International Journal of Engineering & Technology, 7 (3.34) (2018) 41-45

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Quality Improvement through Mechanization of Tail Gate Weather Strip Assembly Process

R Suresh [1]*, R Palani [2], S Rajamanickam[3], K Arumugam[4], V Sathiyamoorthy [5], D Logeshwaran [6]

[1,5]*Associate Professor, Department of Mechanical Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai - 600062, India*

[4]*Professor, Department of Mechanical Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai - 600062, India*

[2,3]*Assistant Professor, Department of Mechanical Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai - 600062, India*

[6]*UG Scholar, Department of Mechanical Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai - 600062, India*

**Corresponding author E-mail:sureshr77@gmail.com*

Abstract

The Assembly plant #1 at Hyundai Motors India Limited consists of assembly line A1, A2 and A3. In these, assembly line A1 and A2 are semi-automatic in manner where at some stations manual assembly is involved. Cycle time should be considered a viable option when an organization is trying to improve efficiency and productivity and hence this paper deals with the reduction of fatigueness as well as cycle time in station #190 of ASY#1 where tailgate weather-strip is fixed manually. The Journal undertaken was to design work assist system (standalone device) which is used to position tailgate weather strip for GS Model (Hyundai Creta). For this many activities were done and analyzed the problem and designed the work assistor seeing through all the constraints. Thus the entire machine assembly will be done to minimize the operator fatigue, to improve quality and also the chances of disorientation are reduced by elimination of manual hand operation. Fatigue reduction was shown by calculating the difference of frictional force between hand and the standalone device and the frictional force was reduced by 4.91N.The shower results bettered with less rejection by using the operator-friendly work assist system.

Keywords: *Industrial rubber, Accelerometer, Weather strip, Polyurethane*

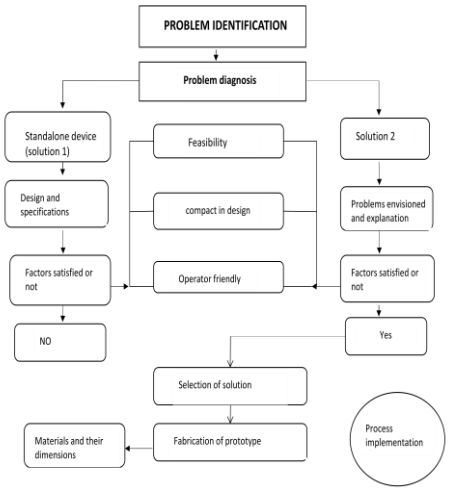
1. Introduction

The Assembly Line study identified many real time problems occurring in the line, out of which I have opted to provide a solution to one of them. Hyundai Motor India Ltd is one of the pioneers in the automobile industry and hence by using the advancements of technology the plant is fully automated whereas some stations are requiring manual effort from the workers and thus increasing chances of error.

At one of the stations where the tail gate weather strip is fixed , there they use their hands to fix it which is around 50 seconds per cycle, it is also prone to water leakage and hence there is scope to improvise and get a lesser cycle time. Manual assembly involves complete human effort to lift, move and fix parts to vehicle body hence the human effort cannot be 100% efficient always. It tends to fluctuate based on physical and mental fitness

Although these cars are made by precise robots and skilled operators, around 20 cars are put offline every day in the PDI (pre delivery inspection) due to quality issues out of which 10% are due to this orientation of weather-strip which is done manually. We decided to reduce the fatigue as well as cycle time of operator hence by designing the work assist system would satisfy the above criteria consequently quality of the car is not affected by fatigue of the operator.

2. Methodology



Copyright © 2016 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

3. Measurements

The observations and experimentations done in HMIL were the follows:
The Tailgate dimensions and the cycle time for seating of weather-strip by skilled labour and a fresher were noted down.
1.TIMINGS:

Table 1: Seating Time

Sl.No.	Time for Weather Strip seating in Secs			Average
	Observation1	Observation2	Observation3	
1.	49	53	52	51.3

3.1. Tail Gate:

Table 2: Tail Gate Length

Sl.No.	Length of Tail Gate in mts			Average
	Observation1	Observation2	Observation3	
1.	3.925	3.918	3.926	3.923

The weight of the weather strip and the sealant were noted down



Fig.1: Weight of Strip



Fig.2: Weight of Seelant



Fig.3: Weight of Weather Strip with Seelant

3.2 Weather Strip Specifications

Weather strip details
Material Industrial Rubber
Weight of weather strip without sealant 1.222 kgs
Weight of sealant 0.147 kgs
Weight of weather strip with sealant 1.264 kgs
Minimum force on weather strip 28.876N/100mm
Maximum force on weather strip 61.7 N/100mm
Young's modulus of weather strip 1-5 MPa
Density of weather strip 930 kg/cubic m

3.3. Weather Strip:

Table 3: Weather Strip Length

Sl.No.	Length of Weather Strip in mts			Average
	Observation1	Observation2	Observation3	
1.	3.945	3.944	3.496	3.945

4. Modeling and Analysis

4.1 Solution:

After analyzing all thedesign solutions, we had thought to have a ball and socket type of joint at the junction of handle and stem.The radius provided for the socket depends upon the diameter of the ball joint and the maximum turning point in the tailgate weather-strip panel.
This maximum turning point is an important factor used while deciding the diameter of the ball.

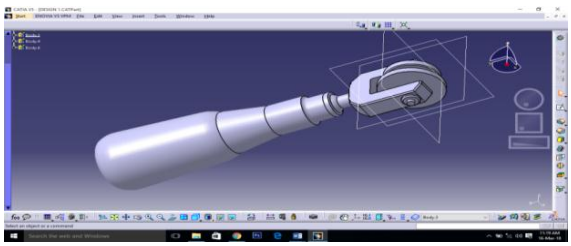


Fig.4: Design Solution

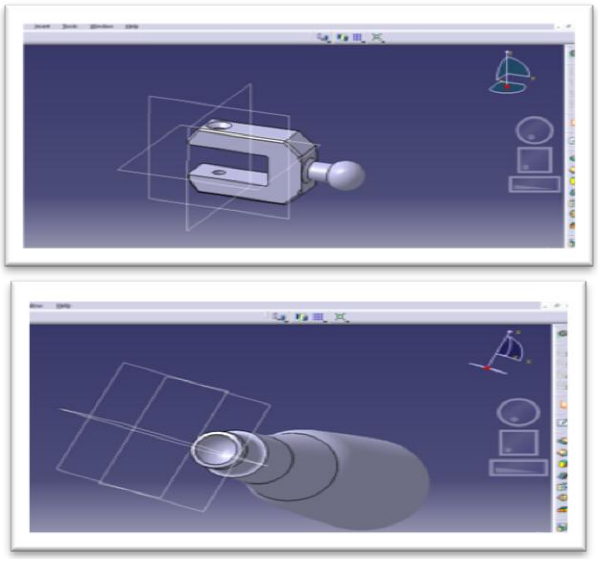


Fig.5: Solution with Ball and Socket Joint

4.2 Concept Explanation:

The final solution had very few problems envisioned such as worker ability to use the assistor. But those problems wouldn't increase the time much as well as worker's fatigueness.
The final process after implementing the work assistor is

- Firstly, the weather strip is manually seated at four different positions for better handling while using the assistor.
- After the strip is once set on the tailgate panel, worker uses the assistor and seats the weather strip with minimal force in different sections as shown previously.
- The ball and socket mechanism at the junction of stem and handle provides smooth turning of the stem alone on tailgate panel

The roller has been designed such that the bulb of the weather strip comes in contact with the roller hence applying the sealant properly and due to minimal contact; the expansion is also reduced to a far extent.

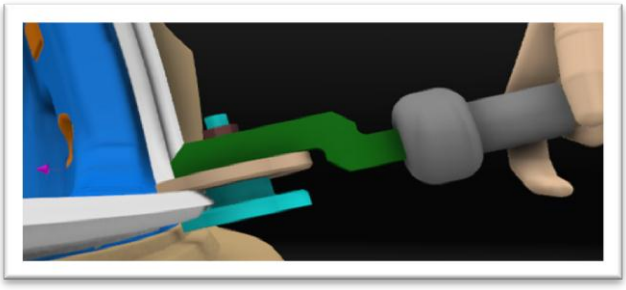




Fig.6: Positioning the Proto Type

4.3. Analysis:

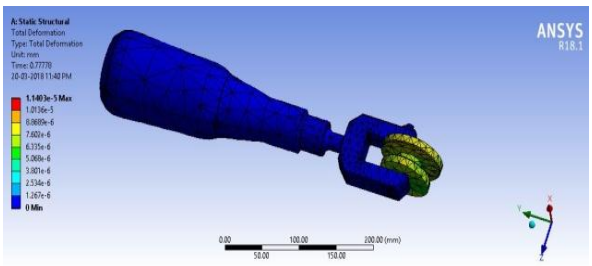


Fig.7: Total Deformation

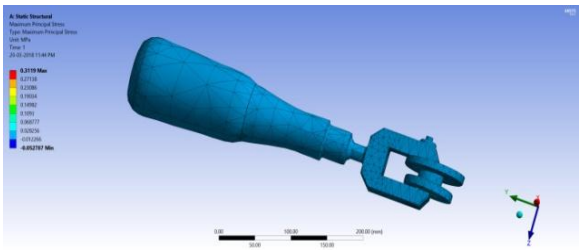


Fig.8: Stress

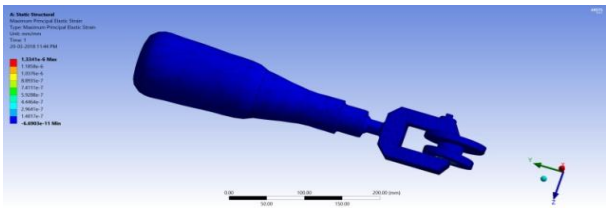


Fig.9: Strain

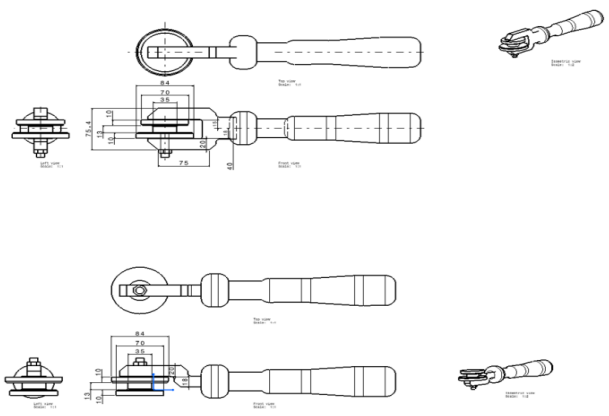


Fig10: Prototype Specification:

5. Calculations:

Calculation of Frictional Force And Other Parameters

5.1 Calculation of Coefficient of Friction for the Following Interfaces:

Hand- Industrial rubber (weather strip) interface
Friction is resistive forces that opposes an objects motion or intend motion. The formula to compute the frictional force (f) is

$F_f = \mu F_N$

The coefficient (μ) is unique for different materials. The normal force (F_N) here is the maximum force which is sufficient on weather strip for complete seating of sealant. It is the countering force that the surface exerts on the object to oppose its weight.
The aim was to devise a method for measuring friction at the hand /handle interface during a frictional handgrip task. No description of methods of this kind was found in the literature. and indirect method of measuring normal grip force was employed to determine friction at hand / handle interface .
Method for Calculating Coefficient of Friction (μ):

- Firmly attached the accelerometer to wrist.
- Placed the rubber weather strip (a cut piece) on the wrist.
- Hit 'collect' in LoggerPro and gently raise your forearm up.
- Hit 'stop' when the object starts sliding.
- Determine and record the component of the acceleration due to gravity (a) parallel to wrist at the instant that the object slips.
- After performing this experiment, we needed to compute the angle (ɵ) at which the cut piece starts slipping. Since we know the acceleration components:

  $\sin\theta = a/g$

- After calculating the critical angles the coefficients μ can be calculated as follows

  $F_N = mg\cos\theta$

  $F_f = mg\sin\theta = \mu F_N = \mu mg\cos\theta$
  $\mu = \tan\theta$

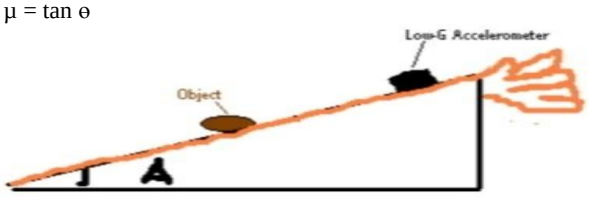


Fig.11: Cut Portion of Weather Strip



Fig.12: Accelerometer

The data below contains the recording and calculations:

Table 4: Material Properties

S.No	Material	Acceleration (m/sec)	Angle (deg)	μ
1.	Rubber (cut piece)	6.34	40.3	0.84
2.		6.36	40.5	0.83
3.		6.354	40.4	0.84

Average Value: 0.84

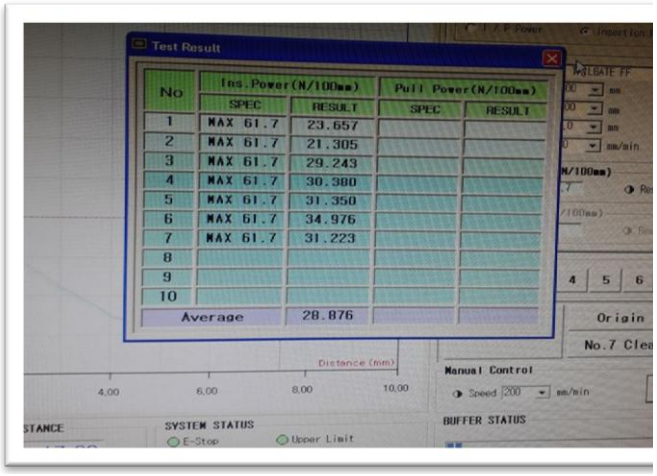
Polyurethane (Prototype material) and Weather strip (rubber) and Interface:
The coefficient of friction for Rubber (60 A) against Polyurethane material is given in the table chart:

Table 5: Rubber Coefficient

S.No	Material	Against material	μ
1.	Rubber	Polyurethane	0.67

5.2 Calculation of Normal Force (F_N) :

Now that the coefficient of friction has been calculated,we next calculated the normal force (F_N) with the aid of UTM and found the following results.
These values show the maximum and the minimal amount of force required for proper seating of sealant in the tailgate pane.



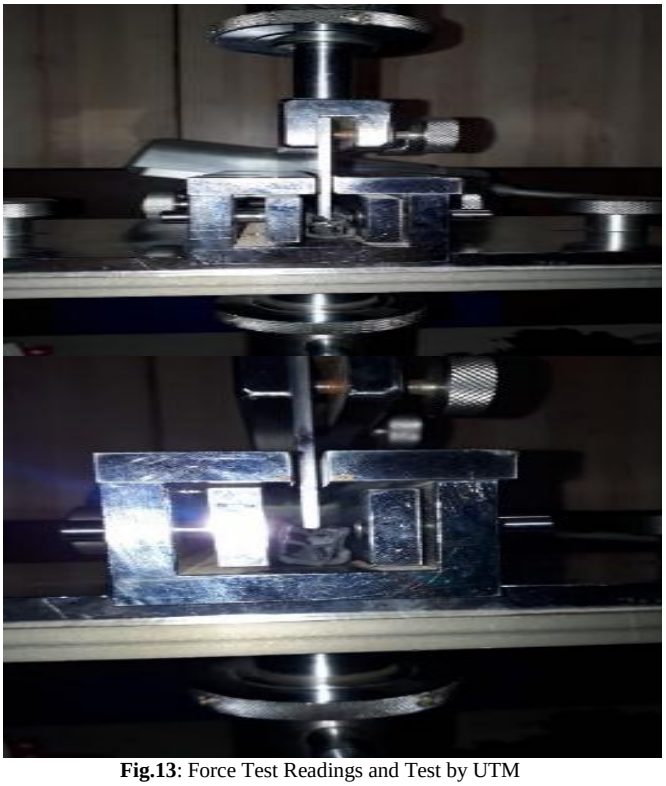


Fig.13: Force Test Readings and Test by UTM

5.3 Difference of Frictional Forcei Both the Cases:

CASE 1: Hand -weather strip (rubber) interface

Frictional Force, F_{f1} = μ* N
= (0.84) *(28.876)
= **24.25 N**
CASE 2**:** Polyurethane (prototype) – weather-strip interface
Frictional Force, F_{f2} = μ* N
= (0.67) *(28.876)
= **19.34 N**
Difference in frictional force **=** F_{f1} - F_{f2} **=4.91N**
Hence the work assist system i.e. the standalone device has reduced the frictional force by **4.91 N**
when compared to the existing method in which manual seating of weather strip is being done.

6. Conclusion

The standalone device cum roller helps in decreasing human fatigue as shown in the friction force calculations that with the work assist system is less when compared to the manual process and also the cycle time would decrease along with very less rejections in shower test due to improper seating of weather strip.
The work assist system would be beneficiary to the operators working in the line due to the following reasons,

- Less fatigue
- Proper seating of weather strip
- Operator friendly

The results we obtained in the shower test and the observations of the sealant application over the panel implies that the assist system is designed in such a way that minimal problems are envisioned at the same time meeting the objective and the functionality of the project. For this many activities were done and analyzed the problem and designed the work assistor seeing through all the constraints Thus the entire machine assembly has minimized the operator fatigue and also improved quality as well as cycle time by reducing 4.91N frictional force with better shower results and less rejection .

References

[1] O'Meara DM,Smith RM (2016) "Functional handgrip test to determine the coefficient of friction of the hand/handle interface". Ergonomics-ELSEVIER, vol. no. 10, pp. 717-731.
[2] David J.Cottenden,AlamM.Cottenden (2013)"A study of friction mechanism between a surrogate skin and nonwoven fabrics". Mechanical Behaviour of Biomedical Materials-ELSEVIER, vol.no. 28, pp. 410-426.
[3] R.Lewis,M.J.Carre,S.E.Tomlinson (2014) "Skin friction at the interface between hands and sports equipments".Procedia Engineering-ELSEVIER, vol.no. 72, pp. 611-617.
[4] M.Zhang,A.F.T.Mak (2015) "In vivo friction properties of human skin".Procedia Engineering-ELSEVIER, vol.no. 23, pp. 135-141.
[5] J.R.Cho,K.C.Han,J.S.Kim,S.B.Lee,O.K.Lim (2012) "Fatigue life prediction and optimum topology design of EPDM weather strip".Finite element in analysis and design- ELSEVIER, vol.no. 60, pp. 57-63.
[6] Y.S.Haa,J.R.Choa,T.H.Kimb,J.H.Kimb (2008) "Finite element analysis of rubber extrusion forming process for automobile weather strip".Journal of materials processing technology-ELSEVEIR, vol.no. 20I, pp. 168-173.
[7] Q Wei-Ta Chu,Xiang-You Zheng, Ding-Shiuan Ding (2017) "Camera as weather sensor: Estimating weather information from single Images". Visual communication and image representation-ELSEVEIR, vol.no. 46, pp. 233-249.
[8] G.P.Zhou,Z.Y.Liu,Y.Q.Qiu,G.D.Wang (2009) "The improvement of weathering resistance by increasing P contents in cast strips of low carbon steels".Materials and design-ELSEVEIR, vol.no. 30, pp. 4342-4347.
[9] VikasWaghole,RajivTiwari (2014) "Optimization of needle roller bearing design using novel hybrid methods". Mechanism and Machine Theory-ELSEVEIR, vol.no. 72, pp. 71-85.
[10] Xiuxing Yin A,HaigangGuB,GuangFeng C (2014) "Analysis of non-uniform abrasion evolution for cylindrical roller bearings".

Mechanism and machine theory-ELSEVEIR, vol.no. 117, pp. 148-159.
[11] David Goncalves,TiagoCousseaub,AndreGamaa,V.Camposc,Jorge H.O. Seabrad (2017) "Friction torque in thrust roller bearings lubricated with greases, their base oils and bleed oils". Tribology international-ELSEVEIR, vol.no. 107, pp. 306-319.
[12] Carlos M.C.G.Fernandes, Pedro M.P.Amaro,RamiroC.Martins,JorgeH.O.Seabra (2017) "Torque loss in cylindrical roller thrust bearings lubricated with wind turbine gear oils at constant temperature". Tribology international-ELSEVEIR, vol.no. 67, pp. 72-80.
[13] V.Martsinkovskya,V.Yurko,V.Tarelnik,Yu.Filonenko (2012) "Designing Thrust Sliding Bearings of High Bearing Capacity". Procedia engineering-ELSEVEIR, vol.no. 39, pp. 148-156.
[14] Jing Liu ,ZhanglinYan,Yimin Shao (2018) "An investigation for the friction torque of a needle roller bearing with the roundness error". Mechanism and machine theory-ELSEVEIR, vol.no. 121, pp. 259-272.
[15] Ulf Olofsson(1997) "Fatigue life reduction due to wear in boundary lubricated spherical roller thrust bearings". Wear-ELSEVEIR, vol.no. 207, pp. 74-78.
[16] Ulf Olofsson, Senad Dizdar (1998) "Surface analysis of boundary-lubricated spherical roller thrust bearings". Wear-ELSEVEIR, vol.no. 215, pp. 156-164.