Delivery of Engineering Processes Safely as a Team

Using Engineering Processes and Working in Teams

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Report aims

The main aim of the following report is to show competency when working in a team in order to complete an engineering objective, with said objective being the production of a metal screwdriver. The report discusses ways in which effective team organization can be attained from both mental and practical standpoints such as morale and motivation, planning, time management, and communication, as well as the way in which team members have been organized and allocated according to their individual strengths and weaknesses. From there, the report shows and discusses the actual production procedure itself from the research and design stage all the way to finishing the functional product while showcasing the thought process that went through every stage. The report also provides the logbook for both the sessions and the actual work that has been done as well as the meeting reports in the form of meeting minutes. Concluding the report is an assessment of what went well during the production process and potential improvements to what could have gone better.

Contents table

Effective team building

Brief

Team building is a major aspect within any given industry, as having a great team would elevate the production process by making it more efficient, smoother and works without hindrances, and the overall quality of the product is generally better. However, building a team should be done effectively and cautiously as it relies on a variety of different aspect from the human factor of individual team members, their mental and physical wellbeing, effective and clear communication between team leaders and members, as well as setting a firm foundation of rules that should hold the team together. All of the stated points have to be taken into account as to ensure the trust between members is held and the overall morale and mindset of the team stays high while remaining focused on the required productions tasks.

Communication

Importance of effective communication

For a team to be able to communicate effectively means an increase in overall productivity and thus and increase in the quality of the product since being able to communicate properly allows for both team members and leaders to receive an idea about each team member's current ongoings with the production process as well as receive feedback for potential improvements.

Meeting schedule

The communication schedule that would be ideally placed is to have a mandatory before any practical session for a minimum of around 20 minutes during the afternoon (around 4PM after school) which would be held even if no significant matters about the product or production process had to be discussed, since mainly discussion about the current progress of team member's ongoing task is what is going to be talked about. However, if needed, the meeting could be prolonged if a major task or issue had to be discussed, in addition, team members should have the ability to communicate with each other throughout the day and not only in a set range of time, as this would allow members to freely share any ideas or changes that they have in mind about the product itself or the production process, since waiting until team members are able to meet in person could potentially lead to a person and having additional feedback from team members quickly is always helpful.

Online communication method

The application and method in which team members are going to communicate outside of work has to be chosen with care, since a great application would allow for team members to express their ideas in a more understandable and easier manner. The main candidates that were discussed to be chosen were Microsoft Teams, Zoom, or Discord, or WhatsApp, by the end, Discord was the application chosen due to giving its users a lot of freedom in terms of customizing and editing the discord "server" in which meetings are going to be placed by allowing the user to organize the server by sectioning for different stages of the production process such as a channel for general discussions, 3D modeling, sessions planning, and so on. In addition, discord allows for text, voice, and video communication while also providing the able to live stream the current speaker's screen with ease, giving full freedom and ease of communication to the user. All of the other stated application lacked in some sort of area that discord did not with exception of MS Teams, however, discord seemed and easier to use and more reliable and therefore it was the one chosen.

Communication mannerism

Communication protocol and mannerism is an essential aspect that each team member should have, since without it, communicating with each other would be unorganized, and overall, even if a given idea was great, it would not be understood properly by the other team members. When it comes to exact protocols that should followed, they are the following: Give time for each member to speak and do not interrupt them as to respect them and in doing so the idea that is trying to be given is not going to be understood clearly by anyone in the team. Additionally, respect each team member's feedback and allow room for negotiation as if that is not done properly, then the entire point of communicating with each other is lost, since being insistent on a single idea restricts the range of potential modification and improvements that could be made to the product and therefore also decreases the quality and could easily lead to product failures.


MS Teams


WhatsApp


Discord


Zoom

Morale and motivation

Importance of maintaining high morale

Having high morale within a team is an essential aspect in ensuring success, since without, team members would be unwilling to give their best in ensuring product quality, due to a decrease in motivation as a result of morale being low causing team members to find enthusiasm and reason to work on the product, potentially leading to burnout and consequently decrease in workflow productivity and quality.

Mental support

Throughout the entire production process, a team member that initially might have contributed a lot to the product and worked hard could easily get burnt out by the end of the process or even in the middle, and if that were to occur, the overall productivity and mindset of ensuring the product is made with great quality is worsened, which generally leads to issues with the final product. During these circumstances, team members should assist each other mentally and try to motivate each other and support one another outside of the work environment by checking in on them on regular basis, while during work trying to motivate them by showing them the progress and letting them know about their importance within the team. Additionally, if necessary, even suggest seeing a healthcare professional.

Fairness

Both during discussions and working on the product, fairness should be always kept, since if not, team member relationships would generally be bad, as a team member would feel they are being undervalued compared to their peer. Ensuring fairness could be done by assigning tasks to team members that feel they are most comfortable in while also making sure that they are able to work on said task adequately. Additionally, the team leader of a given section in the production process should not be biased which although cannot be ensured, team members should be speak up whenever they feel that the current leader is not being fair and for them to provide an explanation about the reasoning for their choice as to let the team member know and ensure them that they are trying to be fair.

Constructive feedback and criticism

Criticizing a team member should be done in a constructive manner with which the person being criticized can understand what exactly their error or mistake was and how they might be able to improve from it. Since simply allocating blame onto a team member would not assist in ensuring that they do not make the same mistake once again, with the only thing that it does assist in is decrease the morale of the criticized member. However, on the other hand, team members should be willing to take feedback and criticism and understand that it is to ensure the final product is going to meet the quality requirements, and that said criticism is not directly aimed at their overall ability, but rather at the work for a particular section and is for the sake of improvement.

Non-concrete deadlines

Although having deadlines at a specific date could ensure members work effectively throughout the entire lifespan of the project and potentially ensuring that members do not procrastinate, however, it could also lead to major issues such as an increase in stress levels in trying to make sure they meet the deadline, this could in consequence lead to burnout, thus worsening the quality of the final product. The main way of solving this issue to by setting deadlines that are flexible and within a time frame rather than a set date, this way, even if a section of the process was not met within the expected date, there is still a time frame in which it could be postponed do, consequently avoiding the issues that would be met due to planning fallacy (the underestimation of time expectancy)

Respect

Respect is an essential aspect that has to be seen between members and leaders alike. If each team member were to respect their peers, each member would feel like they are appreciated and they their work is of use, making them motivated and willing to give their best to ensure their work is up to required standards. Additionally, if a person were to be respected by and respectful to their teammates, they would be able to positively influence the team and motivate them towards the production goal, and if the same could be said about every team member, then the overall morale of the team would be consistently high even if unfortunate circumstances were to occur.

Planning

Importance of proper planning

Planning is one of the major aspects of a successful team, which is the case since even if a team were to be extremely capable in terms of their abilities, without set plan to lead them and show them what they are meant to be doing, and which roles each individual is meant to fill, the team would be in disarray, leading to improper management of the production process, which consequently lead to producing a product of poor quality. Additionally, a proper plan is able to streamline the production process, making it easier for the team to know their next step by improving on the dynamics of the team.

Consideration of everyone's plan

Proper planning involves being able to negotiate and consider a variety of different views and perspectives about a given section of the production process that might even contradict one's own, as in doing so, both the drawbacks and advantages of all stated views could be analyzed as to create a single plan which incorporates the advantages from all plans while avoiding their drawbacks. Additionally, having multiple plans could function as a form of backup in the case that original one did not go as expected, this way, even if the initial planed failed, time related setbacks would not be as significant.

Settings targets

Before the starting the initially starting to work on the product, targets should be set for each section that is going to be done throughout the entirety of the production process, with said targets consisting of the expected time frame in which the process ought to be done and the tolerance for the quality of the product by the end of the process. In terms of the time frame, it is going to be displayed onto a Gannt chart as to give the team a visual idea of the time frame in which each task is expected to be done. Setting targets should motivate team members as it would show them the relevancy of the goals and tasks, they are working on to the overall scope the project while also ensuring that each process is done according to a desirable standard.

Allocating team leaders and members accordingly

Although it was stated earlier that members should be appointed as leader to the task they feel most comfortable in, a leader should nonetheless, leaders should not be appointed spontaneously but rather be allocated according to the task they are most skilled or knowledgeable at as to ensure that the leader of a given proves is able to work for themselves as well as lead other team members during the process, consequently leading to successful completion of the process while avoiding mistakes that someone that might not be as knowledgeable about the task make. The same process should additionally be done for all team members even if they are not the leader of the section they are working on, as to let everyone know what roles they are meant to do and how they are meant to operate throughout the lifespan of the production process.

Teamwork

Team allocation and flexibility

When allocating the number of team members to a given task, it should be done according to the skills and abilities, in that if a team member required assistance, the person that is most capable of helping them in the task or process they are working on should be the one that actually goes to assist them, since if a person less capable were to go, they could potentially be more of a hinderance rather an aid to the person that required help. Additionally, when tasks are relatively simple, only a single person should be working on rather, while on the other hand if a task were to be difficult and requires certain precision, then multiple – or even all – team members should assist each other in completing it, difficult tasks could be done while ensuring a higher level of quality and precision, while during simple tasks, the team would split up as to work on multiple processes at the same time. However, with that being said, team members should nonetheless strive to be flexible and able to work under a variety conditions and with any team member.

Safety awareness among team members

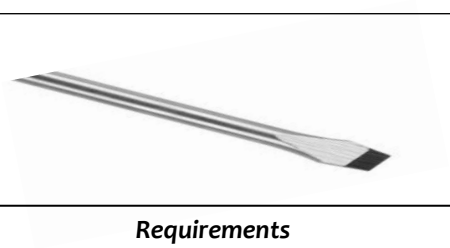
When working together, team members should constantly be notifying each other whenever they see their teammates violate a safety rule, since a person could accidentally do so without realizing, therefore posing risks upon themselves that - especially when working with machinery - could be extremely dangerous. As such, a part of working as a team involves realizing potential safety violations and hazards, and never taking them lightly when working together. Additionally, team members should know where emergency button are located throughout the workshop and on utilized machines as to be able to quickly help their teammate in the case an accident happens, since in severe cases if stopping a machine or providing aid was not done in immediately – especially in an environment such as the workshop – major or even fatal injuries could be inflicted, as such, team members should additionally know how to utilized a first aid kit and always keep one nearby.

Product requirements

Flat head screwdriver

The product that is going to be made and discussed throughout the entirety of the report is a flat headed screwdriver. Due to the restriction posed by technical limitation, the process in which the screwdriver is going to be made involves making the handle and head of the screwdriver separately and for them to be joined at the later stages of the production process. As such, the requirements are going to be split into three sections, two of which being for the handle and head specifically, with the third about general requirements for a screwdriver

Head



Requirements

Dimensional accuracy:

Due to screw dimensions being standardized, the head of the screwdriver also must meet strict dimensional tolerances in order for the screwdriver to fit properly into screw slots and function as required. Additionally, when it comes to picking the specific standardized size that is going to be utilized for making the screwdriver, the one most utilized throughout the world is going to be the one chosen as to ensure that the screwdriver is going to be functional for the majority of screw slots that it might be used on.

Sturdiness:

Although the general usage of a screwdriver does not necessarily require for it to be strong, however, on certain occasions, users of might utilize the head of a screwdriver in opening certain items that might be hard or to lightly hit an object, and in said cases, the material is expected – and fairly so – to hold up and not break easily, as such, the brittleness and other factors that might go against the screwdriver remaining sturdy and strong such as heat-related effect from machining processes would have to be taken into account during production.

Handle

Requirements

Grip:

Due to the work environment in which a screwdriver might be utilized potentially involving manual and hard labor, for the user's hands to emit a fair amount of sweat is something to be expected, as such, the handle required having a good grip in that even in circumstances where friction from the user's hand might not be great due to sweat, the screwdriver should nonetheless be easily holdable, which can be ensured by adding a textured surfaces, utilizing a cylindrical shape, increasing the size of the handle's end, and so on.

Comfort:

For certain applications and projects, a screwdriver might be utilized quite frequently, as such, the handle from which the screwdriver is held has to remain fairly comfortable in a way that makes it so even after hours of utilizing the screwdriver, the handle should not be directly responsible strain caused to the user's hand. The way in which this can be ensured is by adding specific gripping locations which incorporate grooves for the user's fingers. Additionally, if a textured surface were to be used, the texture should not be pointed and sharp.

General requirements

Aesthetic appeal

Although aesthetic appeal is not necessary whatsoever in terms of allowing or enhancing the function of a screwdriver, it nonetheless is an added features onto the screwdriver that will potentially attract customers towards the product in comparison to another screwdriver even it had the same specifications that the consumer is looking for. Specifically, the major part in which the aesthetic appeal of is going to be focused on is going to be on the handle, with major aesthetic additions being mainly in the handle's design, however, the head also necessitates some care in terms of aesthetics in making the material smooth and relatively shiny and potentially even adding a type of logo or engraving on it. Moreover, aesthetic related issues could arise from machining or joining process such as welding problems or overestimated cuts, as such, said mistakes should be taken into account and their risk must be anticipated, and if they were to occur, they would have to be resolved before considering the product to be finished.

Sturdy assembly

The joint that is going to be made in order to join the screwdriver's head with its handle has to be stable enough to that point that even if the screwdriver were to be used for unconventional situations the two pieces would not get separated from each other. Additionally, the type of join that is going to be utilized should not interfere with the function of the screwdriver nor cause any discomfort to the user.

Production process

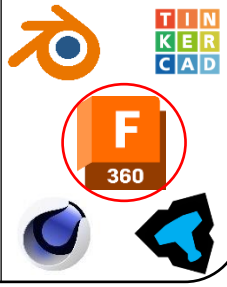
Research and design

Research

The first stage of the research and design process is going to be collecting data from various sources and researching about popular screwdriver brands with the main focus being on the handle's design and their products unique features, said task is going to be done as a way of knowing possible client attraction when it comes to screwdrivers and what features could be incorporated into the design of the product while additionally avoiding mistakes that other major brands might have made.

3D modeling

From there, 3D models of potential design ideas for the product are going to made, this will assist in knowing any issues with the design with greater ease, lower time consumption, and without the potential of wasting material during the process. Additionally, 3D models can be easily converted to orthographic format without having to manually draw them on a CAD project, further decreasing the time consumption of the process, allowing us to easily print them and have them with us as physical dimensions sheets. In terms of the application utilized for making said 3D models, although there are many that are suitable for merely producing the model such as Blender, Cinema 4D, TinkerCad, or Unity's ProBuilder, the one that is going to be utilized is Fusion 360 due to its emphasis on mechanical engineering-based 3D modeling. After the 3D models have been made, a meeting in which unanimous decision from the entire team about the preferred design of choice is going to be held, with the main criteria that said designs are going to be ranked upon being the difficulty of production relative to the technical limitations as well as the product and client requirements.



Testing (3D printing)

From there, the model of choice is going to be 3D printed as to be able to have idea for how the tactile feel for the final product is going to be, providing additional information on the design for any potential issues that cannot be noticed from the model alone. This will mainly assist in meeting and enhancing the product requirements relating to the grip of the handle and its comfort. In terms of the 3D print specifications, the printer that is going to be used is an FDM printer known as the Ender 3 Pro, the reason for it being specifically chosen is simply due it being available. When it comes to print settings, around 80% infill, 0.4mm layer height, 225°C nozzle temperature and 80°C bed temperature since the material to be used is going to be PETg. Said print settings were specifically chosen as they would be ideal for testing mechanical products due to the chosen infill and layer height being able to provide a strong and sturdy print, while PETg is known for it being cheap – making it suitable for prototyping – and for it being strong enough to provide a rough idea of how the final product might turn out.

Preparation

Preparation process and required items

The preparation stage of the production process involves acquiring all the required tools and materials that are going to be needed when making the product, with said tools being the lathe's cutting tools, specifically, the turning, facing, chamfering, forming, knurling, parting, the center drill and the centering tool. As well as that, tools for measuring, forging, and finishing would be required. In addition to that, as stated, the person responsible for the preparation stage is also going to have to acquire the material for the product, however, the institution (RGOTC) is providing us with the materials that would be utilized for all the products that are going to be made for the learning aim, with said material being …….. Although the stated task does seem to be relatively simple, extreme care should nonetheless be taken when acquiring he necessary tools, since in the circumstance that said tools were to be flawed, the quality of the final product would be negatively impacted significantly, and in the worst-case scenario, a redo of the entire product would have to be done, leading to a massive waste in time and resources.

Machine safety inspection

Inspection process and machines to be inspected

Safety checking is a process that involves conducting a risk assessment to each of the machines and heavy equipment that are going to be utilized as to know anticipate any potential hazard and ensure that any work that is being conducted with the use of said tool is done safely without heavy risk of injury. Said risk assessment is going to be done on two different processes throughout the manufacturing stage, with them being metalworking center lathe, conventional/hand forging, and the belt sander, all of which are going to have the risk assessment conducted via varying criteria that is relative to their individual processes, however, each of said criteria is going include a description of the hazard and are going to be rated depending on the level of risk and potential of injury and the seriousness of the injury if it were to occur, from there, methods to be used by team members in order to avoid the or minimize risk are going to be stated. Moreover, the center lathe is additionally going to be inspected and tested in order to ensure that the main components and mechanisms found within the machine work as expected and do not have the change of spontaneously malfunctioning which would consequently pose a major threat to team members that are going to use the machine. The stated testing process would be done by each individual in the team to ensure that the machine has been inspected thoroughly, since if only one person were to inspect it, the chance of them missing an issue is much greater in comparison to if everyone in the team inspected it as well.

Manufacturing

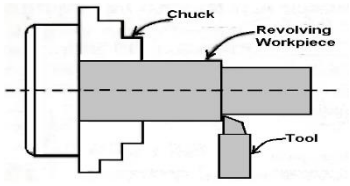
Lathe RPM calculation

Before initiating any cutting operation using the center lathe, the first that would have to be done is calculating the lathe spindle's RPM speed, which is the speed at which the spindle is going to rotate, since utilizing the same RPM speed for any cutting operation could lead to deformations in the final material, and due to the wide majority of the manufacturing process being dependent on the center lathe, inaccurate RPM usage could cause major issues. Calculating said speed is done through the use of the following expression: $(\text{rpm} = \frac{\text{sfm}}{3.82 \times \text{D}})$ *, with sfm being the surface feet per minute, a constant number that varies depending on the utilized material and D being the diameter of the tool the lathe is going to work on, however, with the given formula, the diameter would have to be given in inches.*

Screwdriver handle production

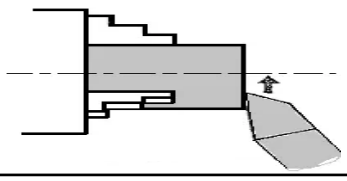
Turning

The initial step required in making the handle is going to be to decrease its diameter to the required size for the handle. This procedure would be done with the use of the turning tool, which is a tool utilized in simply decreasing the size of piece being worked on. The process involving the use of this tool initially required for the tool to be placed perpendicularly relative to the piece and for the machine to start turning the piece only when the tool is not actually touching the piece, but rather is slightly towards the side of the piece, from there, the tool is going to be pushed inwards towards the piece at a reasonable distance and then moved horizontally towards it until it reaches the end of the piece, during which, the tool is going to be sizing down the piece. After which, the tool is moved horizontally away from the piece, returning to its initial position, then moved inwards, and the process is repeated until the size of the tool is just above what is required, which is going to be determined by measuring it with the use of a caliper. From there, a round nose turning tool is going to be utilized to finish the turning process, ensuring a better final surface.



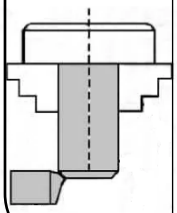
Facing

After the required diameter has been acquired, the next step is to size the material down to the required length. This process is going to be done using the facing tool, which is a tool used to trim down the component or piece from its ends in order to decrease its overall length as well as smoothen out the ends of the piece which could have been roughened with a saw during the initial cutting process. Just like the turning tool, before facing, the tool has to be set perpendicularly to the piece, however, in this case, the piece should not to the side of the piece, but rather slightly in front of it, in that when the machine is started, the tool is going to only be moved inwards until the center of the piece is reached, however, in doing so, a small amount of material would still be remaining on the middle of the piece, removing it could simply be done by putting moving the piece upwards towards the middle and moving the tool ahead until the entirety of the surface is flat. From there, the tool is going to be pulled backwards, and in the process, it is going to remove a small amount of material from the surface, providing a smooth surface finish as shown by (Toms Techniques, 2013).



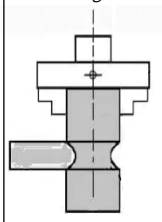
Shape forming

Chamfering tool



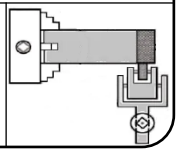
The stated turning and facing processes are simply preparation stages in which the piece of material available if given the required shape. After which, the shape forming stage starts, which is when the overall shape and required design is going to be made. This stage could use a variety of different tools depending on the final chosen design, the main tools that might be utilized are the following: Chamfering tool in order to produce a smooth downwards angle which would assist in making the handle's grip feel more comfortable, the turning tool to make certain areas of the screwdriver smaller than others, , or forming tools, which are tools that are formed to the exact shape that is required to made, which assist in creating specific designs and shape that are required for the handle, however, due to the fact that these tools are made for specific intents and designs, and considering the expenditures needed to tailor make one, we are heavily restricted depending on the forming tools available at the institution.

Forming tool



Grip design

The grip design stage of the handle manufacturing process is where the main aesthetic features are going to be added to the handle. This procedure will utilize the knurling tool, a tool designed to provide a diamond-like grid design onto the surface of the piece for the purpose of enhancing the aesthetic appeal as well as providing a better grip, since if the handle of a tool that required being firmly held were to be entirely smooth, it would be easier for it to slip from the user's hand, while a diamond-like design like the one provided by the knurling tool assist in ensuring that would not occur even if user's palms were to be sweaty.



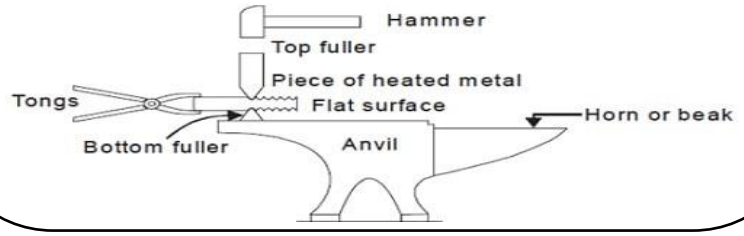
Screwdriver head production

Turning and facing

The piece of material that would be initially provided for the screwdriver's head might not have the required dimensions relative to the size of the handle, as such, it would also have to be reshaped using the center lathe with both the facing and turning tools. The same process that was utilized when turning and facing the handle would also be done here, as such – to avoid repetition – the process would not be explained again. However, it should be noted that during the turning process, the diameter of the head's end which would be touching the handle would be around 50% of the handle's size.

Forging

The forging process is when a material is consistently hit with a heated solid object, thus flattening the surface of the material which is being hit making it thinner, which consequently also makes it become wider and longer due to the material that initially made up the thickness being spread out, thus increasing the piece's other dimensions. This process is going to be done to the end of the screwdriver head in order to make it thin enough to be used for a slotted screw. From an industrial standpoint, this process is done using a machine that raises a solid block of material upwards and downwards in a rapid manner, under which, the piece to be worked is placed. However, due to technical restrictions, the forging process is going to be done manually, which involves placing the piece onto a hard surface which in our case would be an anvil, and from there, the surface that required flattening is going to be heated with a blowtorch in order to heat the material, which consequently makes it more malleable, from there, is going to be hit using a hammer wielded by the team member responsible for the forging process until the required shape and approximately achieving the correct dimensions for a slotted screw.



Dimensions adjustment

During the forging process, it would of extreme difficulty to ensure that the flat side of the head is exactly to size relative to standard slotted-hole screw/s dimensions due to the inconsistency that could occur when hitting the material from aspects such a difference in the force being applied for each hit and consistency in the hammer hitting the center of the area to be flattened. As such, after the forging process has concluded, a stage in which the size of the flattened surface is going to be adjusted with the use of grinder while constantly measuring the current size of the head as to ensure that it meets – or at least be relatively close to – the standard slotted screw dimension requirements.

Joining

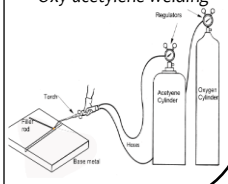
Joining process

The main joining methods that could be utilized at the institution's workshop are threading with the use of a tap and die kit to carve the surface of the material to create a thread pattern or by using oxy-acetylene welding, a form of welding that utilizes a mixture of oxygen and acetylene, creating an easily combustible mixture that can reach temperature of up to 3200°C as mentioned by (TWI, 2022). However, out of two, the one that is going to be used is to simply create a thread on both the handle and head and then join them together, which is the case since utilizing welding could lead to further aesthetic issues which would have to be removed during the finishing process, consequently increasing time consumption, and potentially even requiring further expenditures. Additionally, using a welding process would create a permanent join, meaning the user would not be able to switch the head if they ever wished to do so, which is an option that would be available to them if threading were to be joining method of choice.

When it comes to the head, to create the required external thread, a tap and die would also be utilized, however, in this case, it only the die would be used, as the area of the head that required the thread would be placed in the die, and from there, the die would be twisted to carve the thread in. From there, the center lathe would again be used to drill a hole through the center of the handle using a center drill, from there, the drilled hole would be lubricated, and an appropriately sized tap would be inserted into a die and rotated while being placed within the drilled hole to create an internal thread. After which, both the head and handle would simply be joined together using the created external and internal threads.

Tap and die kit

Oxy-acetylene welding



Finishing

Available finishing processes

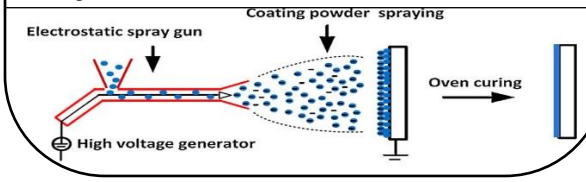
The available finishing techniques and processes available within the institution are – at the time being – powder coating and sanding, with sanding being available as both manual sanding as well as machine sanding with the use of a belt sander.

Polishing

The sanding process involves using a cloth with a gritted/rough surface known as emery cloth, which is utilized by rubbing it onto the surface of the product in order to smoothen out the surface as by removing small deformations and inconsistencies along the surface, making the surface even. However, an important point that should be kept in mind is the roughness of the emery cloth which is being utilized, in that if very rough emery cloth were to be used when the surface is already relatively smooth, the emery cloth would not assist in smoothening out the surface but rather have the opposite effect as it would deform the surface and cause it to be rough, in addition, if emery cloth with a light grit were to be used on a rough surface – although it would not damage it – it would have no perceivable effect on the quality of the surface, meaning it would simply lead to wasting time, as such, the adequate grit should be chosen before starting the sanding process and then slowly go down the grit level as the surface becomes smoother to ensure that the grit level being used is always adequate for how smooth the surface is. In terms of the methods that sanding could be done in, it could either be done by hand or with the use of a sand machine which turns a roll of emery cloth at relatively high speeds while the user places the piece onto the rotating emery cloth. A belt sander is available at the institution, and therefore if sanding were to be used, it would be the machine utilized as it would be much faster process in comparison to manually sanding the surface of the product.

Powder coating

Powder coating is a dry painting technique used instead of conventional painting processes of simply applying liquid paint onto the material. The powder coating process is done by acquiring pigment but in powder form. After which, said pigment is placed within a barrel and then loaded onto a specialized powder coating gun. The gun is then connected to an air compressor which bursts air through the gun whenever the trigger is pulled. From there, the powder within the barrel is pushed through the gun and before exiting through the barrel/nozzle, the powder moves through a an electromagnetic coil, and in doing so it becomes positively charged, as such, the powder is attracted to the nearest negatively charted object, and due to that, the piece being worked is grounded using a wire to make it negatively charged, consequently causing the charged pigment to stick to it and coat it. From there, the piece is placed within an oven at a temperature above that of the paint's melting point which is generally around 160-210°C – according to (HowStuffWorks, 2021) – for 20 minutes in order to let the paint melt appropriately and soak into the piece. As stated by (Reliance Foundry, 2022), this process compared to conventional painting is much superior as it makes the paint resistant to scratching and would not easily wear over time, which is the case due to the curing process that it underwent giving it the stated characteristics, additionally, powder coating can be applied in thicker layers which also assists in making it scratch resistant.



Finishing process of choice

Between the two stated finishing techniques, only sanding would be utilized. That is the case since relative to the requirements of the products, only sanding it necessary as it would be able to make the handle more comfortable to hold and also make the product look aesthetically better, and while powder coating would be able to do that by changing the color of the product to one that might be more appealing, not to mention health risks that come with such a process in terms of VOCs. As well as that, the color of aluminum does not look bad, and for a significant addition in terms of expenditures and time consumption, the advantages that powder coating provides do not seem very important for the overall quality of the product. As such, even though both processes could be utilized, only sanding would be used.

Team allocation and time management

Team members

Mohammed Al-Hosni (myself)	Mohammed Al-Farsi	Omar Al-Ramadani
Strengths: *Has great experience in using Fusion 360 and has some in utilizing the center lathe.* ***Weaknesses:*** *Does not have much experience in terms of practically working with material.*	***Strengths:*** *Is physically strong, has experience with the lathe and working with material.* ***Weaknesses:*** *Can be bad at multitasking and is sometimes inflexible.*	***Strengths:*** *Can work fast if needed and is a great team worker with good communication abilities.* ***Weaknesses:*** *Prone to distractions, has rarely used the lathe and worked with actual material.*

Team leader allocation

R&D	Preparation	Health & Safety	Manufacturing	Joining	Finishing
Al-Hosni: *The only one with good experience in using 3D modeling software, especially Fusion 360.*	***Al-Ramadani:*** *Ramadani is the team leader for preparation since he is familiar with the workshop's tools.*	***Al-Farsi*** *Al-Farsi is in charge of placing any safety precautions as well as checking the risk assessments made.*	***Al-Hosni:*** *I have a great sum of experience using the center lathe and the various tools that we are going to utilize.*	***Al-Ramadani:*** *Al-Ramadani asked to be responsible for the joining process as everyone was already allocated.*	***Al-Farsi:*** *Al-Farsi has great knowledge about grid requirements relative to how smooth the surface is.*

Plan outline

Overall, the plan initially consists of myself researching on the most popular screwdriver on the market and creating a 3D model based on such research in the first session. While doing so, Al-Ramadani would go ahead and prepare the machine and tools required while Al-Farsi adds any further health and safety actions, from there, during the second session, the design of the handle would be completed and the manufacturing process would be initiated with the full team, with myself and Al-Ramadani facing and turning within the same session, while Al-Farsi would be focusing on the forging process and shaping the shaft, after which, the third session would focus on turning the middle and knurling, and the one after it would be for smoothing out the edges and joining the product while also starting to it finish it. Finally, the last session would simply be dedicated to finishing the product.

Time distribution

Activity #	Weeks					
	Week 1 (9/5 & 10/5)			Week 2 (16/5 & 17/5)		
R&D						
Preparation						
Safety check						
Manufacturing						
Joining						
Finishing						

Activity logs and production results

Brief

The following section is going to discuss and show the results that were gotten and the thought process of each section that was went through during the production process while explaining the thought process and events that occurred.

Research and design

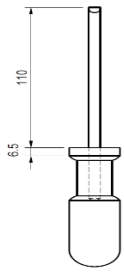
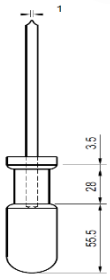
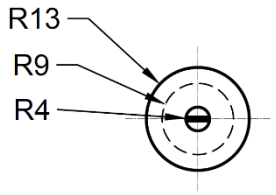
Idea behind the first design

The main idea behind the initial design that was created is to produce a screwdriver that was relatively simplistic and looked comparable to most screwdrivers on the market that are considered to be ergonomic. The butt of the screwdriver is rounded, making it smooth and comfortable grip for the user to hold. From there, the starting section of the screwdriver would be thicker and would be the area that is going to be knurled, that is the case since said section would be the area in which great grip would be needed as the natural way that this specific screwdriver design would be held is with the use of the palms rather than fingers, and due to said section being the one that would be the one covered the most by the user's palms, it was the one knurled. When it comes to the thinner section of the design, it both starts and ends with a chamfer, which is very helpful as it assists in making the design much more comfortable and safer in terms of not having sharp edges, it would also allow for comfortable thumb placement, in that the user's thumb would slide gradually from and out of the thinner section, providing a comfortable place for the thumb to sit in, this additionally helps in improving the grip as it means that the thumb would have an area to push on, however, this section of the design was not knurled as it focuses more on comfort rather than grip, and knurling could make it slightly uncomfortable.

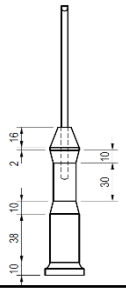
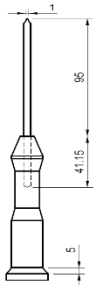
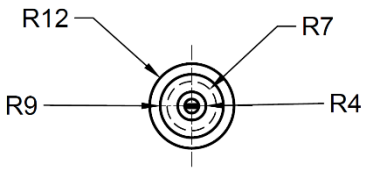
Idea behind the second design

The main idea behind the second modelled design is to create a product that looked unique compared to screwdrivers that are popular on the market, with uniqueness not being the only selling point, but rather the design also functions comfortably and ergonomically. The main function of the design is for the user to be able to comfortably hold the screwdriver either by holding it using their palm or by twisting the screwdriver using their fingers. This function is achieved by the screwdriver's butt, which was designed to be a knurled flat area in which the user could easily twist the screwdriver with using their fingers. While on the other hand, if the user wanted to hold the screwdriver using their palms, they could do so by holding the area right after the discussed flat section of the handle, from there, the screwdriver's designs is relatively simple, with the start being thicker and then for it to chamfer down into a knurled thinner section, which would assist in providing a more comfortable place for the user's thumb to sit in. Unlike the initial design, the knurling here is on the thinner section, which was done as due to the shape of the design making the main area to grip being the thinner section. Additionally, the design's slanted section and curved edges assists in making the design safer due to not having sharp edges. Overall, the design is relatively longer and thinner compared to the many screwdrivers on the market.

First design

Front	Side	Top
		

Second design

Front	Side	Top
		

Design of choice

Between the two designs, the one that was unanimously chosen by the entire team was the first design, justification to which being the fact that it is easier to manufacture relative to the given tools and available time, in addition, although the second design is agronomic and functions well, it was deemed by the team to have poor aesthetic qualities in comparison to that of the initial design. As well as that, it was deduced that if the user wanted to hold the screwdriver using their palm, although it is functional, it might not be very functional. As such, due to the second design going somewhat against both the aesthetic appeal and handle comfort product requirements, the first design was chosen as it did not have any significant issues overall compared to the second design.

As such, design one was then 3D printed as a way of getting a better feel for the grip, and in doing so, it was deemed that the design was both comfortable and had a decent grip, therefore it did not require any further improvements.

Preparation

Lathe tools

Facing & Turning

Used to smoothen the face of the piece and decrease its diameter. Only one tool is available for both jobs.

Rounding tool

This is a special forming found at the institution that is utilized for creating external radiuses and curves.

Chamfering tool

This tool would be utilized in creating angles known as chamfers on any edge seen in the design to make the edge smooth.

Parting tool

The parting tool would be used at the end as to trim off the unnecessary material which was to hold the piece in the chuck.

Knurling tool

The knurling tool would be used to provide a diamond-like grid on the surface to improve aesthetics and grip.

Chuck key

The tool is used to tighten the chuck and make sure the piece would be stable as the chuck rotates.

Cutting tool key

This tool is utilized in order to tighten the cutting tool to make sure it does not go off-center

Centering tool

This tool is placed in a hole at the center of the piece as to stabilize it and prevent it from vibrating.

Center drill

The center drill tool can would be used to drill a hole in the center of the piece to stabilize it for the center tool.

Measuring tools

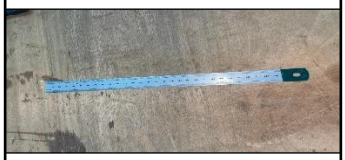
Caliper

The caliper would be used to measure diameter and hole depths

Marker

The marker is utilized to indicate the stopping point during cutting.

Steel rule



It will be used to measure and mark the sections required to be turned.

Forging preparation

Anvil

Used as the flat surface that the head would be placed on. Preparation should include checking if the surface is even.

Ball peen hammer

Used to hit and form the head. When getting the tool, the person should check for any flaws on the hammer's head

Grinder

Would be used after the head has been forged to adjust the head's slot dimensions.

Welder

Would be used to heat up the head, making it malleable. When preparing, It should be ensured that the valve is clean.

Additional preparation

Machine preparation

Although the lathe, belt sander, and grinder require prior preparation before use, we would not have to worry about that since the institution's technician would take care of it as we're not equipped nor knowledgeable enough about the machines – especially the lathe – in order to fully prepare them ourselves.

Emery paper preparation

The emery cloth grit that would be initially used during the finishing process would be around 120 since the machined finish is not extremely bad to the point that it required a vert rough grit. From there, the grit level would gradually increase until the finish is deemed to be good enough.

Material preparation

As stated earlier, the material provided would be given from the institution and it would be an aluminum alloy. Two pieces of material were given, one for the handle while the other is for the head, with the original handle material being 30*130 *and the head's being* 8*140*. However, the specific alloy that was given is unknown, which is the case since the material was purchased a long time ago, and the merchant's invoice has been lost since them, what this means for our process is that we would not be able to accurately determine the surface feet per minute that would be required for the RPM calculations, and therefore the one that would have to be utilized for the RPM would be an estimated speed. According to our supervisor, said speed would be approximately around 450 to 550 RPM, as such, said speed was utilized and no major issues were detected upon using it.*

Head	***Handle***
	

Health and safety

Personal Protective Equipment

Coveralls

The main attire that is going to be worn during any practical work that is going to be done within the workshop would be wearing overalls. That is the case since the design of overalls is able to cover the majority of the body excluding the face, and even though they are not necessarily thick, they nonetheless would add a layer of protection to the body from any tiny flying objects, additionally, overalls can be used in order to prevent oils and other working fluids from getting in contact with the body. Additionally, the material utilize for coveralls is generally made from non-synthetic fibers, which assists in ensuring that if hot substances or material were to come in contact with them, they would burn rather than melt, in that if they were to melt, the melted substance becomes extremely adhesive and could easily stick to the skin, causing further damage. Finally, it should also be noted that sleeves on coveralls should always be folded up when working with rotating objects as said sleeves could get stuck, resulting in extremely bad injuries depending on the RPM at which the object is rotating at.

Heat resistant gloves

Heat resistant gloves would not be worn the entire time during the production process, rather only during forging, since heat would have to be applied to the material in order to cause to be malleable, heat resistant gloves would be necessary in order to hold heated piece of material.

Safety boots

Safety boots are boots with puncture resistant outsoles and are a general PPE that has to be worn when working in an environment such as a machining workshop due to the likelihood small pieces of material lying on the ground, which – if not seen – could be stepped on and cause damage to the foot.

Safety goggles

Safety goggles are a necessary PPE when utilizing any manufacturing process that has the potential of ejected tiny shards or ejecting swarf. In our circumstance, the stated processes would be working on the center lathe and the forging the shaft of the screwdriver into the required shape.

Risk assessments

Centre lathe			
The hazard and its category	**Who might be harmed and how?**	**Prevention methods**	**Further actions and current control measures**
Loose objects getting stuck in the spindle – Caught in-between machinery	*One of the most hazardous aspects of utilizing a machine such as the centre lathe is for any loose object to get entangled with the spindle as it is rotating. People at risk are the ones that would be working with the lathe. Examples of items that could get stick include long hair, watches, necklaces, long-sleeves, and so on. Overall, the level of risk posed is extremely significant as if said objects were to get stuck, it could easily lead to breaking bones, disability, or even potentially death.*	*The main way of avoiding the stated issue is to never wear wrist or neck accessories while working with the lathe, for anyone with long hair to tie it, and for long-sleeves to be folded. In addition, the user should be never under any circumstance lean towards the machine or physically interact with the chuck until it has ceased rotating entirely. Although it cannot be added in our circumstance, sensors could be added that detect and automatically turn off the machine whenever they sense an object is at a distance that is dangerous.*	***Current measures:*** *Supervisors do not allow students to work if they have loose items on them.* ***Further actions:*** *Print an image reminding people of removing items that could potentially get stuck, tying their hair if it was long, and reminding them of folding their sleeves. (In 1 day by Al-Farsi)*
Closing movements – impact with heavy objects	*A closing movement is one that causes to surfaces to close on each other. An example of a closing movement on the centre lathe would be the tailstock and the headstocks' guard. The reason that closing movements are dangerous is that the operator could easily get their hand stuck, and a consequence of which being that the movement would close, therefore crushing their hand or finger. However, this issue could also occur to anyone that passes by or works in the nearby proximity of the machine.*	*The way injuries from closing movements could be avoided is for the user to try and move them slowly as to give themselves time to move away in the circumstance that their or someone else's hand in stuck. Additionally, the operator should never move closing movement in the circumstance that someone is very close to the movement itself as they could get their hands stuck without realizing they did so, rather, the operator should inform them to back away from the machine prior to moving the mechanism.*	***Current measures:*** *No actions are currently taken to prevent this issue.* ***Further actions:*** *Glue a small rubber pad to the front of the tailstock in order to prevent it from closing all the way in. (In a week by the workshop's manager at the institution)*
Excessive noise from the lathe – Hearing damage	*This issue is most prominent with the machine's operator; however, it nonetheless poses a risk to everyone within the workshop that the machine is placed in. Said noise issue could potentially lead to permanent hearing damage, which is the case since – as mentioned by the (CDCP, 2020) – constantly being exposed to loud noises causes cells found within the ear that are responsible for hearing to be overworked, consequently causing some of them to die and therefore decrease the person's hearing ability*	*A crucial method in decreasing potential hearing loss is to try and work in an open room or have an door leading to the outside open, as this would prevent the noise from echoing back and causing further damage, however, if the stated solution is not feasible, hearing aids such as earmuffs should be utilized when working with the lathe.*	***Current measures:*** *Earmuffs are provided and the workshop has great ventilation to the outside.* ***Further actions:*** *No further actions should be taken, current measures are sufficient.*
Contact with cutting fluids – Hazardous substances	*This issue being of great significance to operator and the person cleaning the machine as they would to most likely be in contact with said fluid, additionally, they could be dangerous to people in proximity to the machine as the cutting fluids could be inhaled. Cutting fluids are made out of fossil fuels, which are dangerous to humans if they get into contacted with the body as they could cause skin irritation, however, they are especially dangerous when swallowed or inhaled in high concentrations and could lead to major respiratory and heart diseases.*	*Avoiding getting in contact with the cutting fuels could be done by wearing gloves when cleaning the lathe in order to ensure they do not get on the operator's hands and then potentially for the operator to touch crucial parts of their face that could lead the cutting fluids into the body. Additionally, the area in which the lathe is located should be well ventilated to ensure that if cutting fluid fumes were to be emitted, their concentration within the workshop would be significantly lower.*	***Current measures:*** *Ventilation within the workshop is good and gloves are provided. Additionally, grease cleaning soap is provided.* ***Further actions:*** *Using gloves when cleaning and using grease removing soap after a working session should be made mandatory. (In a week by the institution's workshop manager)*

The hazard and its category	Who might be harmed and how?	Prevention methods	Further actions and current control measures
Swarf – hazardous substances and impact at high speed	*The main people affected by the stated issues are the ones that are going to clean the machine as they could easily inhale swarf and the machine's operator as they are the ones most vulnerable to being hit by ejected swarf. With that being said, swarf is dangerous for potentially accumulating in large quantities but as a fine dust that could be easily inhaled or swallowed accidentally, which – in the case of aluminium – could lead to significant health risks such as Alzheimer's, Osteoporosis, and kidney failures according to* (Usman, 2022) *. Additionally, swarf could be ejected out of the centre lathe at high velocities while during the machining process, leading to the swarf potentially hitting and injuring the operator.*	*The main way swarf-related issues could be avoided is making sure the person that is going to be cleaning the machine is wearing a face covering their mouth and nose as to avoid potentially inhaling any material. In terms of the operator, they should never look directly at the piece unless they are behind a safety guard, additionally, they should always wear safety goggles or face shields when working with the lathe as the face would be the most sensitive part of the body that would have to be protected from swarf being ejected from the machine.*	***Current measures:*** *A safety guard is available at every lathe within the workshop, safety and gloves are also provided* ***Further actions:*** *Provide a vacuum in order to suck the swarf from the machine rather than manually having to remove it. (In two weeks, person responsible is the institution workshop's manager)*
Lose mounting – impact at high speed	*Due to the spontaneous nature at which a piece would fall from the chuck, this issue could occur while anyone is walking by the machine, and therefore it poses a risk on anyone in the nearby proximity of the lathe. This issue could occur in multiple ways, first of which being the operator not tightening the chuck enough due to wariness of it damaging the piece, them forgetting to push the stabilizing tailstock all the way in, or by holding the component from a very tiny section. All of this could potentially cause for the piece to vibrate during manufacturing, consequently either falling off and being ejected out of the machine as it is rotating at an extremely high velocity or for the piece to fall and hit a rotating mechanism, causing the mechanism to break, potentially leading to other safety hazards.*	*The stated issue could be avoided by placing at least 30% of the tool to be machine in the chuck if it is stabilized, and around 70 or 80% if it is not. Additionally, the tailstock should always be checked whether or not it is fully cantered to ensure that the entire piece is stabilized properly. This way, the piece is going to be held firmly and is not going to be vibrate during the manufacturing process, consequently making it safe to cut without the potential of it becoming loose during machining as long as the chuck has been tightened sufficiently.*	***Current measures:*** *A safety guard is available for every lathe within the workshop.* ***Further actions:*** *Print a sheet reminding operators to keep 80% of the piece inside the chuck if the centre tool is not used. (In 1 day by Al-Farsi)*

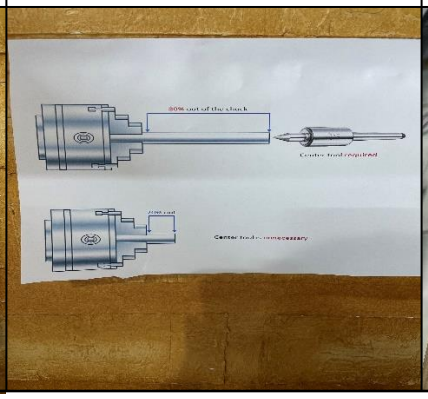
Hand forging			
The hazard and its category	**Who might be harmed and how?**	**Prevention methods**	**Further actions and current control measures**
Working with hot material – fires and burns	*The stated hazard is most prominent with the forger, in that as stated earlier, before initiating the forging process, the material would have to be heated in order to make the material malleable. However, from there, the material would have to be handled carefully, since if not, it could potentially cause third degree burns if it were to get in contact with the skin. Additionally, if the material were to be placed on a surface or an object with a low enough flash point, said object would catch on fire, creating a much greater hazard especially in an workshop environment.*	*To avoid getting in contact with the material, the forger should wear gloves and when physically interacting with the material while it is hot, overall sleeves should be down as to make sure that that the metal does not come into direct contact with the skin. Additionally, if possible, the overalls worn should not be made out of synthetic fibres as they could melt at high enough temperature, meaning if the heated metal were to cause a section of the overalls, this would the melted material at extremely high temperature to stick to the skin.*	***Current measures:*** *Gloves are available at the workshop and the overalls provided are made of natural fibres* ***Further actions:*** *No further actions are required.*

The hazard and its category	Who might be harmed and how?	Prevention methods	Further actions and current control measures
Excessive noise – Hearing damage	*Just like with the center lathe, the forging process of consistently hitting an anvil produced a loud noise, this is a major problem that the forger is mainly affected by as the distance between the forger's ears. However, unlike the noise issue discussed about the lathe, only the forger would be affected since the noise emitted would not be loud enough to effect other people within the workshop.*	*A solution to the stated issue is to wear earmuffs during the forging process. Additionally, as stated earlier, if possible, a method of preventing hearing loss due to loud noises is to try and work in an open area as to prevent noise from echoing back into the forger's ears.*	***Current measures:*** *Earmuffs are provided within the workshop and the area the anvil is within is sufficiently ventilated to prevent echoing* ***Further actions:*** *No further actions are required.*
Broken hammer head – impact at high speed	*The main people at risk due to the stated hazard are the forger and anyone at near proximity, since if the forger were to use a flawed hammer with a hammer head that is not fitted properly or became loose due to long-term usage, the potential of the hammer head flying off and hitting the forger or anyone nearby is high, with said impact being extremely dangerous due to the fact that when the forger would swing the hammer they would put a lot of force into it, and therefore the momentum that would carry carried through would cause the head to be thrown at high speeds. In addition, a flawed hammer head could chip easily, and therefore creating swarf which could hit the forger and causing an injury.*	*Although there is not a way of preventing hammers wearing down than trying to maintain the ones available as best as possible, however, working with broken hammers is preventable by checking for any possible prior chips on the hammer and to also check how tight the hammer is on the handle, and if it were to be lose, it should be tightened using an adhesive or rethreading it depending on the initial joining method.*	***Current measures:*** *No measures are currently taken to prevent the issue.* ***Further actions:*** *Technicians should regularly check and maintain the hand tools within the workshop.* *(No specific time scale, done by the workshop's technicians)*

Belt sander			
The hazard and its category	**Who might be harmed and how?**	**Prevention methods**	**Further actions and current control measures**
Loose objects getting stuck in the spindle – Caught in-between machinery	*The shown issue is most relevant to the operator as they are the only one with potential of getting in contact with the rotating mechanism. Similar to the spindle issue discussed on the lathe's risk assessment, the same could be applied here due to the rotating wheel which spins the emery cloth, in that if the any loose objects, pieces of clothing, or accessories were to get stuck while it is rotating, it could pull the operator.*	*A way to get by this issue is to simply tie or restrict any loose objects from moving such as long hair or sleeves. Additionally, any wrist or neck accessories should be removed make sure they do not get pulled in by the machine as it is spinning.*	***Current measures:*** *Supervisors do not allow students to work if they have loose items on them.* ***Further actions:*** *Print an image reminding people of removing items that could get stuck, tying their hair if it was long, and folding their sleeves.* *(In 1 day by Al-Farsi)*
Material inhalation – hazardous substances	*The person that is most affected by this issue is the operator, since the amount of material is not sufficient in enough to the point that it could affect other people working nearby unless they are in really close proximity. This issue occurs due to the friction that is placed upon the surface of the material when polishing causing a slight amount of material from the surface to be removed, creating a very fine dust that can be easily inhaled. As stated earlier, inhaling aluminium has significant life-threatening medical issues*	*The main solution to the dust emission is to simply try and work in a ventilated area as to decrease the chance of inhaling it since the chance of it staying within the operator's vicinity would be less likely. Additionally, wearing a basic face mask should also assist in preventing dust from directly entering the operator's mouth or nose.*	***Current measures:*** *The area in which the belt sander is placed is relatively ventilated* ***Further actions:*** *Face masks should be provided within the workshop* *(In 1 day by Al-Farsi)*

The hazard and its category	Who might be harmed and how?	Prevention methods	Further actions and current control measures
Static electricity – electrical shock	*The main person that could be harmed by the stated hazard is the operator themselves as they are the ones that would touch the screwdriver as static electricity is being discharged, which is the case since to the amount of friction acting upon the surface of the material from the polishing process could cause static electricity to be generated, which is electricity that contains itself on the surface of an object that occurs due to friction causing electrons to leave one objects and going to another, which in this case is the emery cloth to the screwdriver. Although the amount of static electricity is not significant enough to cause serious damage, it could potentially cause a painful shock to anyone that might touch the material after it has been finished.*	*Due to the polishing process fundamentally involving friction, there is no real way of avoiding static electricity from being generated on the surface of the product, however, in order to avoid getting shocked, the operator should initially touch another conductive object before touching the section of the screwdriver that was just sanded, this way, the static electricity from the finished section would be transfer to the other conductor through their body, and in doing so, the electricity would not be concentrated on one area, in that if they were to just simply touch the finished section immediately, the entire voltage from the static electricity on the surface would transfer to their hand, and therefore cause a painful shock.*	***Current measures:*** *Students working within he workshop have been educated on static electricity and how it could occur.* ***Further actions:*** *No further actions are required to be taken.*

Machine setup	
Machine RPM	***Chuk and safety guards down***
	

Further actions evidence		
Loose clothing warning	***Piece insertion percentage reminder***	***Face masks***
		

Identification of general hazards

Uncovered power cords

A potential hazard that could be found within workshops is uncovered power cords connected to either the machines or other power supplies throughout the workshop. The stated hazard could affect anyone within the workshop as uncovered power cords could be easily damaged by any tools throughout the workshops, potentially leading to a major electrical shock hazard if anyone were to touch the cord accidentally or a fire risk that could occur due to the heat generated if a conductive material were to touch the cord. As such, machines near uncovered power cords should not be utilized and said cords should immediately be reported to a supervisor.

Unclean workspace

An area such as a workshop could easily become cluttered which can lead to many safety risks and hazards, some of which being potential of tripping on objects and falling over, stepping on sharp objects that might have been placed in a spot they were not supposed to be in, or slipping on wet floors due to lack of general cleaning of the workspace. Overall, the working area should at all times be kept relatively clean by simply moving all objects to their known locations after being used and always cleaning the working and removing potential grease and dust from the machine after the working session has concluded.

Hand tool hazards

Although hand tools are not as dangerous and do not carry hefty risks in comparison to machines or power tools, safety should nonetheless be a major concern when using them. The main areas of safety that should be considered when using hand tools is making sure that the hand tools is broken as it could to pieces breaking and being ejected, and finally, hand tools should never be utilized while applying full force as although it could be convenient as it would assist in speeding up the process, it could also lead to accidental cuts or blunt hits when using tools such as files, saws, or hammers.

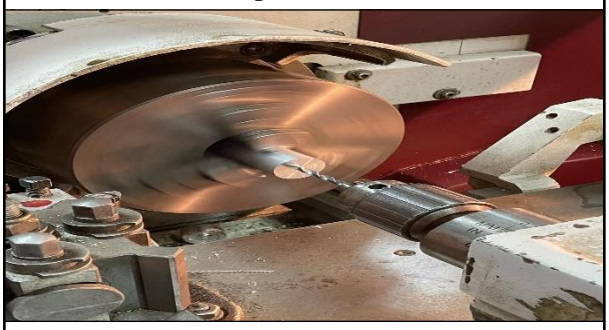
Manufacturing

Handle machining

1. Facing

As stated earlier, the process initiating the machining section is facing. At first, around 100 of the 130mm of the handle's length was placed and tightened within the chuck in order to for the handle to be held firmly as the centering hole for the center tool was not drilled yet. From there, the tool was checked and deemed to be centered and was then placed right next to the handle's face and moved backwards. Following that, the spindle was turned on at 450RPM, and the facing tool was manually and slowly moved forwards, although it was quickly noticed that circle marking were being cut into the face of the handle, as such, after the initial facing turn was over, the tool was replaced, and the handle was faced again, however, the same marks remained nonetheless. However, said markings were not deep and could be removed during finishing, as such, the manufacturing process was moved along to not waste further time.

2. Drilling the center hole

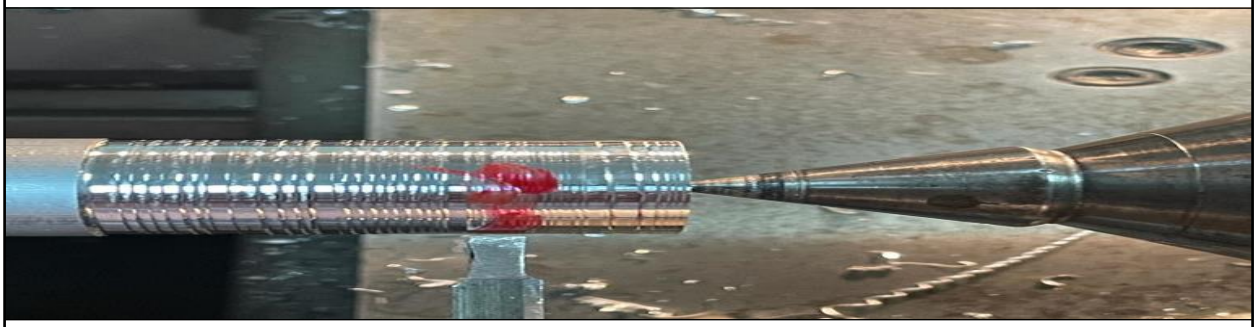


After the facing process has concluded, the second process that was immediately done was drilling in a hole that would be small enough for the center tool to fit in, with the drilling process simply being done using the center drill of the lathe which was pushed in towards the handle using the tailstock, although a specific tool is available for making the center tool's hole, simply the center drill was utilized as it provides the same function. This procedure was done as a preparation for the tuning process, which would require having a significant amount of the handle sticking out of the chuck, and therefore making it unstable to work with unless the center tool was applying horizontal force to the handle as a way of preventing it from vibrating and moving while it is rotating, therefore preventing it from falling out of the chuck and potentially hurting somebody in the circumstance that it is ejected at a relatively high speed.

3. *General turning*

The turning process initially started with inserting the center tool onto the recently drilled hole, from there, the turning tool itself was moved inwards until it was touching the handle and then moved to the side. From there, the tool was moved 1mm inwards as to decrease that amount from the diameter of the handle even though the amount that required being cut was 4mm in order to achieve the necessary 26mm diameter, however, cutting 4mm at once would have led to an extremely bad finish that would have probably been unfixable using sanding only, as such, 1mm was done at a time for four different cycles until the required diameter was achieved. It should also be noted that the turning process was done automatically via the automatic movement available on the lathe that was being utilized, which helped in maintaining consistency throughout the entire handle.

4. *Parting the middle*

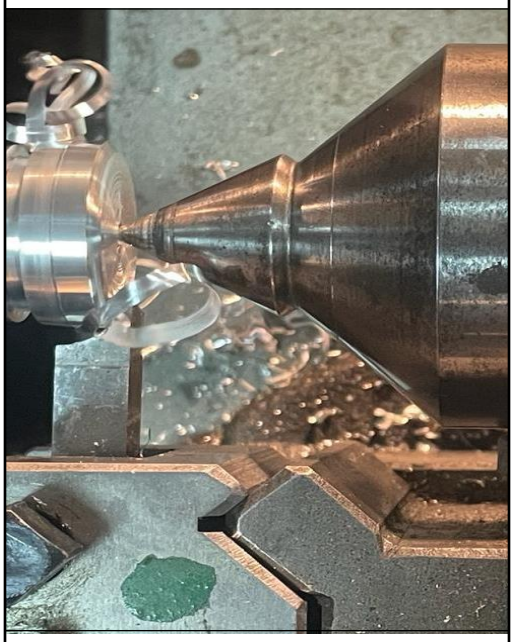


The way that turning the middle section of the screwdriver was meant to be done was by initially parting one end of the thinner section and then turning it as to make the turning process easier due to having an already thinner section to move the turning tool inwards in as to measure the diameter to be cut. As such, to do this, the first that had to be done was marking the location that would be parted by measuring 28mm from the right of the handle. After that, the parting tooled was placed in and simply moved inwards towards area to be cut for it remove 6mm as to leave 20mm on the thinner section. However, it should be stated that the parting process was not done in one cycle, but rather around 3 or 4 since the tool kept getting stuck due to the trimmed material left on the surface of the parting tool.

5. *Turning the thinner section*

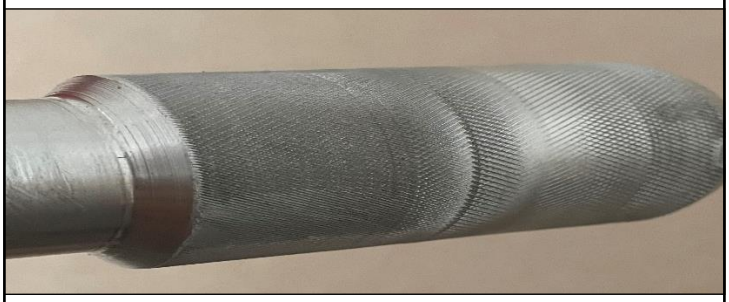
After the start of the thinner section has been parted, the turning tool was once again utilized in order to trim down the remaining area of the thinner section. Just like with the initial turning process, the tool was moved inwards until it touched the handle, move sideways until it was over the parted section, and finally moved inwards 1mm, and then the lathe was turned on the automatic vertical movement was turned on. This was done over 6 cycles, 1mm each, as to get the thinner section to an even 20mm. However, an issue that was encountered during the turning process was that the turning tool being utilized was relatively thick, therefore the body of the tool kept constantly shaving off a small amount of material from the area to the side of the parted section, which caused a somewhat of a chamfer-like form on the handle, however, the intention for that section was for it to be chamfered either way as such the problem was not given a lot of concern.

6. *Rounding the edges*



As shown in the design, the edges where the thinner section starts, and ends have been chamfered to ensure both safety and comfort. As stated earlier, a chamfer like shape was formed at the end of the thinner section due to the turning tool being relatively thick, therefore, it caused a slight issue in that the chamfer that would have to be made would be slightly bigger than expected due to the fact that a bigger section would have to be chamfered in order to cover the one caused by the turning tool. As such, from there, the chamfering tool was simply placed in, aligned, and pushed inwards, which was done for the start of the thinner section, however, the chamfering tool that then had to be flipped so that it is left-handed as that is what would be required for the end of the thinner section, as such, the tool was disassembled, flipped, and assembled again. Finally, after that, the same stated process for the start of the thinner section was followed. After which, a small forming tool that was utilized for rounding creating fillets was utilized in order to create the small fillet that can be seen at the front of the handle, and just like the chamfering tool, it was simply aligned, placing in, and moved inwards until the radius of the curve that was formed was deemed to be sufficient, however, it should be noted that due to the size of the rounding tool being relatively big for the size angle of the chamfer required, the overall radius did turn out to be bigger than what can be seen from the design, however, it was deemed by the team that this did actually look better than what was initially intended to be done.

7. *Knurling*

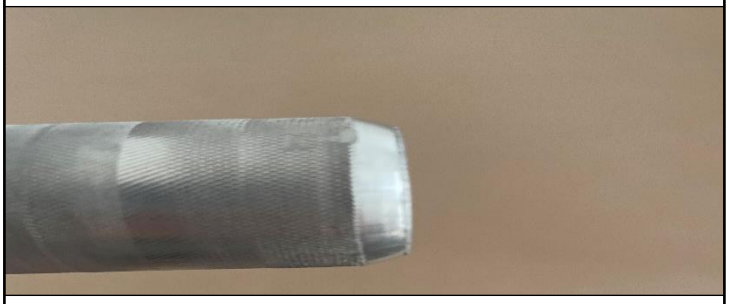


After the smoothing section of the machining process has concluded, the knurling process is the only thing remaining before the section the area held at the area held within the chuck has to be parted off. As such, the area to be knurled is marked using a marker and a ruler, and from there, the knurling tool is aligned with start of said area, and then moved inward while the chuck rotating, as the knurling tool touches the handle, additional force is then slightly placed onto it, and from there, the automatic movement is turned on until the tool reaches the end of the marked area.

8. *Parting the extra material*

After the handle has been knurled, the only thing remaining being the butt of the screwdriver, but before starting to round it, the part that was held within he chuck from the start of the machining processes has to initially be parted off. This was a relatively simple and fast process that involved flipping t he screwdriver and placing around 100m of its 130 within the chuck, and the just aligning the parting tool with the additional area, turning on the machine, and moving said tool inwards until it fell off.

9. *Rounding the start of the handle*



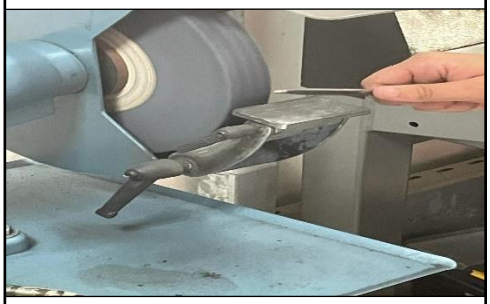
By this point, the screwdriver is technically useable, however, one additional feature has to be added before the overall shape can be considered finished, which is rounding off the butt of the screwdriver, which was done a bigger forming rounding tool. Just like the smaller rounding tool used for the front of the handle, utilizing the bigger one involved initially aligning the tool with the area to be rounded, and then simply moving it inwards as the handle rotates.

Shaft forging

1. Forging

At the same time during the machining process of the handle, Al-Farsi has started working on the hammer, with the initial process being forging in order to get the general shape. As such, Al-Farsi initially heated the material as to make to softer and more malleable, from there, it was placed on the anvil available and the forging process started and after a number of hits on the material, the overall shape was formed, however, it was slightly bent, as such, Al-Farsi went to hit the material again, however, in doing so, the front of the shaft broke off, which was the case due to the material becoming relatively cold in comparison to how it was right after it was heated. However, although the damage was relatively significant, it was fixable, and in order to avoid wasting time in making another one, the process was moved along to the grinding process.

2. Shape adjustment

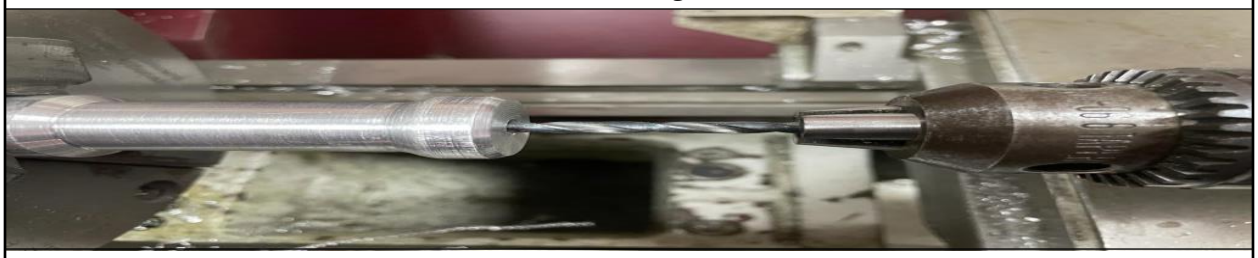


After the stated incident during the forging process, Al-Farsi started the grinding process, and while doing so, ensured that all sides are grinded evenly as to produce an even final shape. Overall, the process was relatively short and took around 15 mins, and after concluding, the final shape was as expected, and although the overall length was slightly shorter due to the end of the shaft breaking, it would not be noticeable as long as the length of the thread for the handle is shortened accordingly as to ensure that the part of the shaft sticking out of the handle remains the same.

Joining

Handle

1. Drilling



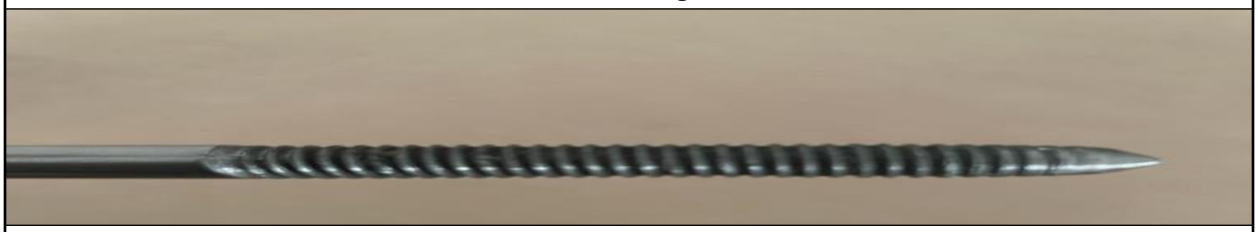
Before the threading process initiated, a hole had to initially be drilled through the center of the handle where the hole utilize for the center tool was originally located, which is the hole that would be internally threaded in order to fit the screwdriver's head in. This process was simply done by utilizing the same drilling tool as earlier, however, this time just simply going deeper until the depth of the hole is 41mm as shown in the 2D design drawings. Admittedly, this process could have been done during the initial drilling process, however, it was simply forgotten about.

2. Threading

After the drilling process has concluded, a thread that would fit the 8mm hole that was made was placed within a die. From there, a lubricant was placed on the thread in order to make the threatening process smoother by decreasing friction going against the turning rotation during the threading. After which, the thread was placed within the hole, and a manual rotating motion was done, with it going 360° clockwise and then 180° anticlockwise, which was done in order to clear any of the swarf produced by the threading process which hindered the process as was getting stuck on the thread.

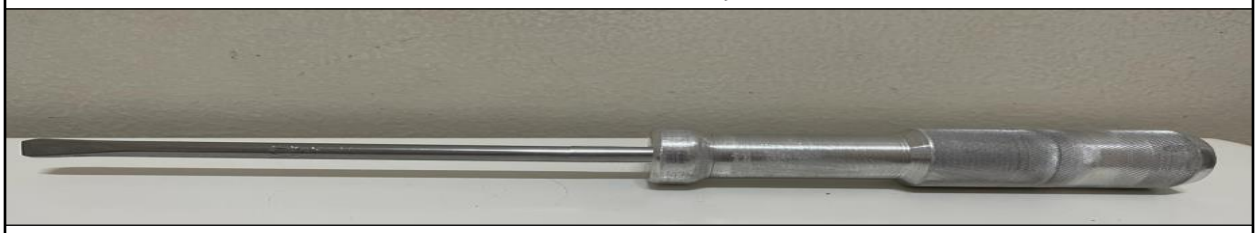
Shaft

Threading



While the handle was being drilled and threaded, at the same time, Al-Ramadani was threading the screwdriver's shaft. This was done initially placing the same lubricant used for threading the hole onto the end of the screwdriver's head, from there, the head was inserted into the die, and same rotating motion that was stated was done here, while this additionally pushing inwards towards the middle of the shaft in order to increase the length of the external thread.

Product assembly

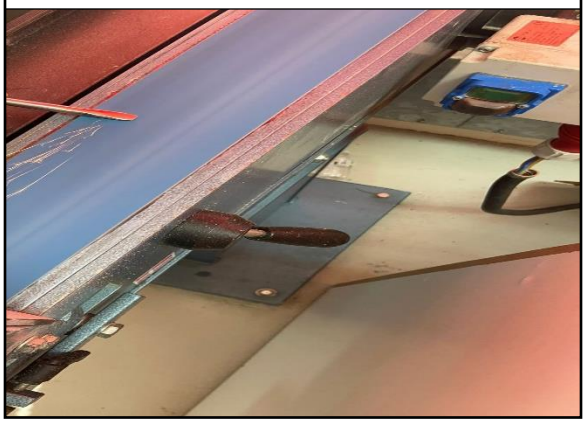


After both the external thread of the shaft and internal thread of the handle were made, both pieces of the production were simply assembled using the created threads, resulting in the final functional product, with the only thing remaining being aesthetic-related improvements which are going to be added throughout the finishing process.

Finishing

Sanding

The finishing process was relatively basic and did not involve anything other than simply sanding the product using the belt sander for until the final finish was deemed to be suitable. However, around the end of the finishing process, manually sanding the product had to be done since the sheet of emery cloth available was not long enough to fit the belt sander properly.



The finished product

Batch production

Note

Due to the limitation posed upon us related to the overall time provided, it would be impossible to produce a quantity of screwdrivers that reaches or exceeds three within the 2 weeks that are given, especially when considering the time given for each session is only 50 minutes. As such, the production process would simply be for a one-off product. However, it should nonetheless be noted, that if the time period given were to be longer, it would take around a week in order to produce 2 more screwdriver as the team would already have gotten accustomed to the production process and designing the product would not have to be repeated, as well as that, any issues or difficulties faced during the initial production process would be known and avoided, resulting in a faster production rate.

Quality check

Overall dimensions

When it comes to the handle's dimensions, all of them are exactly the same for the exception of the thinner section's overall length, in that the one in the design is given at 28mm, while the one actually machine is around 33mm. Although it was not realized initially, the reason to which is most likely due to the improper marking of the section to be parted, which led to the overall length of the handle being longer, and therefore when marking, it was simply missed as the areas that were marked were the thicker sections of the design. Additionally, when it comes to the handle's thinner and thicker sections diameter, they were both the same as that which was given in the design. In terms of the shaft, as stated earlier, the tip of it broke due to it being hit while it was cooling down, nonetheless, its overall length is at 145mm, while the one shown in the design is 150mm, with 110mm of it sticking outside of the handle, however, as stated, the length of the thread was adjusted accordingly to ensure that 110mm was still outside of the handle, in that the instead of having the thread's length 40mm, it was 35mm, while the tip of the shaft was also relatively sufficient for standard slot screws. Altogether, the dimensional accuracy that was produced was almost perfect with the exception of a 5mm difference in the thinner section's length, however, overall, it can be stated the product passes the quality check.

Product shape

Overall, product's shape is relatively consistent to that of the design when it comes to the ratio between the smaller and thicker section and the chamfer points. However, the major differences that can be deduced lie in the rounded edges. The rounded edge at the end of the handle takes up a bigger length compared to what is seen in the design, which – as stated earlier – is the case due to the forming tool available being much bigger than what was needed, however, as mentioned, the team thought it overall provided a better look to the design. The other rounded edge, which is at the butt of the handle has a straight face while in the design it was intended for the entire butt to be rounded, just like the front of the handle, this was the result of the rounding tool that was utilized as it simply did not allow us to create a fully rounded edge. Although the overall shape does look relatively the same, the straight face at the butt of the handle would cause major issues to consumer expecting an exact replica of the shown design, as such, it cannot be stated that the product fully meets the required criteria in terms of following the design.

Handle comfort

Overall, it was deemed by the team that overall comfort of the grip is great, with the chamfered ends seen in the thinner section playing a major role in such regard. Additionally, the knurling placed on the handle's thicker section did not cause any major inconveniences of annoyances to anyone that held that handle. Moreover, although butt of the screwdriver did not meet the exact shape, the rounded edge nevertheless provided the same functionality, as no issues were found there either in terms of the handle's comfort. Overall, it can be deemed that the product passes the quality check in regard to the handle's overall comfort.

Handle grip

Due to the addition of the knurled section, the handle's overall grip can be deemed to be more than sufficient, which was deduced by testing if the handle would slip when a team member's hand was sweaty, and they stated that they were able to hold the handle firmly without any issues. As such, it can be declared that the product passes the quality check for being able to provide a good grip.

Aesthetic appeal

As stated during the design section, the overall design that was chosen is relatively simplistic and comparable to some of the other products out on the market, however, although the product's shape does not match the one exactly from the design, the difference has not caused a significant damage in terms of the product's overall aesthetic appeal, and overall, it is deemed by the team to look relatively good for it to pass the quality check. However, it should be noted that in comparison to other screwdrivers on the market, they most likely do look notably better, which is the case due to the technical limitation posed upon us during the manufacturing process such as the lack of tool and only being able to form cylindrical shapes due to the utilization of the center lathe as it is the main machine available.

Product sturdiness and assembly	
Due to the material utilized being metal, it was to be expected that the overall sturdiness of the product would also turn out to be great. This additionally includes the assembly of the product, as it was strong and not easily removable unless with the use of a bench vice to hold the handle in place. Overall, it can be deemed that the product's sturdiness and overall stability is of great quality and can pass the quality check.	

Logs

Sessions logs

Note
The following session's logbook would not go into major detail as to what exactly happened during each session but rather simply state what everyone's role was during each session since the details were explained during the activity logs section.

Week 1

Session 1 (9/5)	Session 2 (9/5)	Session 3 (10/5)
Al-Hosni: *Research on popular screwdrivers was started as well at the beginning by searching on popular online sellers such as amazon and checking reviews on known screwdriver brands. This process was relatively short, since I was able to work and finish the first design and somewhat started on the second one.*	***Al-Hosni:*** *During the start of the second session, I immediately started at the computer lab working on the second design until I got it done, from there, we all went to the workshop, and I started working on the lathe and was able to get both of the initial facing and turning processes done.*	***Al-Hosni:*** *I went into session three simply focusing on parting and turning the middle of the screwdriver do and then trying to get whatever task next done, however, unexpectedly, this process took a relatively long time to get done as it took the entirety of the session.*
Al-Farsi: *Al-Farsi added the additional health and safety precautions, inspected the machine that we were going to use, and assisted me in researching and modeling the design by providing feedback based on his personal thoughts.*	***Al-Farsi:*** *Al-Farsi started working on the screwdriver's shaft, he first had to wait for the technicians to setup the welder, after that, he started forging, however, the tip broke as stated earlier but he managed to start a bit of the grinding process but not quite yet finish.*	***Al-Farsi:*** *Al-Farsi kept working on the adjusting the shaft's shape, which he was able to get done relatively quickly, as he was also able to finish the shaft and good a relatively good finish on it. After that, at the end of the session, he simply assisted me in turning the thinner section of the handle.*
Al-Ramadani: *Al-Ramadani prepared all the equipment that we were going to require for the manufacturing process and when he was done in doing so, he also assisted in both researching and modeling the design in that he provided his own personal thoughts and feedback.*	***Al-Ramadani:*** *During the second session, Al-Ramadani did not have any particular major roles, however, he did assist me with the lathe until the shaft broke, where he went and assisted Al-Farsi.*	***Al-Ramadani:*** *Al-Ramadani initially assisted me in turning the handle, and when Al-Farsi was done, he started the threading process and was able to finish threading the entire required amount from the shaft.*

Week 2		
Session 4 (16/5)	**Session 5 (16/5)**	**Session 6 (17/5)**
Al-Hosni: *I went into the fourth sessions mainly focusing on chamfering the ends of the thinner section, however, the entirety of said process was relatively short, and therefore I was also able to get the knurling process done.* ***Al-Farsi:*** *Al-Farsi was finished with all of his main areas that he was supposed to focus on for the now; therefore, he did not have any major tasks to get done, and therefore he simply assisted in shaping the handle.* ***Al-Ramadani:*** *Al-Ramadani also did not have any major tasks that he had to do as he had to wait for me to finish handle in order to thread it, as such, he simply assisted with the handle.*	***Al-Hosni:*** *At the start of the fifth session, I was began parting the extended bit of the handle and was also able to face and round the butt of the handle, which concluded the main tasks that I had to overseer.* ***Al-Farsi:*** *Al-Farsi initially waited for me and Al-Ramadani to finish our tasks as his job for these sessions was to finish the handle, as such, when we did both got our tasks done, he started finishing the handle and was able to get the major marks off of it.* ***Al-Ramadani:*** *As soon as I finished, Al-Ramadani started creating the internal thread found within the screwdriver handle and also assembled the handle with the shaft, concluding his tasks within the production process.*	***Al-Hosni:*** *During the final session, I did not have any major tasks to do, therefore I simply assisted Al-Farsi in finishing the product.* ***Al-Farsi:*** *Al-Farsi's task for the final session was simply finishing the product, and since he already got the major marks off the handle, he was utilizing a relatively low grit emery paper at this point in order to polish the surface and try to make it relatively shiny and clean.* ***Al-Ramadani:*** *Just like myself, Al-Ramadani was done with all of his major tasks, and therefore he assisted Al-Farsi in finishing the product.*

Meeting minutes

Note
Both the first and second sessions are relatively close to each other in terms of the time span that is in between them as they are both within the same day, as such, only one meeting is held for both. Meaning that overall, four meetings are held, one meeting for the first two sessions and one for the third one, with the same structure being maintained for both weeks. It should also be noted that the meeting minutes have been written by Al-Farsi

Date: 8 /5/2022	**Pre-start meeting (meeting 1)**
Agendas:	**Discussion**
• ***Potential designs*** • ***Leadership allocation*** • ***Task allocation***	*The main areas of discussion were related to the overall design that we thought would be suitable to be made and also how the team would be allocated. The first that occurred talking about and checking the possible designs that we might want to make since at the time that was our main priority, as such, when we initially joined the meeting, Al-Hosni launched a live stream showing myself and Al-Ramdani some of the popular designs that he thought would be suitable for us to make. Overall, there were 4 different designs that were analyzed. After that was done, we discussed how we were going to allocate ourselves, which was done by initially splitting up the tasks into 6 main sections, R&D, Preparation, Health and Safety, Manufacturing, Joining, and Finishing. After doing so, members were allocated mostly based on preference when it came to preparation and joining, however, the other leaders of the other tasks were mainly allocated based upon each member's strengths and weaknesses. In addition to allocating leadership for each section, it was also discussed what tasks were going to be focused on within the first session.*
Action points for the next session:	**Conclusions**
• ***Modelling*** • ***Preparation of tools*** • ***Risk assessment*** • ***H&S further actions*** • ***Turning and facing (if possible)***	*After the meeting has concluded, it was initially decided that two different models were going to be made in order to ensure that if one did not work or had a certain issue, the other would. With that being said, it was not yet decided what specific design we were going to pursue; however, the number of designs were narrowed to around 5, including them were the ones used as a reference point for the two designs that were modelled. In terms of the team's allocation, Al-Hosni was placed as the leader for both R&D and Manufacturing due to his experience in modelling and utilizing the lathe, Al-Ramadani in preparation and Joining as he preferred doing those, and I was allocated to Health and Safety and Finishing since I had decent experience working with and finishing materials and I personally wanted to overseer the Health and Safety section. In terms of task allocation, we decided that we would prepare for manufacturing rather than work on anything significant in that regards, as such, we concluded the meeting by allocating Al-Hosni to modelling the designs and start turning and facing the handle if he gets the models done, myself on risk assessment and adding any further actions, and Al-Ramadani in preparing the tools.*

Date: 9 /5/2022	Manufacturing discussion (meeting 2)
Agendas:	**Discussion**
• ***Tasks status*** • ***Broken shaft fix***	*The main points that were discussed during this meeting were what exactly we were going to do during the session in terms of both the handle and the shaft. Overall, the points of discussion within this meeting were not significant by any means, but rather it was simply discussing the current state of everyone's task and how we were going to continue the next session. In addition to that, the main point of concern was the shaft that I (Al-Farsi) was working on due to it breaking during the second session, Al-Hosni suggested that we could start the shaft again due to us not having worked on it a lot, however, both I and Al-Ramadani thought that it would be best to simply continue working on the same piece given initially by grinding it and trying to form the required shape.*
Action points for the next session:	**Conclusions**
• ***Parting the middle*** • ***Turning the middle*** • ***Grinding the shaft*** • ***Thread the shaft*** • ***Finish the shaft***	*The main points that were concluded from the meetings were that Al-Hosni would simply continue working on the handle based on the plan that was laid out prior to starting the manufacturing process, in that he would try and work on turning the thinner section of the design and chamfer its ends if the time was sufficient. In terms of the shaft however, it was decided that it would be best to simply keep working using the same piece of material initially given by grinding it and trying to achieve the required shape, and if I was able to do that, would also try to thread and finish the shaft. If all of what was stated was finished in a reasonable time frame, Al-Ramadani would start working on the threading the shaft.*

Date: 15/5/2022	Penultimate manufacturing session discussion (meeting 3)
Agendas:	**Discussion**
• ***Task status*** • ***Change in task order*** • ***Emery cloth grit***	*The points of discussion during this meeting were simply about the possibility of finishing the handle entirely during the two practical sessions and if the same could be done about the shaft. Additionally, another point of discussion was whether we would initially have Al-Ramadani create the internal thread for the handle and then for Al-Hosni to continue working on machining the handle, or we would keep it the other way around. Additionally, the grit of emery cloth that we were going to use for the shaft was discussed, with Al-Hosni and Al-Ramadani suggesting that we start at a girt of 120 and then slowly move upwards, but I thought it was unnecessary to start at that low, and that we should simply start at 220.*
Action points for the next session:	**Conclusions**
• ***Finish machining*** • ***Thread the handle*** • ***Assemble the product*** • ***Finish the shaft***	*In regard to the order in which threading and continuing the machining process, it was decided that it would be more suitable to initially finish the entirety of the machining process first and then create the internal thread as machining simply has higher priority than threading the handle, and from there, it would then be threaded and joint with the shaft. When it comes to the grit level, after some debate on which one would be more suitable to start with, Al-Hosni and Al-Ramadani agreed with my idea of starting at a grit of 220 seeing that I was allocated leadership for the finishing process, and they trusted me to know better.*

Date: 16/5/2022	Final session discussion (meeting 4)
Agendas:	**Discussion**
• ***Finishing the handle***	*During the penultimate session, the majority of the production process was concluded, and the only thing remaining for us was to finish it. As such, during this meeting, there were not many points to discuss other than how long it would potentially take us to finish the product and if we were going to be able to get a decent finish by the end of the final session.*
Action points for the next session:	**Conclusions**
• ***Finish the handle***	*As stated, there are not many points to do during the final session other than simply finish the handle as it was the only thing remaining since everything else was already assembled and the shaft was already finished. In terms of whether or not we were going to be able to finish the product to a good standard, it was concluded that we would since although the handle would require more finishing that the shaft as it would have machining marks, however, with the use of the belt sander the shaft was finished rather quickly, and since we had the entire session simply for finishing the handle, we were confident the final finish would be relatively good.*

Conclusion

What went well?

The majority of the production process was a great success as a whole, as both practical and mental aspects of the process went as expected. Overall, the team performed well, and everyone was supportive of each other, with each team member assisting the other whenever they are in need and performing their own tasks as required and with competency, with the general team dynamic being great throughout the entirety of the assessment period, with the team taking the given job seriously by attending every team meeting and legitimately caring about the product's quality. In addition to that, most of the equipment were of decent quality and we were able to accomplish the majority of our tasks without any hindrances, with said equipment including the machines that were utilized, the cutting tools used, the health and safety measures that were already taken, and the CAD programs that were used in designing the 3D models, and for the most part, significantly aided in attaining the final product while achieving the majority of the product's requirements.

Points of potential improvement

With that being said, there nevertheless were some issues that were faced throughout the production process that required from us as a team to adapt according to the circumstances and tools available at the institution. Overall, there were only two major aspects that could have potentially gone better, with the first being the lack of variety in equipment, in that although – as stated – the equipment available was able to assist us in achieving the final goal, they however were relatively limited and therefore forcing us to change our approach in the desired design, one example of which is availability of turning as the only machining process available to students at the institution, limiting the design to cylindrical shapes only, and also the rounding tool available not being sufficient to create a fully round curve as what was required from the design. The other process that could have potentially gone better is forging, which is the case due to the shaft's tip breaking causing somewhat of an issue and forcing us to work faster than what would have initially been required, in spite of that, we nonetheless were able to overcome this by adapting to the current circumstance and working our way around the issue.

Regarding the potential improvements to the stated issues, in terms of the lack of equipment, a potential solution would be to initially check all the tools that are available in order to analyze them, and based on said analysis, the research and design process would go in a certain direction, in that the modeling process would be entirely according to what can be possibly made rather than having to adjust and adapt during the production process, which – in certain circumstances – might not be possible depending on the product and significance of said adjustment, therefore, the improvement that is being suggested is to add an analysis of the available tools to the research and design process. Concerning the issue faced with the broken shaft, a potential improvement would be to initially analyze the heat deuteriation of the metal to be utilized, and based on that, apply a timer to know the time frame in which the material would be suitable for forging, which would assist in knowing when the time in which hitting the material could potentially cause it to shatter or break.

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“*Teamwork is the ability to work together toward a common vision. The ability to direct individual accomplishments toward organizational objectives. It is the fuel that allows common people to attain uncommon results.*”

- Andrew Carnegie