

DEVELOPMENT OF AN INTERACTIVE APPLICATION FOR THE VIRTUAL REALITY**Omar Hussein¹; Steffen Härtelt²; Christian Vogel³; Alexander Kratzsch⁴**

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⁴a.kratzsch@hszg.de**Abstract**

This project is an attempt to get expert knowledge of VR technology and have a clear perception of the Linator as an example. The main purposes are helping to gain knowledge of this engine, concepts and mechanism, how its animation works and identify each part (geometries and tasks) by using VR- headset. The idea of this project is to find the way to fully understand this machine and to link the theoretical science to practical reality for educational and industrial purposes in three main steps: Digitalization, Data reparation and acquisition and Animation. The presentation ways depend on the capabilities of both the software and hardware. Thus, this is also an attempt to generalize presentation ways which can be used to apply on other mechanical machines.

Keywords

VR-headset; Linator; IPM; HTC-VIVE Pro; Blender; OTAG; LION Powerblock; CREO; Unity.

Introduction

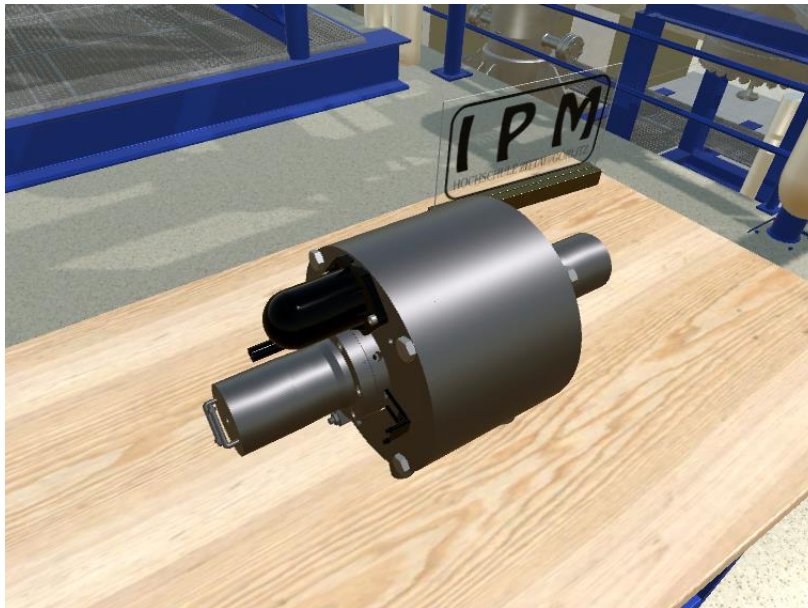
Linking theoretical science to practical reality is one of the most important issues for educational and industrial purposes.

This paper describes how to have a clear perception of the Linator as an example of other similar applications in mechanical field, find out how to fully understand this machine and investigate the best ways to display such mechanical machines and other applications [1].

VR- headset is a virtual reality headset. This is a head-mounted device that provides virtual reality for the user.

One of the most important topics in the IPM Institute is steam technology and using it to produce efficient power. Therefore, the power block from LION Company which contains Linator is a good application in small scale for educational and industrial purposes.

Linator is a free-piston steam engine, used in electricity and heat generation. As shown in Fig. 1, it uses the pressurized steam to move pistons in each side in fluctuating movement (right and left) to move the rotor which is connected in pistons to generate the magnetic field and then generating electricity, the steam circulate from main holes in condensation part [2]. Linator generates electricity using the same concept of stirling engine to generate magnetic field caused by moving the Squirrel-cage rotor.



Source: Own using software CREO parametric 3.0 [13]

Fig. 1: 3D-model of Linator

The main purposes of this project are building experience in the virtual reality field (implementation of further applications for the Zittau/Görlitz University of Applied Sciences) and creating a practical application (Linator) by dealing with Linator and all parts as a real experience and creating a suitable environment to understand all information about it in an attractive way.

1 State of the Art

In IPM institute HTC-VIVE Pro is used as a VR-headset technology and Linator is used as an example of mechanical application.

1.1 HTC-VIVE Pro

“VIVE is a virtual reality brand building hardware, software and creative platforms to unleash imaginations from the limits of our world. Sub-millimetre-precise tracking technology from SteamVR. High-fidelity hardware and an ecosystem of innovation from VIVE. Together, they make a superlative experience unlike any other. Jump into the future of art, storytelling, gaming, enterprise and entertainment.” [3]

1.2 Linator

Linator is a part of the Powerblock LION [4] produced by “OTAG storm mit wärme” company. Fig. 2 shows the company logo.

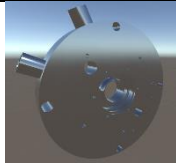

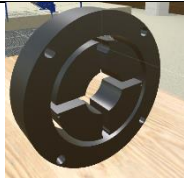

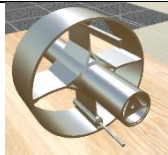





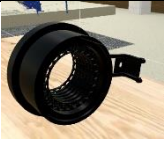
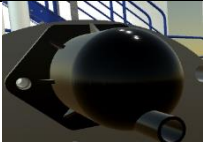
Source: [4]


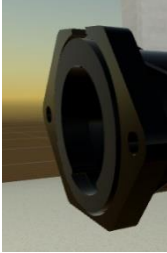


Fig. 2: Logo of OTAG company

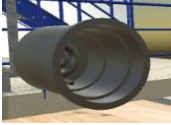
Table 1 describes the basic parts of Linator and the main function for each part.

Tab. 1: Basic parts of Linator and the main function for each part

No.	Description	Image	No.	Description	Image
1	<p>Housing part</p> <p>This part is one of the biggest parts; in this part the expanded exhaust steam comes out through 2 holes in each side and it works as support of another small parts.</p>		9	<p>Main ring</p> <p>This ring connects the "condenser part" with the "outer chamber" and "Rings of holes"; it has special geometry and holes of bolts to make sure that every parts in the correct location.</p>	
2	<p>Stator part</p> <p>In the middle of the Linator, it consist of permanent magnet on the inner perimeter of outer circle that allows to make a magnetic field to generate the electricity and it consists of a plate of conductor materials with lamination to decrease the eddy current losses.</p>		10	<p>Carbon piston ring</p> <p>It is a small part between the "Inner chamber" and the "Outer chamber" and around the first part in the piston, the basic task for this part is to tight the piston and prevent the steam leakage.</p>	
3	<p>Squirrel-cage rotor</p> <p>By connection in each pistons the rotor move in the linear movement to cut the magnetic field lines and generate current that passes to the specific hole.</p>		11	<p>Circular supporting ring</p> <p>Ring with special geometry works as a supporting ring for the carbon piston ring to prevent steam leakage. It is made of a special kind of brass.</p>	

4	<p>Rubber gasket</p> <p>Rubber ring around the centre of the housing part to prevent any leakage in the steam throw other parts and connect parts without scratching, It has a smooth mesh that allows steam to pass.</p>		12	<p>Electrical cable stand</p> <p>It is a stand that helps the electrical cable to move in flexible way.</p>	
5	<p>Rings of holes</p> <p>This part contains lamination of rings, each ring contains 24 holes to allow the steam to move in a specific place and specific movement, and it also contains two paths to prevent to reach the critical pressure.</p> <p>It consists of lamination to make sure the steam is not free but also it can move without a huge amount of losses and pressure drop. [5]</p>		13	<p>Electrical cable cover</p> <p>This part covers the cable and helps to move freely, also it has a hole in the top for ventilation.</p>	

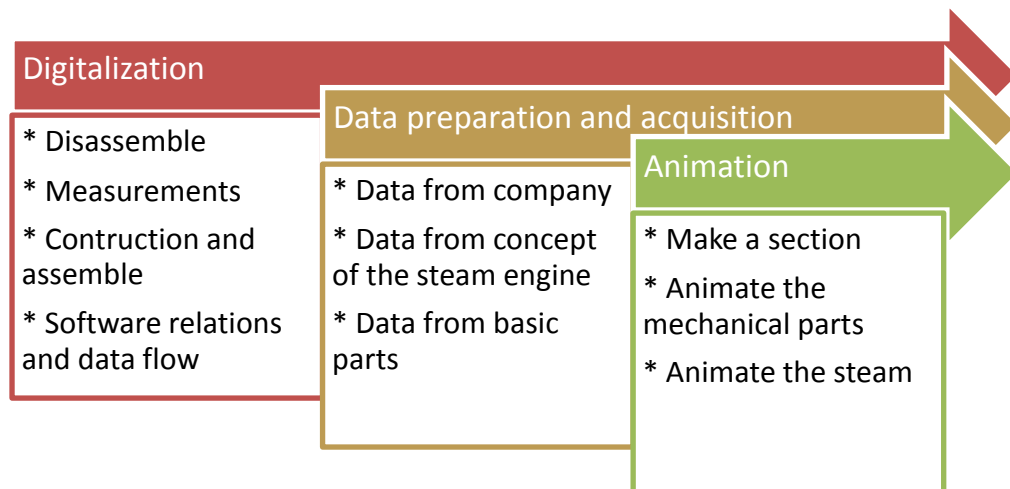
6	<p>Piston</p> <p>The most complicated part in Linator consists of two main parts as shown in the figure, the first part, the cylinder, has smooth outer surface, it enters the high pressure (outer) chamber and has rectangular holes around the outer circle at the end to allow the steam to move to other part at a specific time, these holes work as steam inlet valves and have special radius of curvature to minimize the pressure drop in the steam [6].</p> <p>This image illustrates the shape of these holes. The second part is the part connected to the rotor and has 3 layers, the first and the second layers are made in a special way as shown from carbon to make sure that piston touches the inner chamber and the last one has a star shape to set all pieces in their correct location.</p>		14	<p>Cover gasket</p> <p>It is made of rubber and it has a special hole to allow the cable to come out from cover.</p>	
7	<p>Inner chamber</p> <p>This chamber is where steam pushes the piston to move, these are two important things in this part, firstly, it is the smooth part to reduce the friction between the piston and the chamber at the minimum value, secondly, this chamber has 24 holes, which work as steam outlet valves.</p>		15	<p>Venting part</p> <p>This part prevents over-pressure by allowing the steam come out from these parts, it is connected with the rotor too by the rod.</p>	

8	<p>Outer chamber</p> <p>This part works as a cover of “Rings of holes” and the “Inner chamber” part. This part has 4 sections; the first one is considered the outer chamber that allows the steam to enter the engine by two ports and sustain the high pressure, the second and third section cover the parts and the last one is to connect with main ring.</p>				
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Source: Own; the figures done by authors using software CREO parametric 3.0 [13]

2 Work Flow

To meet the dead-line of this project, the plan of the work was done in short-term and long-term goals as shown in Fig. 3.



Source: Own

Fig. 3: Work steps of project

The sequence of steps illustrates the work flow from the beginning to the end of the working process in this project that concerns to linking theoretical science to practical reality and depends on the presentation ways, the hardware and software that was used and the main purpose of this project.

To reach the goal there was several steps to realize:

- Digitalization
- Data preparation and acquisition
- Animation

2.1 Digitalization

Digitalization is used to convert Linator from the real machine to a virtual reality machine, it is used to make Linator applicable model in SteamVR and other applications. This step is important in this project to be done since that there are no any construction drawings for Linator.

Disassembling the parts of Linator was done by using screw removal tools, as shown in Fig. 4, and hydraulic crane. Linator has about 30 basic parts.



Source: <https://www.amazon.it/Stanley-Cassetta-attrezzi-cromata-lucida/dp/B00TBCMLXM>

Fig. 4: Screw removal tools

A video for disassemble step has been recorded to make sure that every part fits in the correct location, as shown in Fig. 5, and an endoscope was also used to see the small parts inside the engine.



Source: Own

Fig. 5: Disassemble process

2.1.1 Measurements

Since there is no any information about the parts and dimensions of these part, Digital Vernier caliper, shown in Fig. 6. is used to measure the dimensions of the parts with high accurate resolution (0.01 mm). Also using 3D-scanner technology helps to measure the smallest dimensions in many complicated parts such as Carbon piston ring.



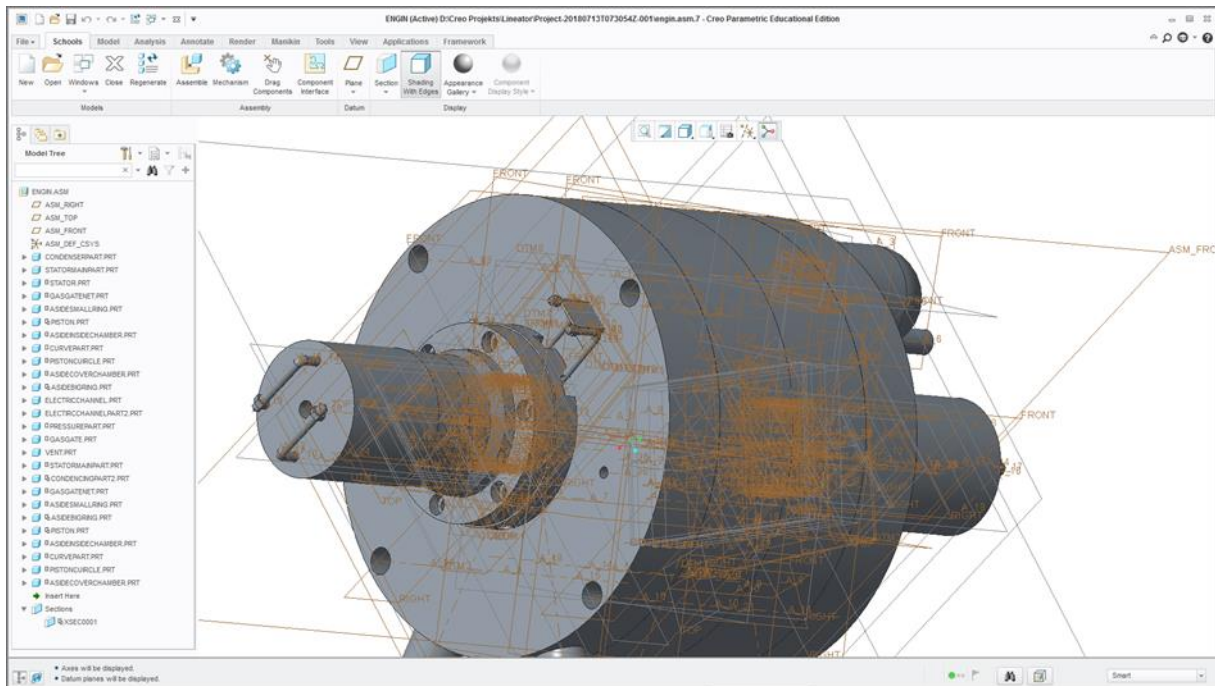
Source: <https://www.amazon.com/Digital-Vernier-Caliper-150Mm-Inch/dp/B00QAG8FXM>

Fig. 6: Digital Vernier caliper

2.1.2 Construction and Assemble

In parallel with the measurement step, the construction was done by using CREO parametric 3.0 program. This includes the geometries, holes and all links between parts.

The assembly step of the digitalized parts was also done by using CREO parametric 3.0 program with taking into consideration the personal errors and the uncertainty in measurements, as shown in Fig. 7.



Source: Own; screenshot using software CREO parametric 3.0 [13]

Fig. 7: Construction and assemble of Linator in CREO parametric 3.0

2.1.3 Software Relations and Data Flow

To export this model to Unity, it must be in a specific extension (FBX, OBJ, etc.). CREO does not support these extensions, so this is done by using a blender as a mediator to convert the extension from STP to FBX and to make custom section for animation purposes.

Parts and their texture are exported to make animation more realistic. In addition to that, linking VR-headset with Linator model is created by using Unity3D program.

Unity program supports the VR-headset (HTC VIVE PRO) by using the SteamVR Plugin Asset and by writing the scripts (scripting programming language is C#) using Microsoft Visual Studio [9] the interaction between VIVE PRO hardware and the parts on the Linator

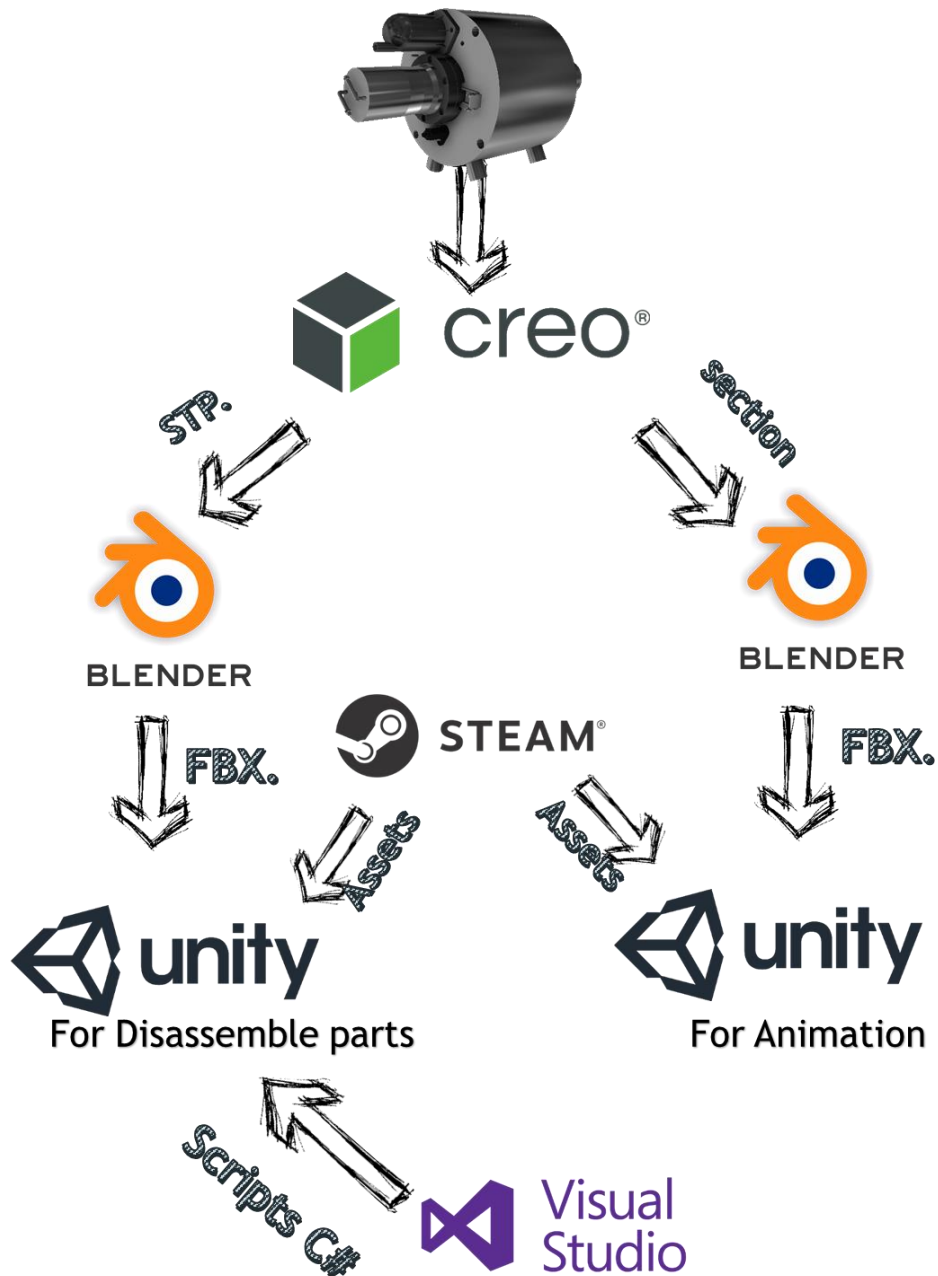
(controlling in position, rotation), as shown in Fig. 8. To realize that work, the following software and hardware are used, as shown in Table 2.

Tab. 2: *Software and hardware used*

Software	Hardware
CREO parametric 3.0 (3D-modelling software from PTC company)	HTC-VIVE PRO
Blender 2.79 (3D Computer Graphics Software)	ASUS
Unity 2018.1.7f1 (cross-platform game engine)	Processor: Intel Core i7-7700
SteamVR (virtual reality system)	Graphics: NVIDIA GeForce GTX1080 8GB
VIVEPORT (official app store for the HTC Vive)	Memory: DDR4 SO-DIMM 16GB
Microsoft Visual Studio	

Source: Own

The chart in Fig.8 describes the relations between the software that was used in this project.



Source: Own

Fig. 8: The relations between software types

In addition to drawing and graphics work, scripts were processed in the Unity3D to accomplish this project with all requirements in three ways [8]:

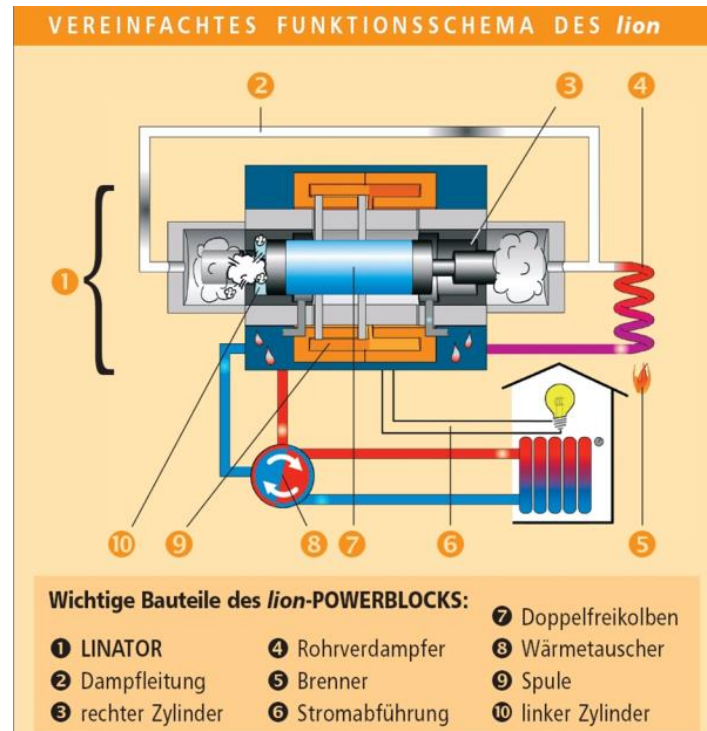
- Using the scripts without any changes, e.g. the player, controller scripts or teleport point.
- Using the scripts with changes to make it suitable for this project like throwable script and start bottoms.
- Creating special scripts for special application like information sound and mesh collider.

2.2 Data Preparation and Acquisition

The purpose of this step is Linator (Tasks, Parts, Materials, etc.) science research by including all theoretical information about Linator in this project. Results are in Table 1.

The data sheets, as shown in Fig. 9, are used from the company, the basic concepts of the free piston steam engine, the shape, materials and assembly of the parts and the holes, valves of these engines [10], [11].

Finally, this research was translated to other languages (German and Arabic) and put in interactive sound in Unity3D to link it with VR-headset.

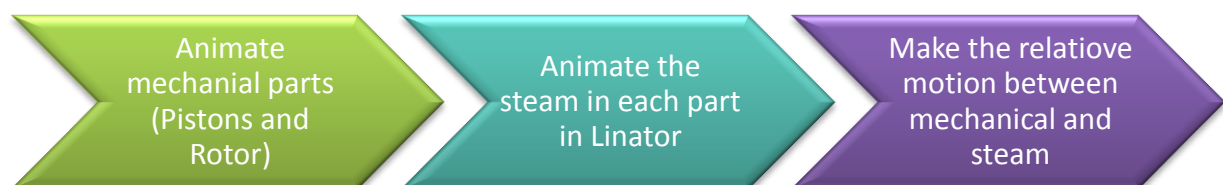


Source: <http://www.bhkw-prinz.de/button-energy-bison-powerblock-holzpellets-bhkw/2771>

Fig. 9: Description of how the Linator works

2.3 Animation

One of the challenges is the animation especially in Unity3D, although it is the best choice to link the digital engine in virtual reality with VR-headset, because Unity3D as a game engine is not suitable for mechanical animation like fluids and relative movement between parts. About 17 different animation for 17 objects were prepared while taking into consideration the relative movement and time delay in each object, as shown in Fig. 10.



Source: Own

Fig. 10: Work steps in the animation

A clear section is done to demonstrate the inside parts and the main valves, and the movement of the steam in the channels, as shown in Fig. 11.



Source: Own using software Unity 3D [8]

Fig. 11: Suitable section for animation

2.3.1 Assumption for Animation and Visualization

- No effect of gravity
- The air resistance (drag) is too large
- No collision between each part
- The connection bolt is static
- The speed in animation is too slow

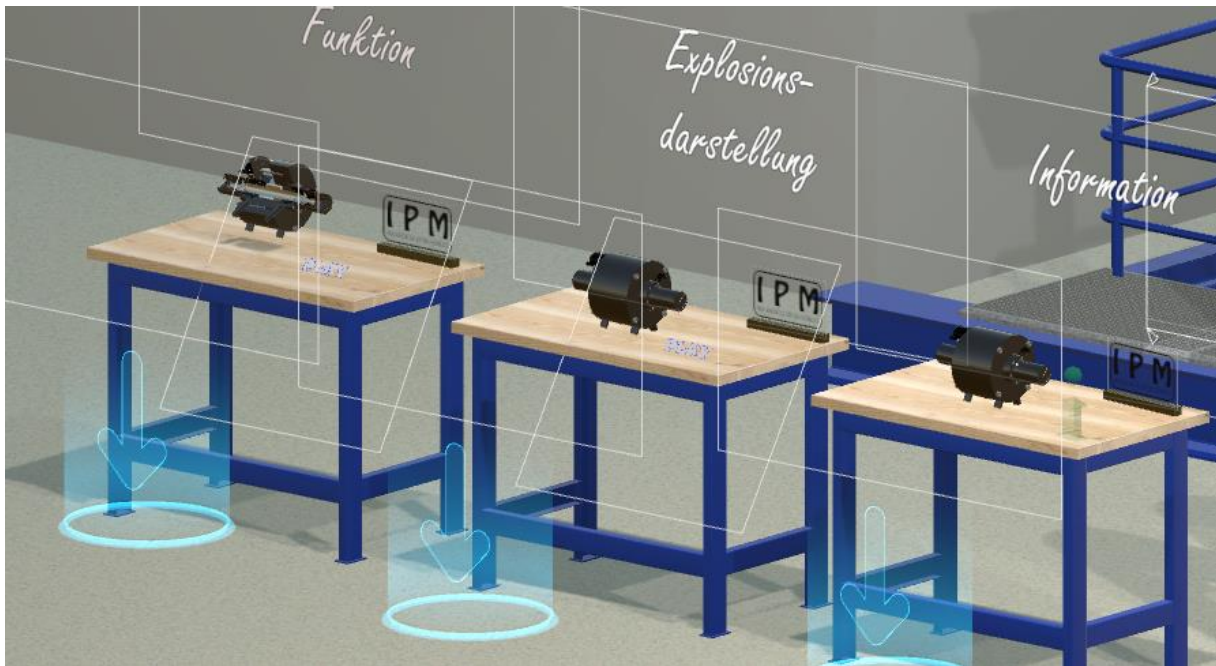
2.3.2 Presentation Way

Firstly, in front of the first table you can disassemble the parts in Linator by hands of VIVE PRO, control all parts in position and rotation and you can see its geometries, shape and size of the parts and hear interactive voices about information of all parts and tasks of it.

Collider mesh in Unity3D is not suitable for complex mechanical parts and every part has inaccurate meshes that cause the destroying in the assembly. This challenge is solved by trying to make the simplest possible mesh, prevent any collision between each part by writing scripts for that, stop the gravity effect and raise the drag to make the part stable.

The second way is animation about explosion of the Linator to the basic parts to describe the configuration of the parts with each other.

In the third table you will see an animation about how Linator work and the movement of the steam and the parts to clear the holes, input and output valve, tasks of parts and the types of inputs and outputs in Linator, as shown in Fig. 12.



Source: Own using software Unity 3D [8]

Fig. 12: Presentation ways

3 Results

Now, the player can make a tour through the laboratory to see the models of the Linator and deal with this engine in three ways; Information: controlling of the parts and seeing the shape and geometry of all parts and listening to the information about any parts in interactive way, Disassemble animation: seeing the animation when the Linator disassemble to the basic parts, Function: seeing the Linator when it works in a special section to display the inlet and outlet valve and the movement of the steam and mechanical parts.

This project is a great application for educational purposes especially in the schools that do not have the possibility to own these mechanical engines or big laboratories. This project contains a huge amount of details in graphics and controlling in all parts.

It can also be used for online courses to reach to the best understanding for this application in the concepts side and physical side (parts, dimensions, tasks and animation, etc.)

On the other hand, it is a nice idea to use it for industrial purposes to simplify the complex processes and display the parts and manufacturing of these parts in interactive tools.

In the marketing, this is one of the most interactive methods to market the products and it helps to display the product in the best way for customers.

Finally, learning through play is not limited for kids, this method gives good understanding in the applications like Linator in an entertaining way [12].

This project helps to understanding all things about Linator and it is the example for application (display, controlling, scripts and animation) that it may be used to make another good applications.

In other words, this project represents a good base to other applications and ideas.



Source: Own

Fig. 13: Application of the project

Conclusion

Studying the Linator in this way helps for good understanding of the main concepts in the steam engines and the definition of free piston. Regardless of the limitation of this technology and this method (programs and hardware), it is still effective because the linking between the theoretical sciences to practical reality for many purposes is one of the hardest things to do in this rapidly progressing science. Since this project is the newest idea to link VR technology with mechanical machines, a lot of challenges were faced, e.g. the exporting process and animations especially in steam movement, etc.

The main advantage of this project is the real experience to deal with mechanical machines in a highly interactive way and replace the real machines with virtual machines that do the same work for special purposes. The attraction of this technology is that it allows students to learn in an entertaining way, the possibility to use it in online courses and in marketing field are other advantages of this technology too.

Unity3D and other game engines are not suitable to deal with complex mechanical machines and parts, which makes dealing in unity and other game engines limited and has a lot of problems like the challenges in mesh collider, animations and presentation ways. Also the high cost of this hardware reduces common personal use of this technology.

Finally, this technology can be developed in many ways such as developing the presentation ways to make it more creative and attractive, developing game engines to make it more suitable for mechanical application and choosing other machines with other types of display and control. It is a great technology to use especially in the educational field.

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VÝVOJ INTERAKTIVNÍ APLIKACE PRO VIRTUÁLNÍ REALITU

Tento projekt je pokusem získat odborné znalosti o technologii VR na příkladu Linatoru. Hlavním účelem je pomocí získat znalosti o tomto motoru, konceptech a mechanismech, o fungování animace a identifikovat každou část (geometrii a úkoly) pomocí VR headsetu. Záměrem tohoto projektu je najít způsob, jak plně porozumět tomuto stroji a propojit teoretickou vědu s praktickou realitou pro vzdělávací a průmyslové účely ve třech hlavních krocích: Digitalizace, Oprava a získávání dat a Animace. Prezentační způsoby závisí na schopnostech softwaru a hardwaru. Jedná se tedy také o pokus o zobecnění způsobů prezentace, které lze aplikovat i na jiné mechanické stroje.

DIE ENTWICKLUNG EINER INTERAKTIVEN APPLIKATION FÜR DIE VIRTUELLE REALITÄT

Dieses Projekt ist ein Versuch, am Beispiel von Linator fachliche Kenntnisse über die Technologie der virtuellen Realität (VR) zu erlangen. Das Hauptziel besteht in der Hilfe bei der Erlangung von Kenntnissen über diesen Motor, die Konzepte und Mechanismen und über das Funktionieren der Animation sowie bei der Identifizierung eines jeden Teils (Geometrie und Aufgaben) mit Hilfe eines VR-Headsets. Die Absicht dieses Projektes ist es, eine Art und Weise zu finden, wie man diese Maschine vollends versteht und die theoretische Wissenschaft mit der praktischen Realität für bildende und industrielle Zwecke zu verknüpfen. Dies soll in drei Schritten geschehen: Digitalisierung, Korrektur und Erlangung von Daten und der Animation. Die Art der Präsentation hängt von den Fähigkeiten von Hardware und Software ab. Es handelt sich also auch um den Versuch um Verallgemeinerung der Arten und Weisen der Präsentation, welche man auch auf andere mechanische Geräte anwenden kann.

ROZWÓJ INTERAKTYWNEJ APLIKACJI DO RZECZYWISTOŚCI WIRTUALNEJ

Niniejszy projekt stanowi próbę pozyskania specjalistycznej wiedzy nt. technologii VR (Virtual reality) na przykładzie Linatora. Głównym celem jest pozyskanie wiedzy o tym silniku, koncepcjach i mechanizmach, o funkcjonowaniu animacji oraz zidentyfikowanie każdej części (geometrii i zadań) przy pomocy headset'a VR. Celem tego projektu jest znalezienie sposobu, w jaki można w pełni zrozumieć tę maszynę i połączyć wiedzę teoretyczną z praktyczną rzeczywistością w celach edukacyjnych i przemysłowych w trzech głównych krokach: Digitalizacja, Naprawa i pozyskiwanie danych oraz Animacja. Sposoby prezentacji zależne są od możliwości oprogramowania i sprzętu komputerowego. Dotyczy to więc także próby uogólnienia sposobów prezentacji, które można zastosować także dla innych maszyn mechanicznych.