# Shape preserving in aerodynamic product profiles using geometric design modelling

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**Keywords**: Aerodynamic, bezier curve, transition curve

**ABSTRACT** – Shinkansen bullet train was inspired by the Kingfisher beak which the nose shape design of the bullet train is streamlined. Longnose design leads to a high production cost. Bezier curve was applied to improve the nose shape design of the Shinkansen bullet train. The designs are analyzed by using linear static analysis and dynamic analysis to identify analysis, stress, displacement, velocity, and pressure. The result from the analysis shows that improved design is better compared to the existing design.

## 1. INTRODUCTION

Transportation requires a good design or shape to run smoothly even with its high speed. Airflow is one of the constraints. Therefore, the aerodynamic design of transportation is very important to travel with less resistance and safety. Aerodynamic shape optimization of any transport will produce a good result as it matches the transition curves. The transition curve defines a curve where a gradual transition from the straight to the circular curve is accomplished, with the curvature changes from zero to finite [1].

A model by model introduced, the nose shape design of Shinkansen increases in length. This will lead to an increase in material usage and high-cost of production [2]. Shinkansen E5 has the longest nose shape design among all of the shinkansen model.

Therefore, this model was taken to study its nose shape design. Thus, the C-shaped transition curve will be applied to this model to replace the nose shape design.

## 2. METHODOLOGY

The nose shape of any aerodynamic product acts as an important aspect of all parts. Shinkansen E5 has the longest nose compared to the other model of Shinkansen. This project studies the nose shape design of Shinkansen E5. The circle template used as a high-profile curve is the C-shaped transition curve. 3D scanner (Rexcan CS2+) is used to scan the scaled Shinkansen E5. This scanner scans the actual model of the product, transfers it into its software which is 'ezScan'. The scan appears will depend on the position of the product, brightness of light and laser pointed during the scanning process. The scan is then imported into design software which is SolidWorks. By this stage, editing work needs to be done before we get solid modelling. The model is now in a cloud point. Therefore, the meshing process needs to be done by using SolidWorks. This is to solidify the model before iteration purposes. Figure 1 shows the model of the existing Shinkansen after the meshing process.

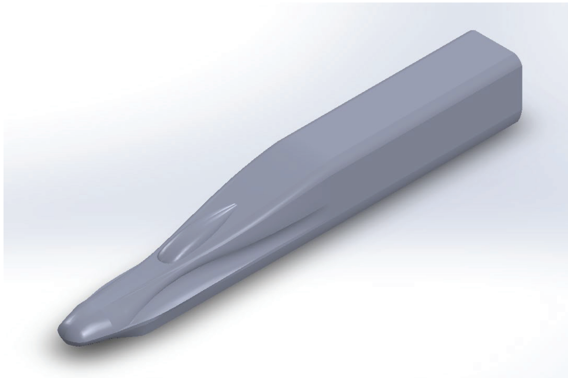

Figure 1 Existing shinkansen E5

## 3. RESULTS AND DISCUSSION

Bezier curve is the high-profile curve that is used in this research. The circle-to-circle C-shaped transition curve is applied in the existing model of Shinkansen E5 as an improved model. Bezier curve is a curve that is characterized by its curvature being proportional to its length. Thus, it makes a great curve property that can be used in roads, railways, and also in aerodynamic transportation [3]. Figure 2 shows the theoretical Bezier curve with a C-shaped transition.

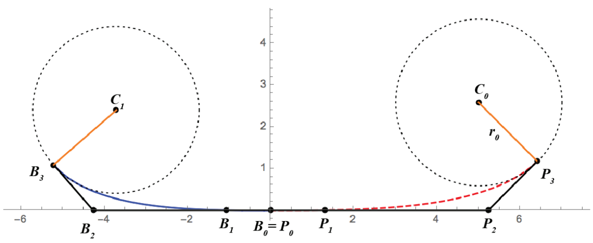


Figure 2 C-shaped transition curve

The improved model is obtained in Figure 3. As can be seen, the nose design is shorter and circular. This model will be analyzed by using 2 analyses which are linear static analysis and dynamic analysis.

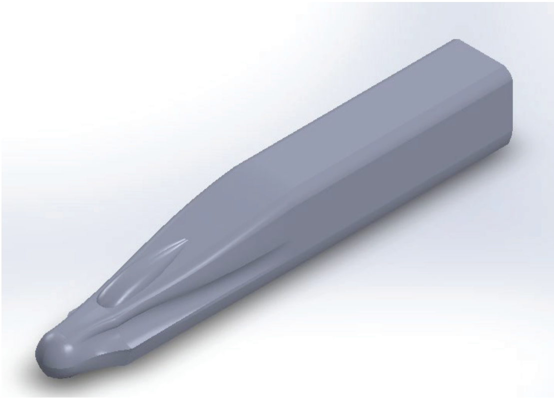

Figure 3 Improved shinkansen E5

For linear static analysis, stress and displacement distribution of both existing and improved design are identified for this analysis. In the analysis, the value for stress and displacement are both increased as the pressure applied increase. However, the failure occurs to an existing design as earlier compared to improved design which means improved design shows better design compared to an existing design. This is shown in Table 1.

Table 1 Result for linear static analysis

| Pressure (MPa) | Existing Design | | Improved Design | |
|---|---|---|---|---|
| | Maximum Von Mises Stress (MPa) | Maximum Displacement (mm) | Maximum Von Mises Stress (MPa) | Maximum Displacement (mm) |
| **0.40** | **50.81** | **1.0854** | 42.81 | 1.2882 |
| **0.45** | **57.16** | **0.9648** | 48.16 | 1.1451 |
| **0.50** | 63.51 | 0.8683 | **53.51** | **1.0306** |
| **0.55** | 69.87 | 0.7893 | **58.86** | **0.9369** |

The design efficiency for improved design is 126% which is said to be acceptable for implementation. For dynamic analysis, pressure and velocity distribution for both existing and improved design are identified for this analysis. Value for pressure and velocity increases for both designs as input velocity increases. However, the result is against the Bernoulli principle where the pressure should inversely proportionate with velocity. It happened due to an increase in the cross-sectional area on the improved design that affects the pressure of Shinkansen.

The results of dynamic analysis are then validated with the coefficient of variation of models (CV). The velocity of improved design is lower compared to the existing design by 0.28% difference showed as better stability model.

## 4. CONCLUSIONS

In this study, the Bezier curve is applied to the nose-shaped design of Shinkansen for improved design. The C-shaped transition curve is applied due to its smooth variation curve. The designs of existing and improved Shinkansen are then analyzed by using linear static analysis, and dynamic analysis. To validate, design efficiency and coefficient of variation method are used. As for the result, the improved design is better than the existing design as DE shows 125% and CV shows the value of improved design s higher than the existing design.

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