
Development of a Mechanical Weld Spatter Removal System

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Abstract

Weld spatters are small droplets of molten metal that arise during the welding process. These small bits of hot material stick to any metallic material around it like the workbench or floor. These spatters are basically small round shaped ball-like structures. The major cause of weld spatter is due to disturbance in the weld pool. Weld spatters are not safe with certain industries dealing with oil and are in general undesirable. Hence, the spatter needs to be removed. The spatter is removed both, by means of mechanical devices operated by hydraulic or pneumatic mode and traditionally by hands using a hammer and chipper. This chipper is in conformity with traditional hand operated chippers and aims to significantly reduce both manual effort and time required to remove the spatter. For removal of spatter, it is simply required to aim the chipper at the spatter and exert force by means of a sliding handle, which in turn removes the spatter. In the current paper, the design and development of spatter chipper have been described.

Keywords

Weld Spatter, Spatter Chipper, Welding Process Maintenance, Manual Spatter Removal Tool, Surface Cleaning in Welding.

1. INTRODUCTION

Weld spatters are small droplets of molten metal that arise during the welding process [1]. These small bits of hot material stick to any metallic material around it like the workbench or floor. These spatters are basically small round shaped ball-like structures. The major cause of weld spatter is due to disturbance in the weld pool [2]. Weld spatters are not safe with certain industries dealing with oil. These unwanted spatters need to be removed. As they are not beneficial for the finishing of the final product, as well as for the surrounding welding environment. To tackle this problem of spatter removal, mechanical spatter remover as described in the paper is made. It aims to remove spatter in a traditional manner, by means of hand but in a more operator friendly manner and in less time requirement. Welding is a manufacturing process that is most commonly used in the automotive, shipbuilding, oil and gas, construction and heavy fabrication industries. Although welding has several benefits in the formation of strong and permanent joints, it is known to release unwanted by-products like fumes, slag and weld spatter. Weld spatter is the term used to refer to the tiny drops of molten metal discharged out of the weld pool as a result of the welding process and deposited onto the surrounding surfaces. These droplets harden very fast and stick strongly to all the surrounding metallic items like work pieces, fittings, floors and equipment's leading to poor finish on the surface, low quality of products and further post processing needs [3]. The parameters of welding that mainly affect weld spatter formation include: current, voltage, shielding gas composition, electrode type and welding technique. These are due to improper choice of parameters or inherent instability of the welding arc which results in disruption of the molten weld pool,

resulting in expulsion of molten metal droplets as spatter [4]. The excessive spatter does not only result in the aesthetic look of the welded joints, it also leads to a wastage of the materials, time in cleaning and operational costs. Weld spatters are severe safety risks in the oil and gas industry, as well as the flammable materials industry, because the hot metal particles have the potential to ignite combustible substances and make the working environment hazardous [5]. Historically, removal of weld spatter has been a manual operation that was done by hand with tools like scrapers, chippers, hammers, and grinding machines. These traditional approaches are time consuming, labour consuming and in most cases cause fatigue to the operator. Moreover, manual spatter removal can create surface damages in case of the use of too much force and this can impact dimensional accuracy and surface integrity of components [6]. Though pneumatic and hydraulic spatter removal equipment has been set up to minimize the manual labour, these systems are not affordable, large, and not suitable to small and medium scale industries in need of cost-effective systems.

Thus, it is required to have a low-profile, lightweight, and effective spatter removal tool that will reduce the physical workload and increase the efficiency of work. The current project is aimed at the design and development of a sliding-handle controlled spatter chipper that will increase the effectiveness of the work and minimize the physical load on the operator. The suggested machine applies mechanical force by using a sliding handle system, which allows the removal of the weld spatter with little effort and time. The design considerations, development process and working principle of the developed spatter chipper are presented in this paper.

2. LITERATURE REVIEW

Welding is used for fusing similar or dissimilar metals by means of heat, it can be done with or without application of pressure or filler material. It is an essential component in automobile, aerospace, construction as well as railroads sectors. Weld spatter formation and its removal have been widely studied due to their impact on weld quality, productivity, and safety. Several researchers and industrial practitioners have discussed the causes, effects, and mitigation techniques for weld spatter in various welding processes.

Cary and Helzer [7] discussed that weld spatter is a common issue in arc welding processes, particularly in Gas Metal Arc Welding (GMAW) and Shielded Metal Arc Welding (SMAW). They identified improper welding parameters such as high current, incorrect voltage, and poor electrode selection as major contributors to spatter formation. Their work emphasized that maintaining stable arc conditions can significantly reduce spatter formation, although complete elimination is difficult in industrial environments. Kou [8] analyzed the metallurgical aspects of welding and explained that disturbances in the weld pool and droplet transfer mechanisms are primary reasons for spatter generation. The study highlighted that short-circuit transfer mode and globular transfer mode in welding processes are more prone to spatter formation compared to spray transfer mode. Kou also suggested that process optimization and equipment design improvements could help minimize spatter. The American Welding Society (AWS) handbook [9] provides comprehensive information on welding processes and their associated defects. According to AWS, weld spatter not only affects the appearance of the weld but also leads to increased cleaning time and operational costs. The handbook also suggests mechanical cleaning methods such as chipping, grinding, and brushing as common industrial practices for removing weld spatter. However, these methods often require significant manual effort and time. Kalpakjian and Schmid [10] discussed post-welding finishing operations in manufacturing industries. Their work highlighted that manual removal of weld spatter using hammers and chippers is still widely practiced, especially in small and medium-scale industries. However, such manual methods lead to operator fatigue, inconsistent results, and reduced productivity. The authors suggested the development of simple mechanical devices to improve efficiency and reduce manual effort.

Weman [11] studied welding process efficiency and emphasized the importance of reducing post-welding operations such as spatter removal. The study suggested that improved tooling and ergonomic designs can enhance operator comfort and reduce time required for cleaning operations. Furthermore, Weman highlighted the need for cost-effective and portable spatter removal tools suitable for industrial use. From the literature, it is observed that although various methods exist for reducing weld spatter, its complete elimination is not feasible.

Additionally, the removal of weld spatter still relies heavily on manual tools, which are inefficient and labor-intensive [12]. Therefore, there is a need to design and develop a simple, efficient, and ergonomic spatter chipper that reduces manual effort and improves productivity. The present work aims to address this gap by designing and developing a sliding-handle based spatter chipper for effective weld spatter removal.

Below figure shows typical welding operation:



Figure 1. Typical welding process

One of the major concerns in welding operation is the generation of weld spatter as shown in figure 2. Weld spatters are small droplets of molten metal that arise during the welding process. These spatters are generated by unbalanced metal transfer force, for instance in metal inert gas (MIG) welding [13]. It is mainly caused due to disturbance in the weld pool. It usually occurs when for a given wire, it is being operated at either very low welding voltage or at very high amperes. These spatters are basically small round shaped ball-like structures as shown in figure 2.



Figure 2. Weld spatters as generated (Highlighted with circles)

Removal of these unwanted spatters is an unwanted cost to the manufacturers and company. Not only do these spatters tend to burn the operators' clothing and skin, but also it causes loss of material from the arc and weld [14][15]. Special efforts are required to be made by the manufacturers for the removal of spatters.

Traditionally in some industries, workers are appointed for the removal of spatters by using low-cost tools like chisel and heavy hammer. But this process is a bit lengthy and time consuming, not only hampering the workers' efficiency to work throughout the day, but also an exhausting process in the long run. To counter the drawbacks of the traditional hammer and chisel method of removing the spatters we have developed a spatter remover as described in later sections of paper. The implementation of this spatter remover not only aids in increasing workers efficiency but also helps reduce all the injuries as caused by using a hammer and chisel and helps to remove spatters from areas difficult in reach.

3. CONSTRUCTION

The assembly comprises of the following parts:

1. Central Bar

The central bar acts as the support for the whole assembly. The slider slides by means of this bar and exerts force on the chisel so attached. The handle is also mounted on the central bar.

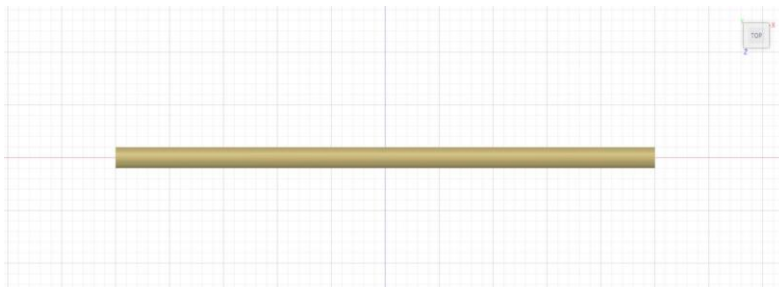


Figure 3. Central Bar

2. Top end handle holder

The top end handle holder is used to hold the device comfortably during operation. It is situated on the trapezoidal shaped metal frame. This holder is affixed with the metal frame in order to avoid slippage.

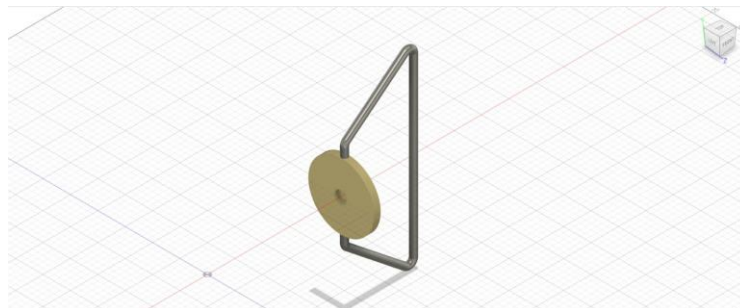


Figure 4. Top endS handle holder

3. Slider

Slider is the only operational part of the assembly. It is used to impact the chisel with required force to remove the spatter from the welded surface. Slider slides on the central bar with minimum friction between them.

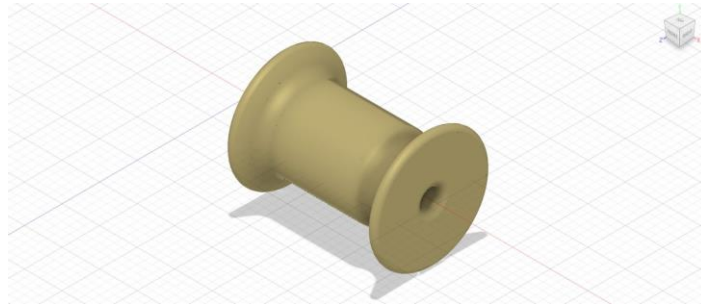


Figure 5. Slider

4. Chisel

The chisel (chisel cutting edge) is the impacting part of the assembly which strikes on the weld spatter in order to detach them. All the force from the slider is transmitted to the chisel which will eventually be used for spatter removal.

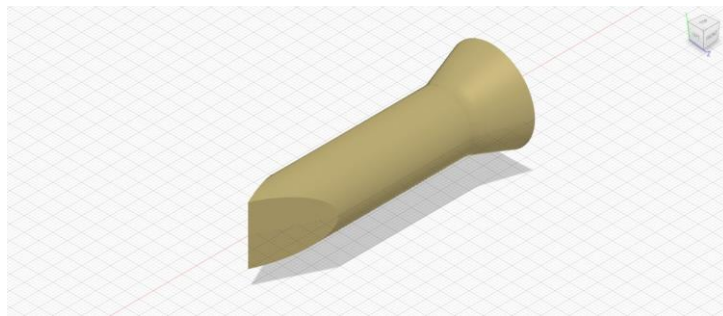


Figure 6. Chisel

5. Chisel case

The chisel is provided with external threading and the case has internal threading. This allows interchangeability of chisels. Suitable sized chisels can be now attached to the product by means of a chisel case.



Figure 7. Chisel Case

4. FINAL PRODUCT

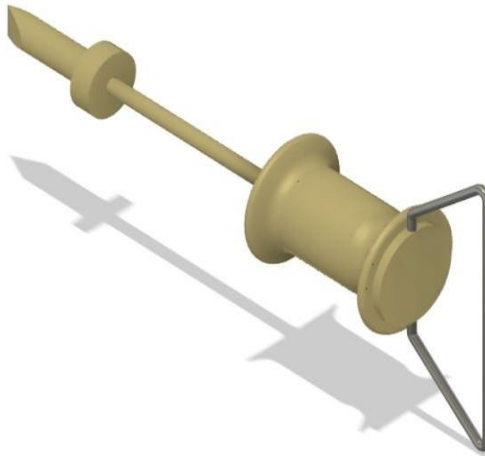


Figure 8. Final Product (CAD) (i)



Figure 9. Final Product (CAD) (ii)

5. WORKING

Since the traditional method of removing spatter was using a chisel and hammer, we made a simpler tool to remove the spatter and is more efficient than the traditional method. With the help of the concept of force transfer, we made a tool (that transfers the equivalent amount of force exerted by the hammer), simply with the help of a sliding motion. The chisel is held in contact with the spatter at a suitable angle. When the slider is rammed on the chisel the force exerted on the chisel is transferred to the spatter resulting in its removal from the surface (As shown in figure 10 and figure 11).



Figure 10. Product in-use



Figure 11. Final Manufactured Product

The removal of spatter using a chisel and hammer is a very time-consuming process. This tool helps to reduce the time consumed and also requires a much lesser force as compared to a hammer. Moreover, being light in weight, this product can be oriented in any manner and at any convenient angle for easy removal of the spatters.

6. CONCLUSION

The design and development of the spatter chipper provide an efficient and user-friendly solution for removing weld spatters. Compared to traditional hand-operated methods, the developed tool offers improved safety, reduced manual effort, and enhanced operational efficiency. The sliding handle mechanism enables effective removal of spatters with minimal physical strain, thereby reducing operator fatigue and improving productivity. Additionally, the compact and ergonomic design allows easy access to difficult and confined areas where conventional tools are less effective. The proposed spatter chipper also minimizes the risk of injuries

during operation, making it safer for industrial use. Furthermore, the tool significantly reduces the time required for spatter removal, resulting in improved workflow and reduced downtime. Overall, the developed spatter chipper proves to be a cost-effective, safe, and efficient alternative to traditional spatter removal methods, making it suitable for various industrial welding applications.

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