Design of Automatic Car Mat Cleaning Machine

S. Hemnath[1],
Assistant Professor,
Department of Mechanical Engineering,
SNS College of Technology,
Coimbatore, India.

P. Janagarathinam[2]
Assistant Professor,
Department of Mechanical Engineering,
SNS College of Technology,
Coimbatore, India.

M. Senthilnathan[3]
UG Scholar,
Department of Mechanical Engineering,
SNS College of Technology,
Coimbatore, India

***Abstract* - A new advanced technique to be launched in India is an Automatic car mat cleaning machine specially designed to wash the car floor mats. Recent washing process is done with the help of manual process and it requires more time to wash the mats and final finishing of the mats is not up to the expectation of the customer requirement. Instead of manual process a new concept is implemented to wash the car floor mats automatically with the help of brush rollers and poly-urethane sponge material to absorb the water particles present in the mat at the final stage of washing process. Dust particles present in the mats will be removed easily with the help of brush roller and good surface finish will be obtained. Though it is an automatic process, it takes minimum time required to wash the mats in 9s/mat. Automatic setup will be useful for all car service stations.**

Keywords - Bush rollers, Brush roller, Poly-urethane sponge rollers, Induction motor, Chain sprocket and V- Belt mechanism.

I. INTRODUCTION

To ensure a good surface finish and removal of dust particles, a new washing process is to be automated. In order to automate a process, a proper model has to be designed and developed .This paper deals with modelling of an automatic car mat cleaning machine .There is a natural quest of the researchers to establish a input – output relationships of a process. [1]Risense china has developed an model of automatic process and they had a problem that the process is not fully automated and time taken to wash the mats is also high. 3D mats cannot be washed, because of these problems developed model is an failure one.[2] BH Canada carried out an analysis regarding the failure of the product which was developed by a Risense and they have also faced the same problems and cost wise it is too high , so they have left their analysis work .[3]Rhino mat USA has developed an automatic process and they have faced a problem regarding the time consumption in washing the mats and manufacturing cost of the product is high and customer is not ready to buy the product. Because of these two problems the product is not launched in the market. [4]Wash mat Germany started their research work in modelling of new automatic washing machine and they have designed the model and developed a working prototype , started their testing process .At the time of testing process time taken to clean the single mat is 3mins and it is not expected to the customer requirements. So they have left their developing process.[5] J-KO New York has designed new model with all these features like Inbuilt drying system with the help of extraction of an hot air from the rollers .Water, chemical and time consumption to clean the mats can be adjusted according to customer needs . Setup has a good long lasting nylon brushes and durable rubber rollers .Drawback behind this setup is that only rubber mats can be washed.

In the present paper automatic car mat cleaning machine has been modelled with the help of design software and mechanisms are changed in order to minimise the cost of the product and time consumption in washing all the mats.

II. CUSTOMER SURVEY

Customer surveys are undertaken to find out the actual requirements of a customer and requirements are analysed and augmented to get the best design of the product. The survey has undertaken in the following car service stations Ambal Maruti, SJB Mahindra, Rajashree Ford and ABT Maruti. From the survey analysis the current mat cleaning process is done with the help of manual power

A. Steps Involved in Manual Cleaning Process

- First process is to remove all the floor mats from the car.
- Second process is to spray the compressed air all over the mat to remove the dust particles present in the mats.
- Third process is to spray the water all over the mat with the help of water gun process.
- Next process is to apply soap oil or shampoo all over the mat and with help of brush dust particles present in the mats are cleaned .
- Finally after cleaning all the mats, with help of compressed air making it to dry. If needed polish is applied at the final stage for rubber mats.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

Fig. 1 Manual Car Mat Washing Process

B. Comparison Table

The comparison among all the car service stations information and features are mentioned in below table 1.

Table 1 Comparison Analysis of Customer Survey

Features	ABT Maruti	Rajashree Ford	SJB Mahindra	Ambal Maruti
Types of mat material	Rubber , fibre , cotton	Rubber , carpet , clear	Air , rubber ,carpet	Rubber , carpet
Water consumption (litre)approx.	Up to 7 litres	10 to 15 litres	20 to 25 litres	Up to 30 litres
Shampoo or oil consumption (millilitre)	250ml	50ml	100ml	20ml
Time in minutes	8mins	6mins	6.35mins	5.26mins
Brand name of shampoo or soap oil	Maruti soap oil	3M – Maxx wash	Soap oil	Maruti soap oil

III. CONCEPT SELECTION

To design a new product concept selection process is to be carried and it is based on the mechanisms and drives used in the new model. Standard template should be followed to select a new mechanisms and drives. PUGH Chart is one of best method used to select the concept mechanisms and drives. Selection process is shown in the table 2

Table 2 Concept Selection for Roller Mechanism

Selection Criteria	Concept 1 Motor with chain sprocket mechanism	Concept 2 Gear mechanism	Concept 3 Belt drive mechanism	Concept4 Chain drive with drip lubrication
Cost	+	-	+	-
Manufacturability	+	-	+	+
Service	+	+	-	+
Power setup	+	-	+	-
cleanable	+	+	+	+
Performance	+	+	-	+
Ease of replacement of parts	+	+	+	+
Vibration	-	-	-	+
Maintenance	+	-	-	+
Summation +	8	4	6	7
Summation -	-1	-5	-4	-2
Total summation	7	-1	2	5
Ranking	1	4	3	2

(+) better, (-) worst, (s) Alternative.

From the above chart concept 1 is selected to design the roller mechanisms for automatic car mat cleaning machine. Ranking here is done based on the more number of positive values.

A. Weighted Matrix Method

The previous method is the basic concept selection method. In that method comparison between alternatives cannot be predicted to provide a clear set of changes to investigate. A more quantitative approach is needed to complete a full selection process from the material usage of a product to the disposal of a product. Weighted matrix method gives a more quantitative approach to complete a selection process. In this method weightage will be given based on the importance of a particular criteria needed to select a concept. The average will be calculated based on the total score and ranking will be allotted based on the total score value as shown in table 3.

Table 3 Weighted Matrix Method for Roller Mechanism

Weighted matrix Criteria	Weightage	C 1	C 2	C 3	C 4
Cost	15	14	10	14	10
Manufacturability	10	9	8	9	8
Service	10	10	5	5	8
Power setup	10	9	7	7	9
cleanable	10	10	7	9	9
Performance	15	15	9	13	14
Ease of replacement of parts	10	8	7	8	10
Vibration	10	8	6	6	8
Maintenance	10	10	6	9	9
Total score	100	93	65	80	85
Average	10	9.3	6.5	8.0	8.5
Ranking		1	4	3	2

C – Concept

From the above weighted matrix chart concept 1 is selected to design the roller mechanisms for automatic car mat cleaning machine. Ranking here is done based on the weightage values and average values.

IV. CONCEPT GENERATION THROUGH SKETCHING

Various sub functions that are needed to accomplish the overall function are identified and generated. The function tree diagram is usually used to identify the sub functions. Concepts are generated by different ways by using each sub function.

In the current study the following sub functions are identified based on the functional diagram. They are 1. Bush roller 2. Brush roller 3. Sponge roller 4. V-Belt mechanism 5. Chain sprocket mechanism 6. Induction motor and power supply. To accomplish the overall function of the product the sub function identified is utilised.

The free hand sketches of sub functions are shown in the below mentioned figure. Based on this sketches concept is selected for the final design.

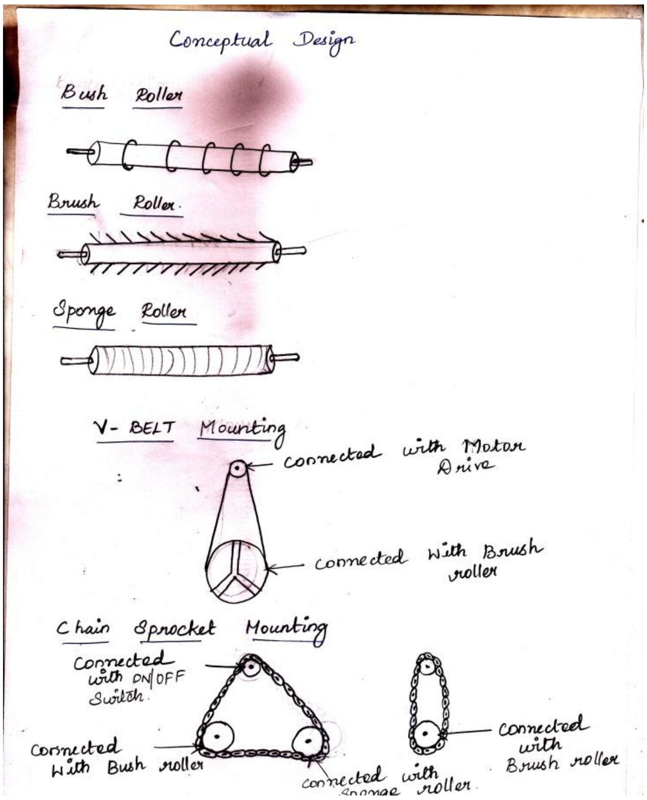

Fig 2. Sub Components of the Setup

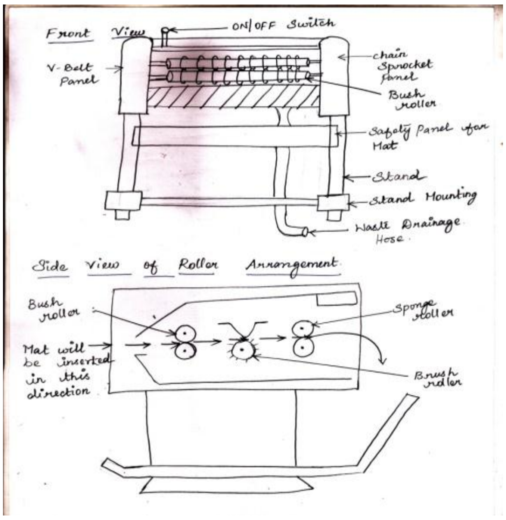

Fig 3. Front and Side View of Roller Arrangements

V. DESIGN CALCULATIONS

For standard values, assumption values, formula values are taken from design data book

A. Motor Power Calculation

N= 265 rpm (assumed value based on rotation of roller)

$P = 2\pi NT / 60$

T – Shaft torque

T = F x R

Spring force F = 23kg (assumption)

=23x9.81 = 226N

Rubber bush D= 45mm, R = 22.5mm

T = F x R

= 226 x 22.5 /1000

T= 5.085Nm

Power P = 2 x 3.14 x 265 x 5.085 / 60

= 0.141kw

= 0.141 x FOS (FOS = 1.3) Assume - To avoid uncertainties

= 0.141 x 1.3

= 0.183

P = 0.20 kw

Standard value is P=0.25kw

B. Dimensions of Spring

Diameter of the spring wire (d)

Wahl stress factor Ks = 4C-1/ 4C-4 + 0.615 / C

= 4 x 10 – 1 / 4 x 10 – 4 + 0.615/10

Ks = 1.448

τ =Ks 8 P C / πd^2

For stainless steel 304 shear stress is 186mpa, C=10

186 = 1.1448 x 8 x 226 x 10 / 3.14 x d^2

d=5.95mm

Standard value d = 6mm.

Mean coil diameter

C = D / d

D = c x d

= 10 x 6

D = 60mm

Outer diameter of the spring Do = D +d = 60+6 = 66mm

Deflection (y) – V belt

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

$y = 8\,P\,C^3\ n\ /\ G\ d$

n=15 (assume), for steel G = 70.3KN/mm2

$= 8 \times 226 \times 10^3 \times 15\ /\ 70.3 \times 10^3 \times 6$

y = 23.14mm

Deflection (y) – Chain drive

$y = 8\,P\,C^3\ n\ /\ G\ d$

n=43 (assume), for steel G = 70.3KN/mm^2

$= 8 \times 226 \times 10^3 \times 43\ /\ 70.3 \times 10^3 \times 6$

y = 66.35mm

Stiffness for V belt

Stiffness = load / deflection

= 226 / 23.14 = 9.76

Stiffness = 10N/mm

Stiffness for chain drive

Stiffness = load / deflection

= 226 / 66.35 = 3.406

Stiffness = 3.4N/mm

C. Chain Drive Calculations

For the speed of driver and driven sprocket, the following calculations have been done.

Transmission ratio (i) = Z_2 / Z_1 Z_2= 42, Z_1=11

= 42 / 11

= 3.81 i= 4 (standard value)

Pitch diameter

D_1= P / sin (180/Z_1) - driving

D_1=130mm taken from feller catalogue for speed ratio

130 = P / sin (180/11)

P = 36.62mm

D_2= P / sin (180/Z_2) – driven

D_2=400mm taken from feller catalogue for speed ratio

400 = P / sin (180/42)

P = 30mm

For the pitch P = 30mm from the data book

20A-2 = ISO / DIN

Chain no rolon – DR100 is selected

D_r=19.05

W=19.10mm

D_p=9.53mm

G=30.10mm

P_t=35.76mm

A1,A2=83.10mm

Bearing area = 52.4mm^2

Weight = 74.530N

Breaking load = 173637N

Total load on the driving side of the chain (PT)

PT= P_t +P_C+Ps

Tangential force (P_t)

(P_t) = 1020N/V in newton

Velocity (V) = Z1 x P x N1 / 60 x1000

= 11 x 30 x 1486 / 60 x 1000

V = 8.173 m/s

P_t=1020 x 0.25 / 8.173

Tangential force = 31.20N

Centrifugal tension (P_c)

P_c= mv^2

= 7.60 x 8.1732

Centrifugal tension = 507.664N

Tension due to sagging (Ps)

Ps=k w a

Position of chain drive is vertical, so k = 1 from data book.

W = m x g

= 74.530 x 9.81 = 731.13

Centre distance a = 200mm = 0.2m

Ps = 1 x 731.13 x 0.2 = 146.226N

Total load P_T = 31.20+507.66+146.266

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

P_T = 685.09N

Calculation for service factor (k_s)

$K_s=k_1+k_2+k_3+k_4+k_5+k_6$

k_1=1.25 (variable load with mild shocks)

k_2=1.25 (fixed centre distance)

k_3=1, k_4=1.25, k_5=1.5 (Periodic lubrication)

k_6=1.25 (double shift of 16hrs a day)

Ks= 3.662

Design load

Design load = P_T x K_s

= 685.09 x 3.662 = 2508.799N

Working FOS

FOS = breaking load / design load

= 173637/2508.799

FOS = 69.211

D. V-BELT Calculations

Selection of cross section of the belt is depends upon the power transmitted

P = 0.20 kw

From PSG data book cross section table

Cross section symbol is A (standard values are)

Area = 80mm^2

Kw = 0.75

Pulley pitch diameter (d) = 75mm

Nominal top width (W) = 13mm

Nominal thickness (T) = 8mm

Mass per metre = 0.106kg/m

Dimensions of standard V-Grooved pulley in mm

Cross section A

l_p=11mm (pitch width)

b=3.3mm(minimum distance down to pitch line)

d_p= 75mm(pulley pitch diameter)

Groove angle 2β=34

h=8.7mm(minimum depth below pitch line)

e=15mm(±0.3)(centre to centre distance of grooves)

f=10mm(±2)(edge pulley first groove)

no of sheave grooves (n) = 6

For the diameter of pulley (D)

Using pulley pitch diameter (d) = 130mm

Standard value is to be selected from table

Smaller pulley diameter (d)=80mm

Larger pulley diameter (D)=250mm

Speed ratio (i)

(i) = D/d

=250/80

(i) = 3.125

Nominal pitch length (L)

$L = 2c+(\pi/2)(D+d)+(D-d)^2/4c$

$= 2x15 + 3.14/2 + (250+80)+(250-80)^2 / 4x15$

L = 487.69mm

Calculation of actual centre distance

C actual = A+ $\sqrt{(A^2-B)}$

A= L/4 – π(D+d/8)

= 487.69/4 – 3.14((250+80)/8)

A = 70.902mm

B= $(D-d)^2$ / 8

= $(250-80)^2/8$

B = 3612.5mm

C actual = A+ $\sqrt{(A^2-B)}$

= 70.902+ $\sqrt{(70.902^2-3612.5)}$

C actual = 108.51mm

VI. 3D MODEL

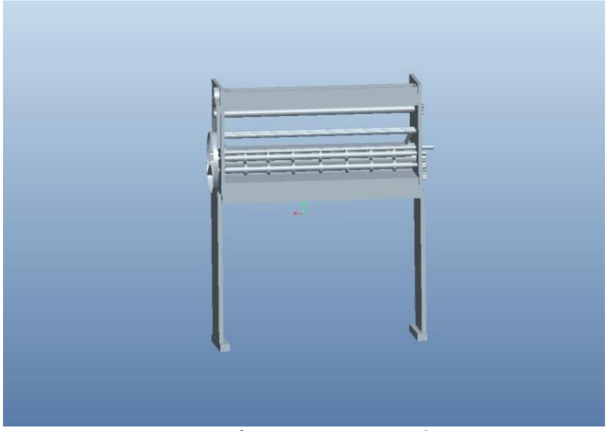

Fig. 4 Front View of an Automatic Mat Cleaning Setup

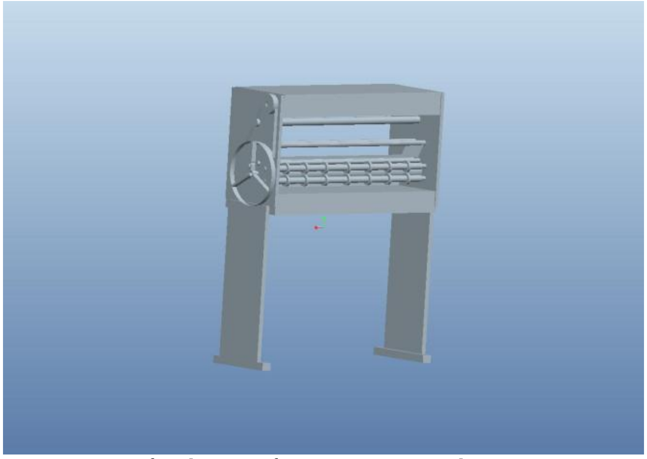

Fig. 5 Left Side View of an Automatic Mat Cleaning Setup

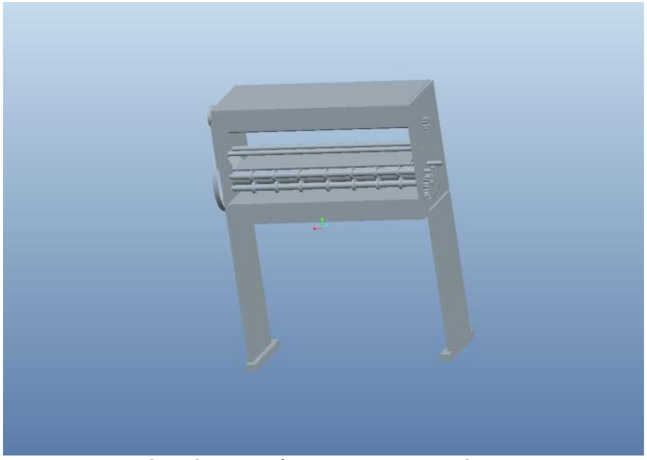

Fig. 6 Right Side View of an Automatic Mat Cleaning Setup

VII. CONCLUSION

In this study, automatic car mat cleaning machine design has been proposed after evaluating the existing washing process in the Indian market. By evaluating the existing washing process, the risks associated with them were found out and which paved ways for exploring a new automatic washing process. The sub functions which contribute to the overall product function are generated from the functional diagram. To accomplish the different sub functions, possible sub functions are identified with help of concept generation methods such as PUGH chart and weighted matrix chart. The new design has been developed with the help of free hand sketches and it is design with the help of proe software.

VIII. FUTURE WORK

With the avail of above conceptual design procedure and 3D model the prototype can be prosperously developed in the future. Manufacturing materials are selected based on the Ashby chart. Cost estimation will be done based on different material usage in the manufacturing process.

IX. REFERENCES

[1] R.S Khurmi "A textbook of machine design", S.CHAND publications.
[2] Peter R.N Childs "Mechanical design engineering handbook", eBook ISBN 9780080982830.
[3] [Online] Available: http://www.google.com/ "Online source for competitor study"
[4] Kevin Otto "Product design techniques in reverse engineering and new product development", Pearson Education publications, south Asia, 2012.
[5] "PSG DESIGN DATA BOOK" Kalaikathir achchagam publications, India 1978.
[6] Karl T. Ulrich and Steven D. Eppinger "Product design techniques", Third edition, Tata McGraw-Hill publishing company limited.