Conclusion and development

Sleeper bus is a suitable means for the in-way-develop countries that limits railway and air-line. It is also suitable for people on low or average income.

The research of seat - bed cabin involves in such multi factors of subjective and objective as road-traffic and weather condition as well as people, customs, religions of the Asean countries.

Seat-bed cabin modelling intent - oriented proposed by Truong Hai company is preliminary studied as the basis for the study of better sleeper bus.

This topic is a part in the cadre of national science and technology project, will be deployed by Thaco in 2015.

The main way of deployment is deeply analyzing the scientific basis of the integrated model, the theoretical-simulation and the design of seats - bed cabin in associating with the modern tools of reverse engineering. We need also the study on the automation control parameters of seat-bed cabin in order to produce new products, suitable with the demand of passengers in long-distance and inter-countries in the Asean in the near future.

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