

# The Application of Rapid Prototyping Technology on Product design—a Case Study on Road Racing Bike Handlebar

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## Abstract

Drooping-style handlebar reserved for the use of road racing bike not only be used for riding operation, but also can ease cyclists' hand ache phenomenon. Therefore, the main purpose of this study is to design a new handlebar to increase the comfortable sensation of drooping-style hand holding positions. First of all, the most comfortable handle wide dimensions were estimated by using regression statistics quadratic function according to the experimental data. And then, a new type of 3D solid handlebar model can be created by using a CAD system (CATIA) and rapid prototyping technology (FDM). The results showed that the new style handlebar in the width of 5.38mm at up position and 4.02mm width at lateral side can obtain the optima contact area, and can also ease the pain region. According to the experiment data, the redesigned road racing bike handlebar is indeed better than the others, and increase holding comfortable sensation.

**Keywords:** Road racing bike, Handlebar, Human factors, Comfortable sensation

## 1. INTRODUCTION

Because the road racing bikes have the characteristics of low wind resistance, light weight and high efficiency, it can reach to a very high riding speed. The shape of drooping-style handlebar will cause cyclists' body to result in forward posture in order to reduce wind resistance and increase riding efficiency. For road racing bikes, the handlebars should contain suitable dimensions

and form to control riding direction and support human body weight. This research tries to find reasonable design parameters and shape which can increase comfortable sensation. The main goals of this study are shown as follows:

1. Analyzing existing handlebar product sold on the market;
2. Deriving more reasonable design parameters which are a balance data between weight and comfortable sensation.
3. Developing a new test handlebar by using FDM RP technology for verifying the design parameters.

### 1-1 Handlebar holding position

Lightweight and comfortable sensation are the basic design requirements of road racing bike. In order to accommodate various riding posture and reduce wind resistance during riding, cyclist has four hold positions as shown in figure 1. In order to disperse pressure happened on palm, the holding position area should as big as possible. Since the handlebar offered four different hold positions, cyclist can change the positions during riding for preventing one posture kept a long time and getting chance to take a rest.

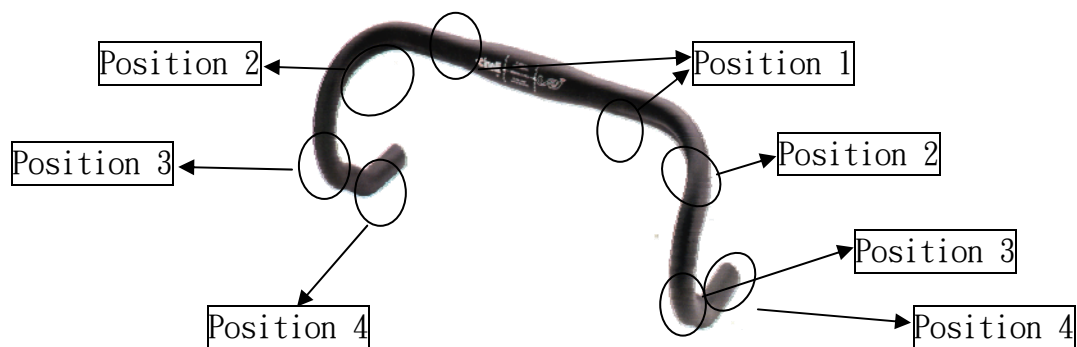


Figure 1. Holding positions

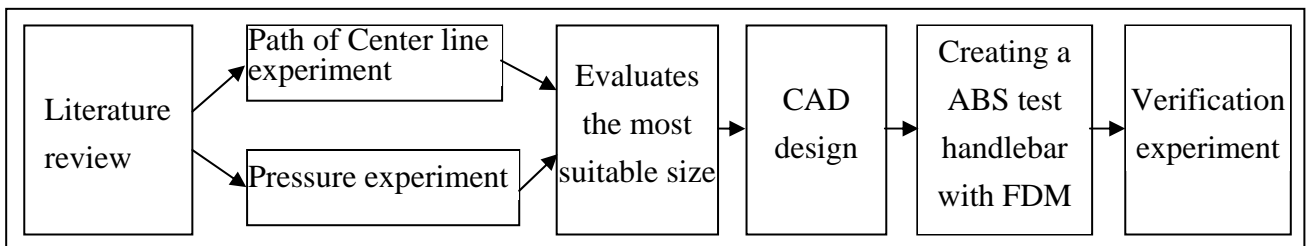
### 1-2 Rapid prototyping (FDM-Fused Deposition Modeling)

This research produced a ABS test handlebar model with FDM rapid prototyping machine which is the Dimension SST (Soluble Support Technology). So the designer simply removes the model from the system, and automatically washes the support structures in a hot water and a soap bath. The FDM process deal with a geometric model created on a CAD software which uses STL formatted files, and then the file is sliced into horizontal layers after the model is oriented for the optimum build position. At the same time, the support structures are automatically detected and generated according to the lice thickness. The material in filament (spool) form is melted in a specially designed head which extrudes it on the model. As it is extruded, it is cooled and solidifies to form the RP model. The model is built layer by layer.

## 2. Research methods and experiment

This study evaluates the most suitable holding dimension according to the path of center line and the pressure area of palm experiments. And then the final design dimension was checked in the verification experiment. The research methods and experiment flow chart are listed in the table 1.

Table 1. Experiment flow chart.



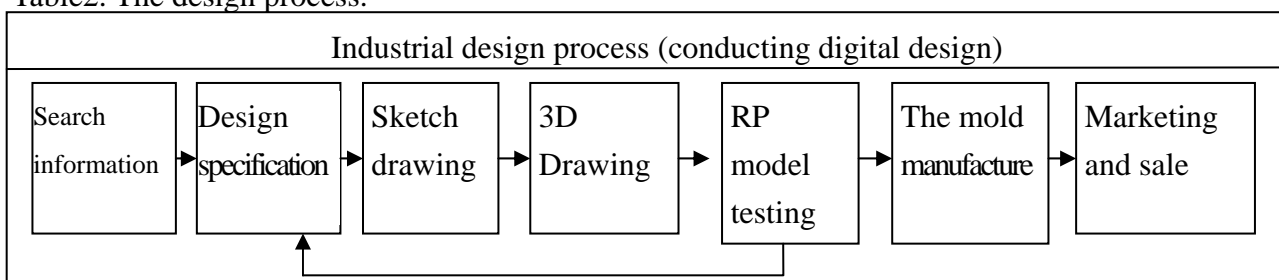
### 2-1. Path of Center line and pressure experiments

The path of center line of handlebar tube experiment is to determine whether the wide grip handles will be affected by the tube's curved. The main purpose of the pressure experiment is to evaluate the suitable dimension of the four holding positions. Both experiments are in accordance with the morphology analysis. Meanwhile, the contact area and pain area of palm on four holding positions were determined by the pressure experiment. Comparing the contact area and pain area with comfortable sensation with the difference analysis method, designer can identify the most suitable holding dimensions on the four holding positions. According to the experiments result, the position 1 and 2 are the most important position for road racing bicycle. Therefore, this study estimated the most comfortable handlebars wide by the regression curve of the quadratic function. The results showed that the best comfort value when  $y = 5$ , the dimension of position 1 are 5.38cm and 0.76cm (0.76cm does not comply with the handle design rule). When the best comfort value  $y = 5$ , the dimension of position 2 are 4.02cm and 2.57cm (the same reason, 2.57cm does not comply with the handlebar design size), finally the new handlebar design dimension adopted 4.02cm for the position 2 and 5.38cm for position 1.

### 2-2. CAD plan

According to the experiment results described as above, designer obtained the suitable dimensions at four positions. And then designer conducted industrial design process and collected design information regarding handlebar product sold in the market to design the new handlebar. The design process is listed in the table 2.

Table2. The design process.



### 2-3. The RP model

This research utilized the FDM rapid prototyping system to produce the test handlebar. All of the design dimensions obtained from experiments were adopted for created the final CAD digital model. The confirmed 3D model and RP model are shown in Figure 2.

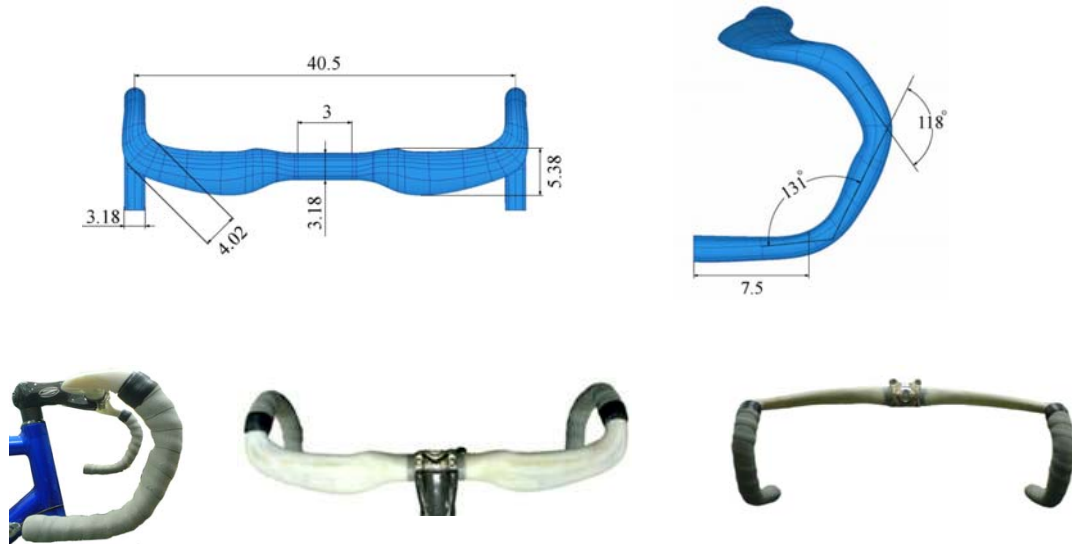


Figure 2. CAD and RP model of the new design handlebar.

### 3. Verification experiment

In order to verify the result of the new handlebar, the new model handlebar F and products C, D, E were used in the verification experiment (as shown in figure 3).

In order to understand comfort differences among the new style handlebar F and three experimental handle C, D and E, the experiment results are shown in table 3. For the comfort difference comparison, the number of positive difference is more than the number of negative differences, which means that the new design handlebar F is more comfortable than product C, D and E. Especially in the position 3, the number of F3-C3 shown the significant differences. For the contact area on the palm comparison, we also get the same results from the experiment. The data shown that new handlebar exactly increases contact area on the palm, and the position 1 has significant differences compared with products D and E. The purpose of this research is indeed to reduce the pain area happen on the palm. From the experiment results show that it really can ease pain area and increase comfort sensation, and all holding positions have significant differences.

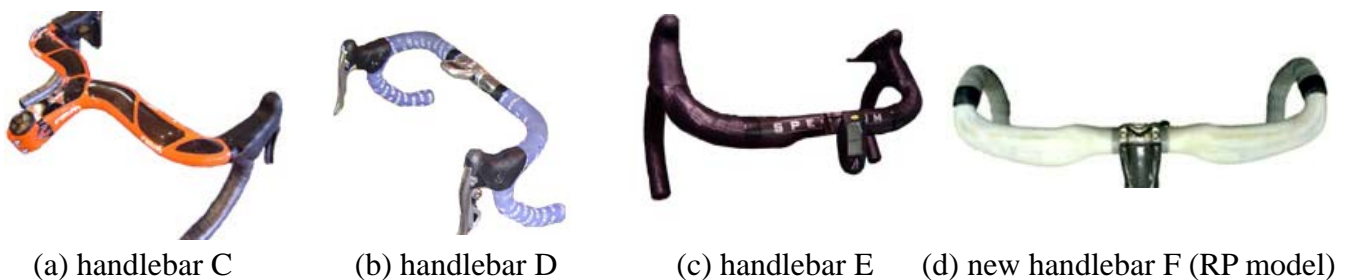


Figure 3. Test samples.

Table 3.

Holding position	(a) Comfort difference analysis			(b) Contact area analysis			(c) Pain area analysis		
	Negative difference	Positive difference	Precision significant	Negative difference	Positive difference	Precision significant	Negative difference	Positive difference	Precision significant
F1-C1	6	7	1.000	5	13	0.096	16	2	0.001*
F1-D1	5	12	0.143	3	15	0.008*	16	2	0.001*
F1-E1	0	11	0.001*	0	18	0.000*	17	1	0.000*
F2-C2	5	6	1.000	5	13	1.000	15	3	0.008*
F2-D2	2	9	0.065	6	12	0.065	16	2	0.001*
F2-E2	4	9	0.267	6	12	0.267	17	1	0.000*
F3-C3	7	6	1.000	7	11	0.096	17	1	0.000*
F3-D3	1	6	0.125	6	12	0.238	18	0	0.001*
F3-E3	4	8	0.388	4	14	0.238	16	2	0.001*
F4-C4	3	7	0.344	5	13	0.344	16	2	0.001*
F4-D4	4	9	0.267	5	13	0.267	17	1	0.000*
F4-E4	2	12	0.13	4	14	0.13	16	2	0.001*

\* p&lt;0.05

#### 4. Conclusion

This research utilized morphology method and statistics analysis to obtain reasonable design parameters for road racing bicycle handlebar design. The final results derived from path of center line and pressure experiment shown that the new design handlebar indeed improves holding comfort sensation and ease pain area on the palm. In order to simulate and evaluate the real riding situation for analyzing comfort sensation, the dynamic riding experiment will be carried out in the near future.

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