International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 11 | Nov -2016 www.irjet.net p-ISSN: 2395-0072

ON 'INDUSTRIAL DESIGN' OF THE MOTORBIKES THROUGH QFD AS AN APPLICATION TOOL: A CASE STUDY PERTAINING TO THE NEEDS OF THE MOTORBIKE DRIVERS ON INDIAN ROADS

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Abstract - India is the second largest producer of the two-wheelers in the world and the industry is growing at a rate of 30% annually. With population of bikes going up, number of motorbike accidents is also increasing exponentially, perhaps, due to inadequate 'industrial design' of the bikes from Indian users point of view. Success of a product basically depends on how the manufacturers meet the customers' needs and expectations. Present study applied Quality Function Deployment (QFD) to understand the motorbike drivers' needs in the Indian market. In literature, few studies have addressed the issue. Present work identified and then prioritized the motorbike drivers' needs on Indian roads located in Delhi-NCR region. The study spanned over twelve stakeholders who responded to the eight number of the considered motorbike drivers' needs pertaining to 'industrial design', through direct and on-line respondents. Results were obtained in terms of the motorbike riders' needs and its ranking, statistical analysis of the stakeholders' responses, and VOC establishment as a part of the QFD analysis. Findings of the present study revealed that when the market of the motorbikes is flourishing day by day, the future motorbike designers and suppliers have to consider such 'industrial design' related needs of the motorbike drivers as 'Pain in arms holding handles', 'Night driving related needs', 'Seat Design related needs', 'Bike-Strength etc. related needs', 'Ease in bike-operation related needs', 'Aesthetics, look etc related needs', 'Driving Safety, Breakdowns' related needs & 'Display-control compatibility related needs'. Implications of these findings are discussed in light of the results of previous researches, conclusions are drawn and scope for future work is presented.

Key Words: *Motorbikes, Industrial Design, QFD, VoC, Indian users & TQM*

1. INTRODUCTION

There are various possibilities of mode of transportation for anybody travelling from one destination to another. In general, a user can choose between car, scooter, motorbike, bicycle, and different forms of public transportation systems like trams, metro, buses etc. These possibilities require different information about different kinds of systems of transportation. A biker for example wants information about difference in altitude he has on his way. Other important factors might be separate bike lanes to avoid the traffic on the streets. Another aspect could be: what information does the rider already have? A possible strategy is to decide first which transport possibility to choose reflecting his membership to a certain group. Depending on the social surrounding and the social resources a person has the possibility to decide on the transport vehicle. To maximize use and minimize costs a smaller vehicle would be preferred by the users. If one has to transport heavy freight, the choice will fall to a bigger van or a truck. In short, purpose leads to the chosen way of transport. Riding a bike is a common way of transport in India and many other countries because the running costs are low compared to the car or truck. Bikes have also other advantages: they are easy to buy, it is easy to park and no parking tickets or nearly no parking restrictions have to be considered. On one hand, the demand of motorbikes is observed to be increasing day by day, and on the other hand, the number of accidents involving motor bikes is also increasing exponentially on Indian road. One of the most pronounced reasons for increasing number of accidents on Indian roads may be traced in terms of the non compatible designs of the motor bikes from the human-vehicle design point of view. This calls for immediate attention of the industrial designers of the motorbikes to review the designs to make them compatible to Indian users. Present paper made an attempt to put forth the needs of the motorbike drivers belonging to the Delhi-NCR region (representing a part of Indian road) from industrial design point of view. The study is based on the VoC (Voice of Customers) of the QFD (Quality Function Deployment) technique.

2. LITERATURE REVIEW

Man has been in search of better and faster transportation systems since eternity, as they form the basis of human existence in every era, be it the present one or the past ones for that matter. Transportation systems ranged from land transport system in the pre-Christ era to the present day

modern rail and air transportation and other systems. According to United Nations, cities are home to half of the world's population, which is going to increase to almost two-thirds in the next fifteen years. The importance of transportation systems gains its importance from this fact too, as the interlinking of cities would give life to the businesses, and hence the homes. The most used transportation system which has really done wonders in connecting people across the major cities is the rail system, like High Speed Rail (HSR) system. The countries like Japan, China, US, France have successfully implemented HSR system in which the train speed is in excess of 200 km/hr [1]. As far as the global scenario is concerned especially in the case of developed countries like Japan, rail-based transit systems are by and large successful [2]. However in Asian countries, the scenario is different because of the lesser number of hi-rise buildings and hence cannot feed very high capacity transit systems. It is because of the need of transporting 15,000 to 25,000 passengers per direction per hour operating on all the major corridors. In that case, modern bus rapid transit systems are needed which can cater to the growing population in these cities. Dinesh [2] also compared the bus transport systems of the metro cities across the world, viz., Bogota (Columbia), Sao Polo (Brazil), Curitiba (Brazil), Porto Alegre (Brazil), Quito (Equador), Kunming (China), Los Angeles (USA), Beijing (China), Chonqing (China), and Lima (Peru). In case of India, Delhi and Mumbai are two mega cities which behave in exactly the opposite fashion so far as the transportation systems are concerned. Delhi, being scattered cannot support only rail transit systems which is very much successful in Mumbai case. That is the reason why Delhi needs a very comprehensive multi- modal transportation system which should include both road and rail transportation facilities, all of them working in tandem. This is true about the mega cities, but when some smaller cities are looked into, it is evident that rail transit systems surely are a must, along with some form of transport system which makes the life of the general public easier. The transportation systems in use, especially the rail transportation system has its limits in reaching the users in the interiors. For example, in Delhi, typically, a person has to walk for at least 200-300 m to catch the nearest metro train, despite taking the different road transport media. This makes the rail transport within metro cities like Delhi pretty redundant, though the cost of travel is much low when compared to other urban means of transport. So far as the National scenario is concerned, it is evident from the facts and figures that urban India, (and, to a larger extent rural India too) relies on two wheeled transport system because of the scattered populations with lesser (or almost nil) means of public transport in many parts of the nation, the most common being the rail transport which is too used to cover distances between towns and cities, which are of course sort of long distances. The cost of the fuel, both petrol and diesel also is responsible for the increase of two-wheeled transportation system on Indian roads. It has been reported that India is the second largest producer of the two-wheeler in the world [3]. The two wheeler segment contributes the largest volume to all the segments in automobile industry in India. The country stands next to China and Japan in terms of production and sales respectively. The industry is growing at a rate of 30% annually. It consists of three segment viz. scooter, motorcycle and moped. Majority of Indians, especially the youngster prefer motorbikes rather than cars. Capturing a large share in the two wheeler industry, bikes and scooter covers a major segment. Bikes are considered to be the favorites among the youth generation, as they help in easy movement from one destination to another, particularly, for the professionals today involved in a large number, in the business of on line shopping undertaken by the masses located in the interiors of even the megacities of India. Under these circumstances, the number of motorbike drivers is bound to go up and then the only those brands of the motorbike would be able to successfully compete in Indian markets which are designed from ergonomics point of view. This eventually demands to determine the customers' needs. The tool that can be employed for this purpose is known as QFD, the Quality Function Deployment. By way of the implementation of Quality Function Deployment (QFD) technique, customer satisfaction and service quality can be improved. Quality Function Deployment technique is an approach which focuses on improving the organization's effectiveness, efficiency and responsiveness to customers' and other stakeholders' needs by actively harnessing people's skills and competencies in the pursuit of achieving sustained improvements to organizational performance. Quality function deployment (QFD) is a management tool that provides a visual connective process to help teams focus on the needs of the customers throughout the total development cycle of a product or process. It provides the means for translating customer needs into appropriate technical requirements for each stage of a product/process-development life-cycle. It helps to develop more customer-oriented, higher-quality products. While the structure provided by QFD can be significantly beneficial, it is not a simple tool to use [4]. Introduction to succeed in developing new products or improving on existing ones is not easy. Studies indicate that as much as somewhere between 35 per cent and 44 per cent of all products launched is considered failures. It is one thing to actually discover and determines the customers' needs and wants but, to achieve results, these findings are needed to be implemented, i.e. translated into company language. Many companies depend on their warranty programs, customer complaints, and inputs from their sales staff to keep them in touch with their customers [5]. The result is a focus on what is wrong with the existing product or service, with little or no attention on what is right or what the customer really wants. It is well documented that the use of QFD can reduce the development time by 50 per cent, and start-up and engineering costs can be reduced by 30 per cent [6].

In the field of manufacturing, the application of QFD appears to be expanding day by day. These applications are well

documented in literature [7]. The above presented literature indicates that number of motorbike drivers is increasing day by day and so is the case with the number accidents involving motorbikes on Indian roads. In the field of ergonomics also termed as industrial design, enough evidence has been reported about other modes of transportation systems like cars, trucks and airplanes etc. in which the drivers/pilot officers did not find their systems designs fit from ergonomics point of view. On similar lines, there exists a need to explore about the scope of industrial design of motorbikes also.

3. RESEARCH METHOD & MATERIALS

In order to have an assessment of the needs of the motorbike end-users i.e., the riders of the motorbikes, data were collected by way of the following two modes:

(a) Direct response collection from the bike riders through the designed questionnaires
(b) On-line distribution of the questionnaires and data collection

The questionnaire or inventory system, as is often termed in the fields of psychology and sociology, were employed as the data-collection tool, a tool that primarily relies on the respondents' responses obtained through the questionnaire. Data collected regarding demographic data of the motorbike drivers included educational qualification, sex, age, length of the driving experience, brand of the motorbike, distance travelled per day etc. In the questionnaire designed, in all, there were 25 questions all related to the 'industrial design' features of the motorbikes and their riders. Each question addressed a particular kind of the feature of the problem. Through the two modes data collection stated earlier, the responses were collected from the motorbike riders driving in Delhi-NCR region of India. . For the purpose of the analysis of the data, primarily, QFD based methodology was employed: Before undertaking this analysis, the demographic data of the respondents were also studied. Primarily, these data were analyzed in terms of the frequency analysis. The quality function deployment (QFD) was employed for the assessment of the motorbike riders' needs. The needs established were ranked statistically. The ranking was done on the basis of the mean scores pertaining to the eight needs as per Likert scale responses (1 to 5) received from the members of different stakeholders (motor-bike drivers). Statistical analysis of data was undertaken through descriptive statistics for the test variables. The software package employed was the SPSS. Under QFD analysis, the mean scores of the respondents' responses were calculated. These means provided the 'weights' required in the QFD methodology. Through the QFD, the Voice of the Customers (VOC) was established.

4. RESULTS, DISCUSSION & CONCLUSION

It was found that most of the riders used the brands like Hero, Honda, TVS, Bajaj, Yamaha, Enfield, Suzuki and Mahindra. Thus, it may be observed that the data collected in the present study covered almost majority of the motorbikes being driven on Indian roads. Literature review [8] revealed that various kinds of motorbikes running on the Indian roads, by popularity in 2016, are Bajaj Pulsar, Hero Splendor, Bajaj Discover, TVS Star City Plus, Hero CBZ, Hero Karizma, Bajaj Platina, Honda Shine, Honda CBF Stunner, and Yamaha Fazer. The respondents i.e. the motorbike riders were asked to provide their demographic characteristics and accordingly, the list of the stakeholders, considered in the present study was prepared. In all, there were 12 stakeholders as listed in the table below (Table 1). It was found that from amongst the 53 respondents who participated in the study the maximum number of respondents (43) were from the stakeholders category 'Right-Handed', while minimum number of respondents (2) were from the category, 'Left-Handed'.

Table-1: List of the stakeholders considered in the present study

BIKE-RIDERS CHARACTERISTICS	STAKE-HOLDERS CONSIDERED [The End-Users of The Motor-Bikes]	
Occupation-wise	1.Employed	2. Others (Unemployed, students etc.)
Qualification-wise	3. Graduates	4. Non-Graduates
Age-wise	5. Youngsters (Below 30 yrs)	6. Elders (30+ yrs)
Gender-wise	7. Males	8. Females
Laterality-wise	9. Right- handed	10. Left-handed
Driving Experience	11. Starters (less than	12. Experienced (2+ yrs)

For each of the industrial design need-related response scores data corresponding to the 12 stake-holders, mean response score spanned over the respective stakeholders, were calculated and the same are presented in Table 2. On the basis of these response scores, it emerged that among all the stakeholders, the 'left-handed' bike drivers gave top score to the 'industrial design' related needs whereas the 'female' bike drivers gave relatively least score to those considered in the present study. Other stakeholders were ranked as shown in the table under reference. It may be noted that all the 'stakeholders' of the motor bike-drivers of Delhi-NCR region carry the response-scores between 2.03 and 2.91, implying that all the considered needs belong to the 'agreed' or 'desired' level.

Table-2: Mean response-scores of 12 different stakeholders for 'Industrial Design related' needs of the motorbike drivers belonging to the Delhi-NCR region

Stake holders	Employed	Others	Graduates	Non-graduates	Elders	Youngsters	Males	Females	Right-Handed	Left-Handed	Experienced	Starters
Mean score	2.33	2.66	2.36	2.7	2.38	2.44	2.48	2.03	2.4	2.91	2.40	2.52
RANK	X	III	VIII	II	VIII	V	VI	XI	VII	I	VII	IV

On the basis of the response scores, shown in Table 3, it was found that among all the industrial design related needs, the

motor bike drivers gave top score to the 'pain in arms holding the handles of the motor bikes' related needs whereas the 'display-control compatibility' related design-needs of the bike drivers got relatively least score among those considered in the present study. Other needs got the ranks as shown in the table under reference. It may be noted that all the 'design related' needs of the motor bike-drivers of Delhi-NCR region carry the response-scores between 2.04 and 2.88, implying that all the considered needs belong to the 'agreed' or 'desired' level. Present analysis of data was employed to determine the prioritized needs of stakeholders for determination of the VoC (Voice of customers) of the QFD technique. The house of quality is the most commonly used matrix in QFD. In practice, varieties of the forms of the house of quality are used as is well documented in literature. In general most of them include: Customer Needs (Whats), Technical Descriptors (Hows), Relationship (between Whats & Hows), Interrelationship (among How's), Competitive Assessments, Prioritizing Customer Requirements and Prioritizing Technical Descriptors. The customer needs (Whats) define what is required to be accomplished, targeting on the stakeholders' needs to achieve the objective. Accordingly, the motorbike drivers' needs were established and then these needs were ranked.

Table-3: Results pertaining to the Ranking of the considered 'Industrial Design' related needs of the motorbike drivers of the Delhi-NCR Region.

S. No.	Needs Considered	Mean of the response scores	Rank of the needs
1.	Seat Design	2.57	III
2.	Driving Safety, Breakdowns	2.25	VII
3.	Display-control compatibility	2.04	VIII
4.	Aesthetics, look etc	2.28	VI
5.	Ease in bike-operation	2.40	V
6.	Bike-Strength etc.	2.55	IV
7.	Pain in arms, holding handles	2.88	I
8.	Night driving	2.76	II

In general, the needs reflected the qualities, attributes, and wants of the motorbike drivers of Delhi-NCR region. In order to develop the 'technical descriptors', the 'primary needs' of the motorbike drivers were considered and demarcated in light of the response-sets of the motorbike drivers of Delhi-NCR region as shown in Table 3. The ranking (I to VIII) of the 'industrial design related' customers' needs emerged as follows:

I Pain in arms, holding handles' related needs
II Night driving related needs
III Seat Design related needs and
IV Bike-Strength etc. related needs
V Ease in bike-operation related needs
VI Aesthetics, look etc related needs
VII Driving Safety, Breakdowns' related needs &
VIII Display-control compatibility related needs

Accordingly, the secondary needs associated with each of the above presented primary needs were determined and these might be used in the 'house of quality' of the QFD. Present work pertains to the motorbike riders and their needs assessment for the manufacturing of those motorbikes which would like to satisfy its end-users. On one hand manufacturers have to look for the mechanical aspects of the vehicle design. On the other hand, to compete successfully in the Indian two-wheelers market, in general, and the motorbike-markets, in particular, the vehicle manufacturers must find out the needs of the motorbike riders. In this context, the list of 'secondary needs', was explored as presented in Table 4. In light of these secondary needs, 'technical descriptors (HOWs)' can be evolved by the experts, the design-specialists in the field of 'industrial design', and the same can be employed in the QFD matrix.

Table-4: List of secondary needs in light of which the 'technical descriptors (HOWs) can be evolved by the experts in the field, and the same can be employed in the QFD matrix

RANK NO.	VoC : PRIMARY NEEDS	VoC: SECONDARY NEEDS CORRESPONDING TO EACH OF THE PRIMARY NEEDS
1	Pain in arms, holding handles' related needs	Considerations about 1. Abduction angle 2. Anthropometric factors 3. Hand grips 4. Grasping factors 5. Handles' size & 6. Handle-shape etc.
2	Night driving related needs	1. Adjustable headlights using twiddling screw adjusters 2. Light-colors of display systems 3. Light-intensity of display system 4. Distance between eyes & display systems etc.
3	Seat Design related needs	1. Absence of the feeling of bums 2. Sufficiency of leg-room, 3. Absence of feeling of burning 4. Comfort for the pillion, 5. Absence of sweating 6. Ease in cleaning the seat, 7. Look of the seat 8. Seat-material 9. Fitness into the bike frame etc.
4	Bike-Strength etc. related needs	1. Material considerations 2. Shape considerations 3. Bike-balancing or stability factors 4. Baggage-carrying capacity considerations etc.
5	Ease in bike-operation related needs	Ease in operating 1. Gear-change system 2. Clutch system 3. Headlight system 4. Pedaling system 5. Ease in learning to drive etc.
6	Aesthetics, look etc related needs	1. Mix between curves and sharp angles 2. Spokes Design 3. Frame Design and Shape 4. Handle design and shape 5. Color scheme for different parts of the bike etc.
7	Driving Safety & Breakdowns related needs	1. Grip provision for the person accompanied by the rider. 2. Grip control for wet days 3. Traction control. 4. Dual clutch transmission 5. Automatically controlled launch control 6. Backup and standby provisions under a breakdown situation etc.
8	Display-control compatibility related needs	Compatibility related ergonomic considerations about 1. Different gauges displaying information like RPM, Speed, Gear, Fuel, Turn Signal, Time, Low/High beam 2. Multi-touch display systems giving the rider a detailed log of driving behavior, mechanical driving record & tuning information etc. 3. Display having a full on navigation system (with built-in GPS, Wi-Fi, and 3-G connection). 4. Viewing mirrors and the horn-blowing systems etc.

Thus, equipped with the above-presented knowledge, the competitors manufacturing the two-wheelers, particularly the motorbikes, can proceed to apply the 'house of quality' based QFD technique of Total Quality Management (TQM) to offer a higher quality and a more acceptable product to the Indian market. It might be observed that the 'Quality Function Deployment' (QFD) is a management tool that provides a visual connective process to help teams focus on the needs of the customers throughout the total development cycle of a product or process. It provides the means for translating customer needs into appropriate technical requirements for each stage of a product/process-development life-cycle. It helps to develop more customer-oriented, higher-quality products. While the structure provided by QFD can be significantly beneficial, it is not a simple tool to use [4]. Thus introduction to succeed in developing new products or improving on existing ones is not easy. Studies indicate that as much as somewhere between 35 per cent and 44 per cent of all products launched is considered failures. It is one thing to actually discover and determines the customers' needs and wants but, to achieve results, these findings are needed to be implemented, i.e. translated into company language. Many companies depend on their warranty programs, customer complaints, and inputs from their sales staff to keep them in touch with their customers. The result is a focus on what is wrong with the existing product or service, with little or no attention on what is right or what the customer really wants. It is well documented that the use of QFD can reduce the development time by 50 per cent, and start-up and engineering costs can be reduced by 30 percent [6]. In the present study, the application of QFD technique to have an assessment of the motorbike riders' needs was the basic objective of the present study. In addition, ranking of these 'industrial design' related needs of the motorbike drivers was also undertaken. Finally, corresponding to each of the 'primary needs' respective potential secondary needs were also explored to help the House of Quality (HoQ) developers. These needs of the products, in general, are getting exceedingly important in the modern days. Another commonly used term for 'industrial design' is known as 'ergonomic design' or 'design based on human factors engineering'. In the present study, the considered 'industrial design' related needs encompassed such aspects as seat design (involving absence of the feeling of bums, sufficiency of leg-room, absence of feeling of burning, comfort for the person sitting behind, absence of sweating, easy in cleaning, the look of the seat, its material, fitness into the bike frame), safety in case of accidents, display control compatibility, aesthetics, ease in operation, ease in use, ease in learning to drive, strength, baggage carrying capacity, gear-change system, balancing or stability of the bike, breakdowns/year, pains in arm while driving, night driving ease in handling display-control system, grip for the person accompanied by the rider etc. For the purpose of QFD, the top ranking needs are required to be considered as the customers' needs in the leftmost column of the House of Quality. In light of the features described as above, the employment of the identified secondary needs would lead to the completion of the process of establishment of the VOC.

To conclude, it has been reported that India is the second largest producer of the two-wheeler in the world [3]. The two wheeler segment contributes the largest volume to all the segments in automobile industry in India. The country stands next to China and Japan in terms of production and sales respectively. The industry is growing at a rate of 30% annually. It consists of three segment viz. scooter, motorcycle and moped. Majority of Indians, especially the youngster prefer motorbikes rather than cars. Capturing a large share in the two wheeler industry, bikes and scooter covers a major segment. Bikes are considered to be the favorites among the young generation, as they help in easy commutation, styling and mileage, and have more aesthetic appeal. Keeping in view the ever expanding growth of motorbikes in Indian market, present research was undertaken to demarcate the needs of the motorbike drivers and also the prioritization of their needs. The motorbike drivers of only Delhi-NCR region participated in the study. The drivers' sample was taken through direct contact and also through on-line surveying methodology. By way of identification and prioritization of the motorbike drivers' needs, the statistical analysis of data and utilization of the motorbike drivers' needs i.e. VOC, in the QFD analysis, the results were obtained and then discussed in light of previous researches. It emerged that the motorbike drivers population, under reference gave top priority to the 'pain in arms' related primary need while 'display-control compatibility' related needs scored least on the scale considered. Other remaining industrial design needs, described earlier (Table 4), fell in between these two extremes. The implications of these findings are far-reaching for the motorbikes manufacturing industry of tomorrow. Feeling of pain in the arms of the motorbike drivers demands redesigning of the motorbikes particularly from the 'abduction angle' point of view. So far as the display control compatibility is concerned, the findings imply that perhaps enough R& D work has already gone into it and, therefore, they do not pose a major problem to the considered population of motorbike drivers.

In terms of the scope for future work, it might be observed that present study remained confined to aim at the identification and prioritization of the VOC part of the QFD only. Complete QFD analysis would have to be undertaken in collaboration with the manufacturer of the leading brands of the motorbikes not only at the National level but also at the global level. This is getting more critical in light of the newer industrial policies of the Indian Government whereby more and more global players are joining the game of manufacturing vehicles in India, be it a car or a two-wheeler like a motor-bike.

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