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DESIGN & DEVELOPMENT OF A NOVEL HOUSE HOLD COMPRESSING DEVICE FOR A WHEELIE BIN

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ABSTRACT

This project consists of researching, designing, developing, prototyping and testing a device that clamps onto a wheelie bin and easily compresses the waste inside. Once attached, by pulling on the lever, the device will compress the contents inside allowing for disposal of more waste. The design is easily assembled, light and sturdy enough so that any household individual can use it. Prototype testing was performed to identify the required forces necessary to compress a sufficient amount of waste and identifying which materials or types of waste can be compressed. The prototype testing showed that the device is capable of compressing the normal household wastes (compressing plastic bottles, cardboards, tin cartons) up to 45% off the original volume. The paper discusses the design, development and testing of this device to appreciate the proof of the concept as well as discussing it in terms of saving the cost of recycling as well.

Keywords: Recycling, Household Waste, Compressing Device.

1 INTRODUCTION

Since emptying up litter of household wheelie bins takes place mostly after fortnight by UK city councils, therefore in medium to large family households, there wheelie bins start to overflow by the end of first week. Due to living in a neighborhood where the local council does not allows waste within the wheelie bin to overflow or be left beside it as shown in Figure 1. Moreover manual compressing of the litter inside the bin is physically very difficult and hygienically unsafe. Therefore a device capable of compressing the all litter contents inside the bin would be highly beneficial to those who are looking to create further space in the bin as well as making the bin area hygienically safe.

Figure 1: Litter lying outside the bin due to overflow (A common problem)

Currently there is no device on the market that can compress recycling waste at an individual household level. The need for the device was further strengthened from initial questionnaire survey results when various members of general public showed interest in such a device. Achieving the final design was a complex iterative process where earlier concepts were modeled in SolidWorks (Reyes, 2012) CAD software but failed during analysis. This was due to the wheelie bin only being able to withstand a maximum force of only 1900kg (BS 6615. 1996, C.A., 1996). Although this is a large amount of force it was still crucial to focus upon the main priority, keeping the weight and complexity to a minimum. There were iterations where it was believed that the ideal design had been determined, however, when analysis of the mass properties of the device was undertaken it could be seen that the device exceeded the health and safety limit of 25kg's. (BS ISO 11228-1 2003). So achieving a large force to low weight ratio was crucial to achieve as can be seen in the following documented design process.

2 DESIGN PROCESS

2.1 Initial Questionnaire Survey

An initial questionnaire survey involving 28 different houses was performed for a clearer understanding to whether a market for this type of product is available. The ratio of people who do experience overflowing within their wheelie bin and those willing to make a purchase in order to compress their waste is shown in Figure 2.

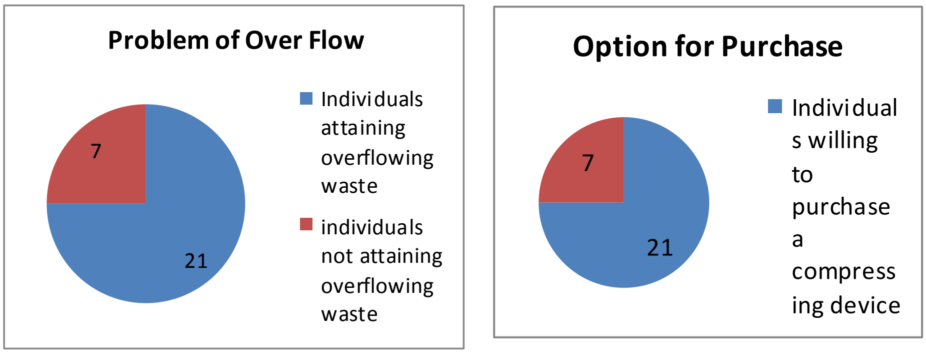

Figure 2: Results of Initial Questionnaire

Clearly all 100% said that they would be willing to purchase a compressing device however it would have to be within the right price range.

2.2 Design Development

Various conceptual designs have been prepared, modelled and tested virtually in CAD/CAE software. Based on the required compression force of 1600 Kg, the first step in the final design was to make sure that the outer periphery of the bin is strong enough to withstand a compressive load application. For this reason a rectangular support plate of 6x578x655 mm was placed on the top surface of bin. Further four 100x50x8 mm box sections of EN8 mild steel (Bolton 2000, Craig 2011) material are inserted under the top edges of bin where the actual clamping device is attached. The actual clamping device consists of a bespoke clamp made up of welding together various hollow cross sections, an off the shelf ratchet to apply compression load and a fabricated pressure plate of 5 mm thickness.

The finite element analysis (Edward 2010) as shown in Figure 4a on the chosen design shows that factor of safety is 203 which means that the bin can withstand 2069kg (203 x 100N = 20300/9.81 = 2069kg) using this given mechanism. Therefore the design is quite safe i.e. it is capable of taking the applied compression force of 1600kg. The displacement is also taken into account with the image shown in figure 4b stating that the largest displacement occurs across the side panels with a value 0.26mm which isn't a massive concern and proves this design is perfectly safe. FEA (Figure 5) was performed on the pressure plate where a maximum force of 1877kg was calculated (18.42x1000=18420N/9.81 = 1877kg). 277kg above the maximum force of the ratchet, therefore safe for use in this application. The displacement shown is also relatively low with a maximum displacement of 0.1mm. This indicates that more increased pressure/force capacities beyond the 1877 mark will require thicker plates.

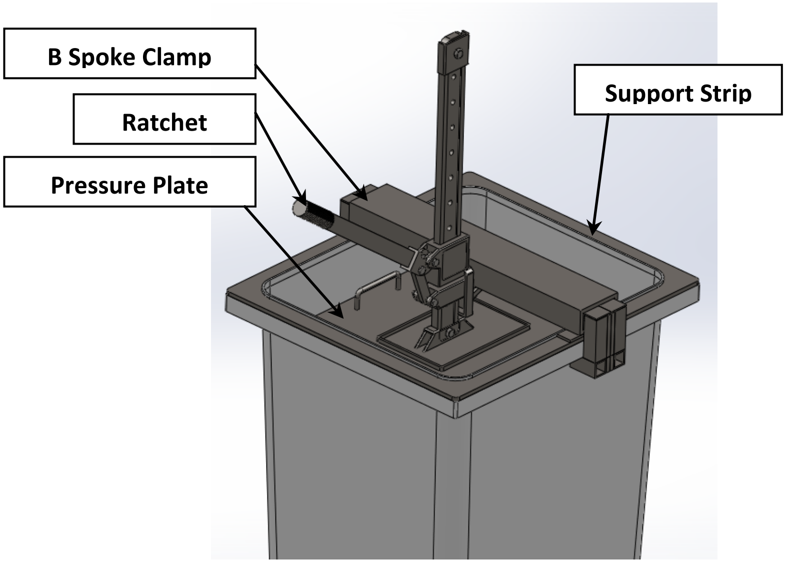

Figure 3: Final Design of the Compression Device

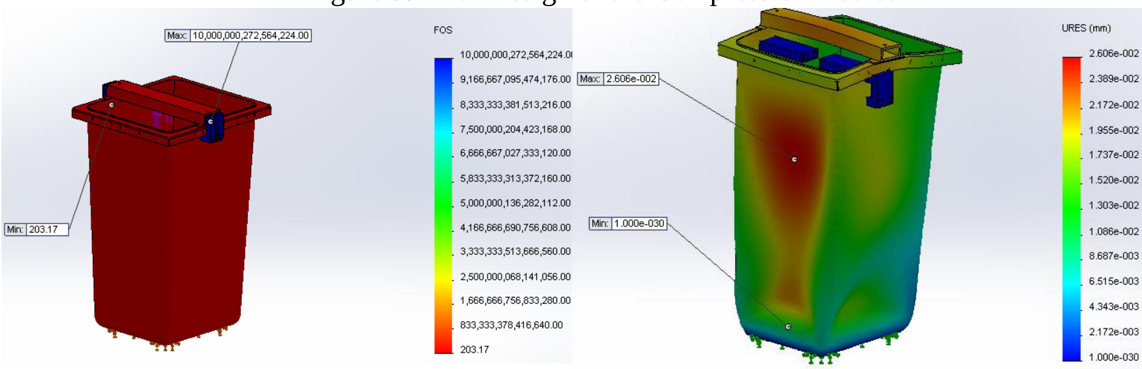

Figure 4: (a) Factor of Safety Analysis in Final Design, (b) Displacement Analysis

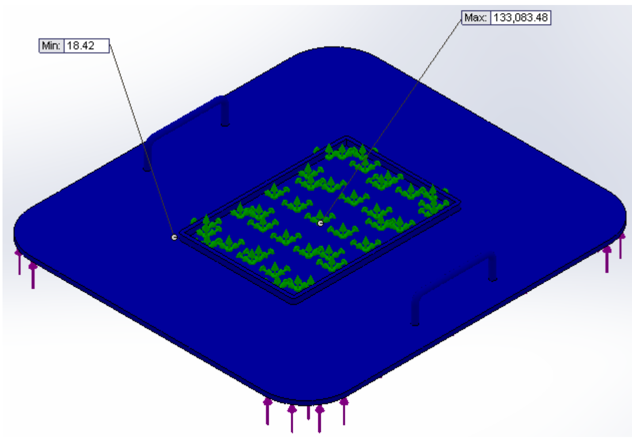

Figure 5: Factor of Safety Analysis of Pressure Plate in Final Design

3 PROTOTYPE TESTING AND EVALUATION

The above design was implemented to develop a full working prototype which was subjected to testing and evaluation. For prototype development, the majority of the joining methods (Beddoes

1999, Groover 2010) implemented were achieved using welding techniques. This was due to analysis conducted on SolidWorks showing that this type of joint would not fail and from advice of different manufacturers that this was the cheapest and lightest solution. All cutting was done using an angle grinder (Maekawa 2000) and again this proved the most practical and beneficial method (Groover 2010. The full working prototype was prepared according to standards (BS 6615. 1996, BS ISO 26303. 2012) and is shown in figure 6. Prototype testing was carried out in two stages:

Figure 6: Full Working Prototype of the Compression Device

3.1 Testing with all Forms of Recycling

The first stage was to be carried out crushing all forms of recycling, for example, glass, cardboard, paper, plastic bottles, cartons, cleaning products, and other various objects. The reason for compressing all types of waste was made due to Bournemouth city council stating that all of the above are classed as recyclable (PD CEN/TS16010 2013). The results are shown below in Figure 7 (a) and 7 (b)

Before Compression After Compression

Figure 7: (a) Before Compression (b) After Compression

The results are fairly significant. Measurements for the amount of compression were taken and are as followed:

Before compression: waste = 100mm from top wheelie bin

After compression: waste = 500mm from top of wheelie bin

Compression = 400mm = 40%, These are excellent results since all forms of waste were under compression.

3.2 Test with no glass

Southampton council laws state that no glass is allowed within recycling wheelie bins so the next task required taking all the glass out of the wheelie bin and keeping all other waste materials. The results are shown below in Figure 8

Before Compression After Compression

Figure 8: No Glass Test (a) Before Compression (b) After Compression

It is clear there is a comparison between both tests as both show excellent results. It is also worth bearing in mind that during test 2 half of the recycled material within the wheelie bin was already compressed due to the previous test. This suggests that the results would have been further improved if all material hadn’t already been compressed. The results are shown below.
Before compression: waste = 80mm from edge of the bin.
After compression: waste = 500mm from edge of the bin.
420mm of compression = 42% with room for improvement.

3.3 Post Prototyping Customer Review

The results from the customer review show that the majority of potential customers were happy with the operation and handling of the compressing device. One lady found it a little heavy and difficult to assemble, however the other 9 study subjects (5 men and 4 women) said it was fine. All the men said operating the device was easy and only two women said it was a little hard towards the end. However this can be overcome just by putting more rubbish in and lowering the compressing distance or just using a more powerful ratchet. A cost price for the device of £55~£70 was indicated to be acceptable keeping in view of the achievement of good results. All the members of the public who participated in the test said that the device felt safe to use up to the point of maximum compression. During disassembly two persons struggled to disassemble the device, however, once the correct disassembly sequence was established and understood, everyone found it easy to do so.

4 CONCLUSIONS

From an idea derived from watching people jump into bins to make more space and developing this idea to design and create something that can manage that task in a much safer and improved way has made the whole project worthwhile. The above discussion clearly shows that the first stage testing of the prototype achieved functional aims and objectives of the project. The device also had to be easily assembled and mounted upon a wheelie bin; again this was also achieved well within time. Assembly takes no longer than 2 minutes and compression of the waste takes no longer than 5 minutes.

Disassembling takes 2 minutes as well with a total of 9 minutes to acquire nearly 50% more waste disposal. Each component weighs no more than a couple kilograms with the whole assembly weighing only 14kg which is well below the defined maximum safe lifting load of 25kg (BS ISO 11228-1. 2003). The device is safe and easy to operate with the full system only. The cost of prototype development was £76 (ratchet cost £28 and device cost £48). After close inspection and advice from different manufacturers it was estimated that if the system was to be mass produced it should cost within the range of £30-£40. Allowing for a mark-up of around 44%, the retail price would be roughly £62.50 (this falls well within the £55 to £70 expected price derived from the questionnaire survey). If recycled metal could be used then these values would be significantly reduced. The market for this type of device exists, according to initial questionnaire survey results.

Further market research with regards to the actual design was carried out with all individuals stating the design was a worthwhile project and some participants even wanted to borrow the prototype to use it at their own homes. Tests also show that no waste protrudes up and out from the sides of the pressure plate as exact dimensions were taken to develop the prototype thereby increasing the safety and reliability of the product.

5 FUTURE WORK

The developed solution proved highly effective and fit for purpose as a compression device. In the next stage of the project, following work can be carried at various stages of the development of the device, so that it can be launched as fully commercial product in the market:

- Identifying further lighter materials in the market with the same or similar strength characteristics, rather than relying only on mild steel.
- Completing further research into ratchets with higher tonnage so that when lower depths are reached compression can be maintained (with a ratchet, as the distance between the base and the lock is increased the tonnage is slightly decreased). This would save having to disassemble, put more waste in and compress again.
- Researching easier assembly methods whereby using lighter materials one component can be assembled upon the wheelie bin rather than piece by piece.
- Identifying different compressing devices for different bins such as general waste wheelie bins and garden waste bins.
- Designing a whole new wheelie bin with a compressing device already attached to it so that the device doesn't have to be disassembled each time it is used. This would save time and would make the device far easier to use. However cost will be affected unless the council would be willing to take interest and invest.

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