Feedback System For Electric Trimmer

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Abstract— Automation and enhancement of the quality of trimming by an innovative way of constructing a trimmer has been devised in this paper. The improvements proposed here intend to increase the functionality of the trimmer by adding an extra perspective to the trimming process, at the same time optimizing the space constraints of adding new or additional components to do so; this has been done by adding a closed loop feedback system for additional control and precision. This closed loop feedback system requires the fabrication of an innovative electromechanical system which has been proposed in this paper.

Keywords- electric trimmer; closed loop feedback; microcontroller, gear mechanism, electromagnetic clutch, bearings.

I. INTRODUCTION

Trimming is a day to day phenomenon, whether it is in front of the bathroom mirror, or in a hospital bed before an operation, or while shearing off the wool of a sheep. However, a problem is always faced by the person while negotiating uneven surfaces. It results in the person bending the trimmer in various ways to effectively trim that part. It results in imperfect trimming and can be quite painful if it leads to cuts on the face or other parts.

Secondly, for people with one hand, or a disability in one hand, or a fractured arm in a sling, trimming becomes an arduous everyday task which they are not able to undertake alone, or if they are able to, they are unable to achieve the desired quality of shave. So, this product also has social benefits too and its development is not purely driven by market motives.

Blaustein et al \cite{1} patented a wet razor and dry trimmer combination so that trimmers can be used while submerged in water. That was one of the first patents approved for trimmers after the first patent for the electric trimmer was granted to Poel \cite{2}. However, there has been no study on the usage of a closed loop feedback control system on an electric trimmer for better control and precision.

Eventually, electric razors got a bit more sophisticated. The injector razor made wet trimming comparatively safer. Then, in the 1970s, wet trimming advanced again with the creation of the twin-blade cartridge. The idea had been around for a while, but the revolution that occurred in the 70s happened from a marketing standpoint. Development on the triple-blade razor began in the 1970s, but apparently there were problems with three blades. They caused irritation. In 1998 the solution to this problem appeared. The Mach 3 trimming system from Gillette uses three blades.

In this paper, a closed loop feedback system has been incorporated with a change in the trimmer mechanical design to allow increased functionality during the process. An electromechanical system in the design allows two degrees of freedom of the blades in contact, while minimizing the addition of new components while doing so, thereby keeping the design of the trimmer feasible in size and ergonomic in nature.

While the design of this trimmer does not innovate in the field of blade technology, or ‘wetness’ factors associated with shaving, as they have already been researched into extensively, it does propose an alternative method to improve functionality of contemporary trimmers while keeping within similar size and cost constraints. The novelty of this design lies in the ability to provide multiple degrees of freedom to the blades of the trimmer, using limited mechanical components.

II. PROPOSED TRIMMER

A. Concept

To improve the entire process of trimming holistically, the approach of maintaining a user defined pressure over the blades in contact of the trimmer has been chosen. This will lead in partial automation of the entire process of trimming, especially over undulating surfaces.

This has been done by using three blade spindles instead of one, on each of which a pressure sensor has to be mounted. The combination of three pressure sensors will sense the pressure being applied to the spindles and the average will be calculated. If any spindle’s pressure sensor detects a difference from the average pressure exerted by all the spindles, it will move in a direction so as to offset the pressure difference. So if one of the blades move over the edge, there will be a drop in the pressure on the spindle compared to the other two, therefore the mechanism will force the spindle to move down to compensate for the change in pressure and the blades will stay in contact with the surface to be trimmed.

In case of sudden pressure increase on one of the spindles, it can retract with the same reverse mechanism to reduce and maintain the applied pressure on the spindles.

B. Development

The model hopes to affect an improved solution for effective trimming. A sleek structure has been adopted both for aesthetic look and good handling, hence ease of usage. However, the housing is limited by the inner mechanism and the types of components planned to be used. The three spindles with inner blades are shown in Figure. 1.

The housing also has the function of holding the fixed components like the power supply, gearbox, motor, the printed circuit board etc. in place.
C. Components of the Trimmer

1) Electronic components

Piezoresistive transducer is used to provide an accurate, high-level analog output signal that is proportional to the applied pressure. The small form factor and high reliability of on-chip integration make the sensor a logical and economical choice for the desired product. The location of the pressure sensor is between the blades and the housing. The output from each sensor is given to signal conditioning board and controller. Voltage proportional to the normal trimming conditions is given as the threshold limit for the activation of the system. Otherwise the system works normally. When the threshold is exceeded, the corresponding electromagnetic clutch is activated by the control system so that upward or downward motion can be transmitted.

2) Gear Mechanism

The ideal motor to be used is a 24V DC motor with speed rating of 3000 rpm. The main constraint for designing the gear mechanism is the size and ease of holding. Keeping this in mind a single motor drive which provides two degrees of freedom to the blade spindle is provided in the trimmer. As the motor is going to be attached to the single motor spindle, it is needed to transmit motion from the motor spindle to the three blade spindles. The gear mechanism has been designed in Pro/E as shown in Figure 1 with the constrained size and contour of the trimmer.

Gearbox consists of the following parts as shown below in Figure 2 which is discussed in detail in the following subsections. This gearbox provides only the translational motion to the blade spindles and does not include the rotary motion transmitted to the blade spindles from the motor spindle by spur gears connected to both.

a) Bevel Gear System

A bevel gear system (‘A’ shown in Figure 2) is used to translate the motion to the blade spindle from the wheel of the worm-wheel arrangement.

b) Worm and wheel arrangement

A worm is to be put on the motor spindle which will transmit motion to the wheel (‘B’ in Figure 2). There is supposed to be massive speed reduction in this. A helical cut has been put on the motor spindle in the assembly drawing shown in Figure 1 to indicate the worm. The speed reduction is done in order to reduce vibration during the linear movement of the blades. The speed reduction in worm wheel is high in order to avoid rapid movement of the blades while trimming.

Figure 1. ProEngineer (ProE) model of the Proposed Trimmer.

Figure 2. Schematic representation of Gear Mechanism used in the trimmer.

A-Bevel Gear (1:1); B-Worm and worm wheel (1:18); C-Spur gear (1:1:1); D Clutch; E-Spur gear (1:1); F-Spur gear (1:1:1)

c) Spur Gear

Spur gear is being used to transmit the rotary motion from the motor spindle to the blade spindle. The gear is mounted on the spindle using an interference fit so that there is absolutely no slip in the motion. The spur gear is not intended for speed reduction but only speed transmission.

Another spur gear arrangement ‘C’ (as shown in Figure 2) is used to transmit motion to the two electromechanical clutch systems. The spur gear arrangement ‘E’ (as shown in the Figure 2) transmits motion to the blade spindle in the same direction as ‘C’, whereas the spur gear arrangement ‘F’ (as shown in the Figure 2) transmits motion to the blade spindle in the opposite direction as ‘C’. These opposite directions of gear motion make it possible to provide two overall opposing directions (upward and downward) of spindle movement to the blade spindle.

d) Electromechanical Clutch System

The spur gears transmit motion to two spindles connected to an electromechanical clutch (‘D’ as shown in the Figure 2) each. This electromechanical clutch gets activated when an appropriate voltage signal is provided to it by the control system, resulting in the clutch getting engaged and transmitting motion to the rest of the gear system connected to it. It is to be noted that the gear configuration used is such that one of the clutches is connected to a system which provides an upward motion to the blade spindle and the other clutch provides a downward motion to the blade spindle.

e) Rack and Pinion System

A rack and pinion system is used to provide a translational movement to the blade spindle. There is one rack and pinion associated to each of the two electromechanical systems. Each pinion is always engaged to its respective rack. The control system activates and deactivates the electromagnetic clutch depending on the pressure on the blade, is responsible for choosing which rack and pinion system will be used to transmit linear motion in alternate directions (upward or downward).
The rack teeth are cut on the deep groove ball bearing which is holding the blade spindle.

3) Ball Bearings

Deep groove ball bearings are used on the blade spindle. The housing of the ball bearing is given a rack cut so that it can act like the rack in the rack and pinion arrangement. This ball bearing performs the function of allowing and transmitting two degrees of freedom for the blade spindle unlike standard ball bearings which provide a singular rotational degree of freedom to its respective spindles.

III. WORKING OF THE TRIMMER

The working of the proposed trimmer is shown in the overall schematic in Figure 3. When the trimmer is switched on, the main motor starts rotating. Rotational motion is transmitted from the motor spindle to the blade spindles using a spur gear at the same speed of rotation as the motor spindle. Speed can be modified for greater or lesser torque.

The pressure sensors detect the pressure applied by the user. At every point of time the average pressure across the three spindles is calculated by the microcontroller and the pressure across each spindle is tested against the average for some set limit, i.e. the threshold value. In case of no variation beyond the threshold, there will be no change in the gearbox configuration and thereby on the position of blade spindle.

In case of a pressure beyond the threshold, the control circuit will send a signal to the power circuit which will activate one of the electromechanical clutch systems attached in the gearbox and start the translation motion for the particular blade spindle either in an upward direction or a downward direction.

IV. DESIGN INNOVATION

The trimmer has certain innovative features which do not exist in existing state of art electric trimmers. This trimmer does not consider the vibratory motion used by existing trimmers to create a shave as demonstrated in [3]. Neither does it concentrate on the torque transmission or the ability to perform wet trimming as well as dry trimming which have already been done in [4]. The blade to be used by the user of this trimmer can be chosen according to the user’s preference itself. However, this trimmer uses a closed loop feedback system to provide an automated stabilization of pressure applied across all blades. This feedback makes it more user-friendly and can be used across different configuration of other types of trimmers as well.

Another salient feature of this design is the ability to control and transmit two degrees of freedom using a singular rotary motor. It has been done by designing a gearbox system using electromechanical clutches to control the linear motion of the blade spindles electronically. The extent of the translation of the blade directly affects the pressure applied on the surface on which the trimmer is applied. This can further be modified by using some damping to actuate the motion of the blade; however, it can also be ignored as the motion to be executed is very small in nature.

Thirdly, the threshold pressure which will be selected by the control system to control the blade spindles is modified according to the user on the basis of the current pressure applied. The average of the pressure on all the blade spindles is taken, and the individual pressure on each blade is adjusted on a step basis by extending or retracting the blade spindle so that all the blades move to attain the same pressure. A step basis is chosen so that the increment or decrements in the extension of the blade spindle does not change in spurts, or rather changes
eventually. Moreover, after each adjustment to the blade spindle position, the pressure input is reevaluated for continual position change in the blade spindle position, for a very user-friendly experience.

However, the ergonomics of the housing of the trimmer is not discussed here. This design involves an innovation particularly to the functionality of the trimmer.

V. CONCLUSION

An effective trimmer, which can give better trimming than contemporary models is presented in this paper. The pressure sensors are incorporated to enhance the quality of trimming. This automated feedback mechanism will avoid manual feedbacks resulting in cuts and imperfect trimming, thereby resulting in a better trimming experience.

However, this trimmer requires the usage of lots of miniature mechanical components, which might make the trimmer more complicated to manufacture. But this also means that it can be as light as, if not lighter, than contemporary trimmers.

Furthermore this trimmer can be modified for a better ergonomically and aesthetically pleasing housing design. The materials used for the housing can be injection moulded synthetic materials.

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