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Deliverable D1.1:
Comprehensive overview of the project

ShotTempering

Shot Peening Integration in Tempering Processes of Steels
for Enhanced Fatigue Performance

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2.0	18.12.2024	Ursula Ofenheimer (i2m)	Formatting check
3.0	18.12.2024	Marcel Egger (i2m)	Coordinator review and approval, deliverable ready for submission

Project Abstract

In response to pressing challenges, such as climate change and the increasing need for enhanced energy efficiency in the transport sector, the ShotTempering project addresses the imperative for advancements in the production process chain. This project introduces an innovative hybrid technique known as "warm peening," which integrates shot peening within the tempering treatment of components, primarily for high-demand applications like electric vehicles (EVs). EVs impose substantially higher loads on their components, necessitating further refinements in the production process to enhance performance and prevent premature failures. The novel warm peening process offers dual advantages. Firstly, it promises to boost the overall efficiency of the process chain in terms of energy consumption, resource utilization, and time savings. Secondly, it holds the potential to significantly enhance the mechanical properties of manufactured parts, particularly their fatigue resistance, through shot peening at elevated temperatures. This technique is recognized for its capacity to augment cyclic residual stress stability, fatigue strength, and, consequently, the longevity of critical components. The ShotTempering project represents a pioneering endeavor poised to revolutionize the manufacturing landscape, catering to the evolving demands of the transport sector while contributing to sustainability and energy efficiency goals.

Table of Contents

Public Summary

The ShotTempering project officially started on July 1st 2024, with a kick-off meeting held in Graz, Austria, on July 9th-10th 2024.

As part of Work Package (WP) 1, a comprehensive project overview is scheduled for December 2024. This initial report (Deliverable 1.1) will provide a concise summary of the project setup and management structure, document key meetings, risk assessment and events, and outline the progress of individual WP tasks during the first six months (M1 to M6) of the project.

The following elements stand out as key achievements during the first six months:

- Submission of Deliverable: *D1.1 Comprehensive overview of the project*
- Submission of Deliverable: *D2.1 Selection and fabrication of the steels*
- Submission of Deliverable: *D6.1 Communication and dissemination plan*
- Development of a management structure
- Creation of the project-website
- Development of the documentation tools

All deliverables (D1.1, D2.1, D6.1) were submitted on time. The project activities are advancing as outlined in the Grant Agreement Description of Action (DoA), with no deviations or risks, which could lead to an extension identified by the end of M6.

1 Introduction

1.1 Rational of this deliverable

Deliverable 1.1 (WP1) provides a summary of the project setup, management structure, key activities, and progress of tasks during the first six months (M1–M6), including meetings, events, and risk assessments.

Objectives of WP1 (from GA):

- Ensure that the research programme is developed as planned and that the project objectives are achieved
- Risk assessment monitoring. To take the necessary actions to avoid or minimize the previously identified risks
- Report the project progress to the Commission

The WP1 consists of three tasks: T1.1 Coordination activities, T1.2 Reporting activities, T1.3 Risk assessment.

<u>Attainment of the objectives and explanation of deviations</u>

At this stage of the project, all tasks have been completed, there have been no deviations and none are currently expected.

2 Project Overview

2.1 WP1 - Project management and coordination [Leader: i2m]

2.1.1 Project management and coordination [i2m; M01-M42]

The ShotTempering project is structured around a clear management framework that includes the Project Coordinator (PC) from i2m and the General Assembly (GA) with representatives from each partner organization. Each organization has one representative and one deputy in case of illness or any other absence.

2.1.1.1 Meetings

Monthly Meetings (MM): The consortium meets once a month via MS Teams to ensure efficient project progress of the tasks, risk identification and any other open issues in the Monthly Meetings. A total of 4 monthly online meetings were held by the end of month 6.

General Assembly (GA) meetings: In addition, GA meetings are held approximately every six months to review overall project progress, address technical issues, implement necessary changes, optimize risk assessment and manage reporting. The locations of these meetings will be decided on an ad hoc basis within the consortium, facilitated by the PC, while additional meetings can be organized online or via conference calls when needed between each partner. Each Work Package (WP) is overseen by a dedicated WP leader, responsible for managing activities, ensuring steady progress, fostering collaboration, and adhering to the DoA.

The consortium consists of following partners:

Table 1: Participants List

Participants			
	Company	**Leader**	**Deputy**
PC	İ2m	Marcel EGGER	Ursula OFENHEIMER
PA	SIDENOR	Ainhoa ERRASTI	Jacinto ALBARRAN
PA	KIT	Stefan DIETRICH	Frauke HINRICHS
PA	STR	Philipp REEH	Carlo SCHEER
PA	CRF	Davide MANGHERINI	Andrea BONGIOVANNI

Kick off meeting: The kick-off took place in Graz, Austria on 09-10 July 2024. Representatives from each company attended the meeting, as well as the project officer (PO). Additionally, three members from i2m, the organizing company, were present.

Figure 2: Consortium F2F Meeting Graz

Figure 1: Consortium F2F Meeting Graz 2

The meeting began with an introduction, followed by a presentation from the PO highlighting the key considerations for the project. Next, the management structure was explained in detail. Subsequently, all work packages were presented, together with an overview of the next steps. Additionally, a dissemination plan was outlined, and the first risk assessment was conducted. The session concluded with a discussion of questions, next steps, and unresolved issues. The next F2F meeting will in Karlsruhe in February 2025.

Kick-off meeting

Agenda – Day 1

Time	Topic	Presenter
13:00 - 14:00	***Welcome & Coffee (incl. Snacks)***	
14:00 - 14:10	**Introduction** *(Tour de Table, Project in a nutshell)*	i2m
14:10 - 14:30	**Project Officer** *(RFCS management aspects)*	Mr. A. Tsakalidis
14:30 - 15:00	**WP 1** *(Project Management and coordination)*	i2m
15:00 - 15:30	**WP 2** *(Steel Manufacturing and Characterization)*	Sidenor
15:30 - 16:00	**WP 3** *(Optimization Warm Peening Process)*	KIT
16:00 - 16:20	***Coffee Break (Group Picture)***	
16:20 - 16:50	**WP 4** *(Evaluation Fatigue Performance Achieved)*	KIT
16:50 - 17:00	**AOB and Wrap up**	all
17:00 – 19:00	**Refreshment Break**	
19:00	***Social Dinner***	

Kick-off meeting

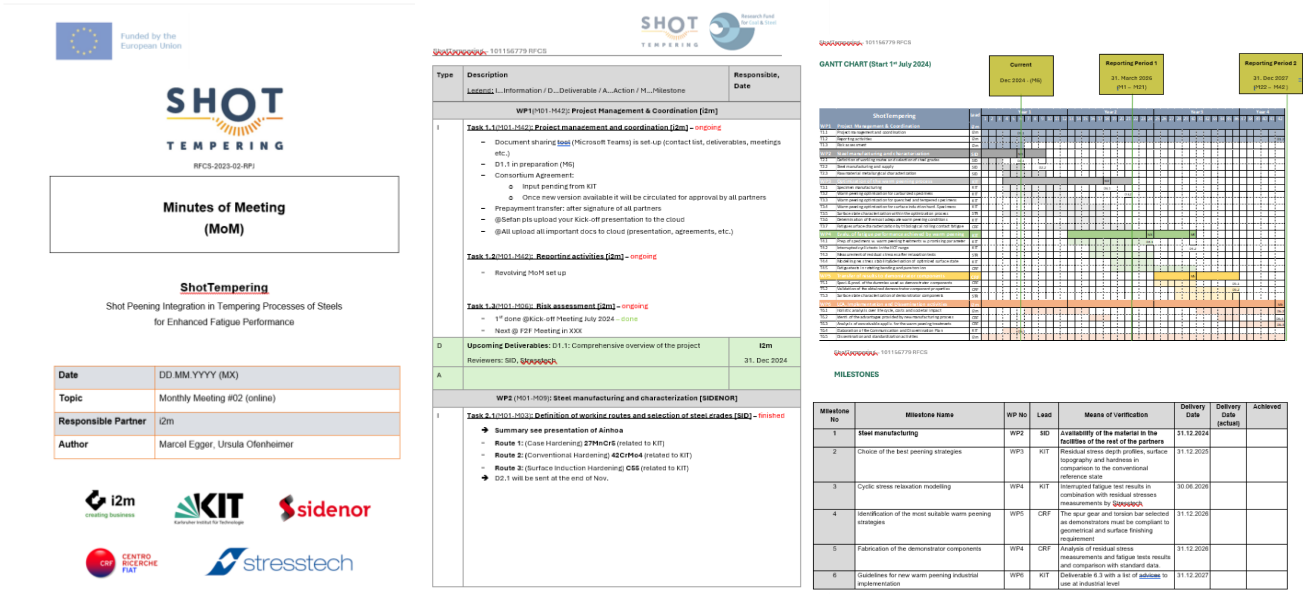
Agenda – Day 2

Time	Topic	Presenter
08:50 - 09:00	***Welcome & Coffee***	
09:00 - 09:10	**Introduction** *(Summary Day 1)*	i2m
09:10 - 09:40	**WP 5** *(Transfer of Results to Dem. Components)*	CRF
09:40 – 10:10	**WP 6** *(Implementation and Dissemination)*	i2m
10:10 - 10:40	***Coffee Break***	
10:40 - 11:10	**Next steps**	all
11:10 - 12:00	**AOB and open points**	all

2.1.2 Reporting activities [i2m; M01-M42]

Minutes of Meeting (MoM): All meetings, agreements and important information are documented in the Minutes of Meetings (MoM). These are sent out to all partners after each meeting and uploaded to SharePoint for everyone to access.

The MoM contains the agenda for each meeting, a participant list, the Gantt Chart, a progress report for each task and WP, as well as dates and information for the next meetings, organizational things and any other open points. Also an overview of the deliverables and milestones and the agreed reviewers.



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Minutes of Meeting (MoM)

ShotTempering

Shot Peening Integration in Tempering Processes of Steels for Enhanced Fatigue Performance

Date	DD.MM.YYYY (MX)
Topic	Monthly Meeting #02 (online)
Responsible Partner	i2m
Author	Marcel Egger, Ursula Ofenheimer

i2m creating business · KIT · sidenor · CRF Centro Ricerche Fiat · stresstech

ShotTempering – 101156779 RFCS

Type	Description Legend: I…Information / D…Deliverable / A…Action / M…Milestone	Responsible, Date
	WP1(M01-M42)**: Project Management & Coordination [i2m]**	
I	**Task 1.1**(M01-M42)**: Project management and coordination [i2m]** – ongoing – Document sharing tool (Microsoft Teams) is set-up (contact list, deliverables, meetings etc.) – D1.1 in preparation (M6) – Consortium Agreement: o Input pending from KIT o Once new version available it will be circulated for approval by all partners – Prepayment transfer: after signature of all partners – @Sefan pls upload your Kick-off presentation to the cloud – @All upload all important docs to cloud (presentation, agreements, etc.) **Task 1.2**(M01-M42)**: Reporting activities [i2m]** – ongoing – Revolving MoM set up **Task 1.3**(M01-M06)**: Risk assessment [i2m]** – ongoing – 1st done @Kick-off Meeting July 2024 – done – Next @ F2F Meeting in XXX	
D	**Upcoming Deliverables:** D1.1: Comprehensive overview of the project Reviewers: SID, Stresstech	**i2m** 31. Dec 2024
A		
	WP2 (M01-M09)**: Steel manufacturing and characterization [SIDENOR]**	
I	**Task 2.1**(M01-M03)**: Definition of working routes and selection of steel grades [SID]** – finished ➔ **Summary see presentation of Ainhoa** – **Route 1:** (Case Hardening) **27MnCr5** (related to KIT) – **Route 2:** (Conventional Hardening) **42CrMo4** (related to KIT) – **Route 3:** (Surface Induction Hardening) **C55** (related to KIT) ➔ D2.1 will be sent at the end of Nov.	

ShotTempering – 101156779 RFCS

GANTT CHART (Start 1st July 2024)

ShotTempering – 101156779 RFCS

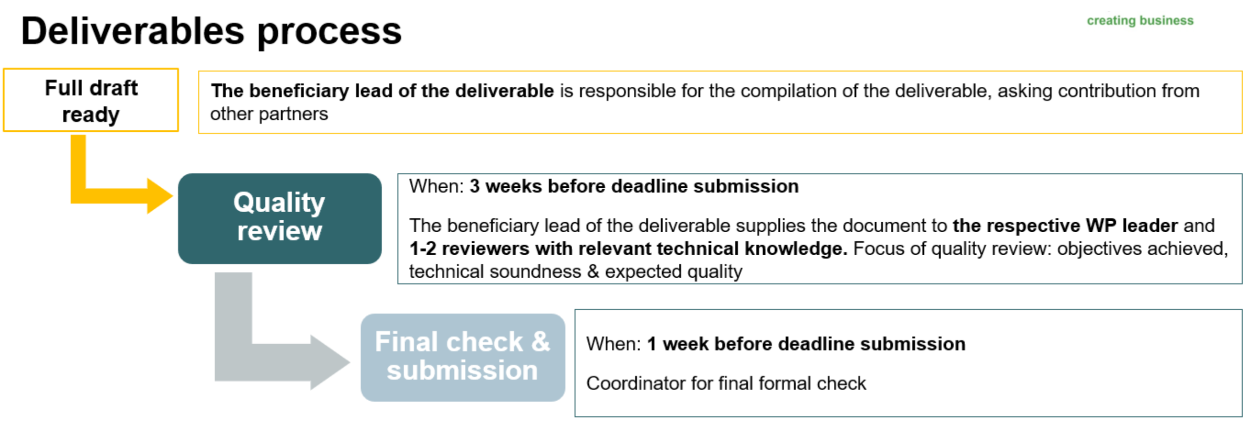
MILESTONES

Milestone No	Milestone Name	WP No	Lead	Means of Verification	Delivery Date	Delivery Date (actual)	Achieved
1	**Steel manufacturing**	WP2	SID	**Availability of the material in the facilities of the rest of the partners**	31.12.2024		
2	Choice of the best peening strategies	WP3	KIT	Residual stress depth profiles, surface topography and hardness in comparison to the conventional reference state	31.12.2025		
3	Cyclic stress relaxation modelling	WP4	KIT	Interrupted fatigue test results in combination with residual stresses measurements by Stresstech	30.06.2026		
4	Identification of the most suitable warm peening strategies	WP5	CRF	The spur gear and torsion bar selected as demonstrators must be compliant to geometrical and surface finishing requirement	31.12.2026		
5	Fabrication of the demonstrator components	WP4	CRF	Analysis of residual stress measurements and fatigue tests results and comparison with standard data.	31.12.2026		
6	Guidelines for new warm peening industrial implementation	WP6	KIT	Deliverable 6.3 with a list of advices to use at industrial level	31.12.2027		

Figure 3: Minutes of Meeting (MoM)

2.1.2.1 Quality Assurance

As previously mentioned, regular meetings have been established to maintain high-quality project implementation. Additionally, a risk management process is in place to support this objective. A clear strategy for managing deliverables and milestones has also been developed. Once drafts of the deliverables are completed, they are sent to two reviewers for quality assessment. Following this, the deliverables undergo a formatting check and a final review and approval by the Project Coordinator (PC). The structure of the deliverable process looks as follows:



In addition to the MoM, every document created is uploaded to the cloud and sent to the partners. The structure of the cloud is as follows: Contact List, Deliverables and Milestones, Meetings, Proposal and Contracts, Templates, and folders for all six WPs.

2.1.3 Risk assessment [i2m; M01-M06]

The initial risk assessment was conducted during the kick-off meeting, documented in the Minutes of Meeting (MoM), and made accessible to everyone via SharePoint. The next risk assessment is scheduled for the next F2F meeting in February 2025. Nevertheless, it is important to note that risks, along with strategies for their mitigation and prevention, are continuously addressed and discussed during the monthly meetings. Below are the results of the first risk assessment.

ShotTempering

09-10.July 2024

Risk management

Risk No	Description	Work package No	Proposed risk-mitigation measures
1	Departure of one partner from the Consortium Impact: high / Likelihood: low	Continuous risk	Work distribution among the rest of the partners. If not possible, an equivalent external partner is searched by the steering committee. No update at this pojnt in time
2	Loss of one partner's key staff: A person very involved in the project leaves is not available anymore: because an illness, because she/he leaves the company… Impact: medium / Likelihood: medium	Continuous risk	More than one person per partner should be informed about the project evolution. Search within the organisation for a person with equivalent skills. No update at this pojnt in time
3	Delays on key tasks which could avoid the correct development of other tasks. Impact: high / Likelihood: medium	Continuous risk	Detailed follow-up of all the activities to detect possible delays as soon as possible. Delays will be addressed with the consortium meetings. If issues persist, a shift in the time plan of the activities may be required, which will also be communicated to the EC in due time. Front-loading of material ordering to allow timely start of sample preparation in 2nd half 2024
4	Deviations in the planned budget Impact: low / Likelihood: low	Continuous risk	Periodic budget monitoring (at least every 6 months) to ensure early detection. Re-assessment of priorities for budgets/resources if needed. No update at this pojnt in time
5	Delay in the steel manufacturing. Impact: medium / Likelihood: medium	2	Start the steel manufacturing the first day of the project. Modify the project planning, increasing the working load of some periods. Front-loading of material ordering to allow timely start of sample preparation in 2nd half 2024

1

Figure 4: Risk Assessment Page 1

ShotTempering

09-10.July 2024

6	Failure and subsequent maintenance of peening equipment and ShotTempering setup due to higher peening temperatures or interfering signals which could interrupt process controls. Impact: medium / Likelihood: medium	3	Evaluate feasibility and interactions already in the design phase of the setup, early replacement of expendable items in the processing chamber and heating setup in order to reduce the chain effect of failing machine parts. No update at this pojnt in time
7	Complexity of the process model is too high to predict a realistic process outcome: Since the residual stress model must be built on a calibrated and empirical material model of cyclic deformation behaviour it is necessary to incorporate a large number material tests and validations which could exceed the scope of the proposal. Impact: low / Likelihood: medium	3	Checking literature data for the material behaviour of similar compositions and reduce the amount of experiments by using the data and spot checks. Reducing the model complexity by model reduction techniques and mechanics of similarity. No update at this pojnt in time
8	Out of production of the component selected: one of the component selected is not anymore produced by Stellantis plants. Impact: medium / Likelihood: low	5	Collect enough components at early stage of project. Determination of another components suitable for the project. Component selected for demonstration is a) gear (1st speed and representative for EVs) and b) torsion bar
9	Project results are insufficient/ non-compliant to the requests: the residual stresses obtained by the project are not compliant to the drawing requests of the component. Impact: high / Likelihood: low	5	The experimental tests and modelling that will be undertaken at the beginning of the project, minimize the risk of not reaching the requests of the component. No update at this pojnt in time
10	Lack of data for environmental, economic, and societal life cycle assessment: The data required to perform the life cycle assessment could not be provided by the project partners involved. Impact: low / Likelihood: medium	6	Conduct a bibliographic search to obtain the missing data (related scientific papers/reports) No update at this pojnt in time

2

Figure 5: Risk Assessment Page 2

2.2 WP2 – Steel manufacturing and characterization [Leader: SID]

2.2.1 T2.1 Definition of working routes and selection of steel grades [SID; M01-M03]

The ShotTempering project analyzes three of the most common manufacturing processes for components which support loadings: case hardening (carburizing), conventional hardening (quenching and tempering) and surface induction hardening through comprehensive testing of three different steels associated to each route.

- Route 1: (Case Hardening) 27MnCr5 (related to CRF)
- Route 2: (Conventional Hardening) 42CrMo4 (related to KIT)
- Route 3: (Surface Induction Hardening) C55 (related to KIT)

Exact details can be found in Deliverable D2.1.

The three steel grades will be characterized as reference materials. Chemical composition and microstructure will be analyzed and mechanical tests (tensile and impact) will be carried out.

After warm peening optimization campaign, additional studies will be developed comparing shot peening and warm peening processes. Residual stresses behavior will be evaluated after fatigue testing in order to modelling the stability of the surface state.

27MnCr5, focusing on its application to gears in electric vehicles, and 42CrMo4, as the steel grade of one of the most common fabrication routes (quenching and tempering), were subjected to extensive evaluations to validate the results through demonstrators.

2.2.2 T2.2 Steel manufacturing and supply [SID; M01-M06]

SID produced the three steel grades for each route, which were identified (red, green and yellow) and boxed for shipment. The steel production chain consists in electric arc furnace, ladle furnace, continuous casting, hot rolling and heat treatment when required. The steel grade for route 1 was supplied in annealed conditions while the steels for the route 2 and 3 were supplied in as rolled conditions. All the material was cut into 500mm bars for easy handling. Once the last material was received, they were sent to KIT and CRF together to optimize shipping costs.

	Heat Treatment	Steel Grade	Demonstrator	Supply conditions	Diameter (mm)	To CRF (m)	To KIT (m)	STRESS TECH
Route 1	Case hardening	27MnCr5	YES	Isothermal Annealing	70	5+5+6	10	-
Route 2	Conventional hardening	42CrMo4	YES	As rolled	60	6	15	-
Route 3	Surface induction hardening	C55	-	As rolled	60	6	15	-
					500mm bars:	56	80	

Figure 6: Overview steel grades

Exact details can be found in Deliverable D2.1.

2.2.3 T2.3 Raw material metallurgical characterization [SID; M04-M09]

The metallurgical characterization of the raw material, including chemical composition, hardness, microstructural evaluation along the bar profile, tensile and impact tests, and fracture analysis, started at the end of November and is ongoing.

2.3 WP3 – Optimization of the warm peening process [KIT]

2.3.1 T3.1 Specimen manufacturing [KIT; M04-M12]

In order to be able to peen the supplied samples in the higher temperature range of WP2, a sample holder design and setup compatible with the implementation in the peening process has been realized and tested. The conductive heating device can be installed in the peening chamber with the base of the sample clamping system mounted in copper contact grips which close a high-power electrical circuit and heat the cylindrical samples within. In addition, the electrical power supply to the heater and the automation of the peening system have been supplemented with electrical power meters to provide energy consumption data for an industrial prototype process. Calibration of the heating curve and temperature in terms of current and voltage for the first heat treatment routes and sample production in the KIT workshop started at the end of November and is ongoing.

Figure 7: Sample holder

Figure 7: Sample holder for conductive heating of the cylindrical samples including copper disk with sample mounting for the top and bottom of the cylindrical samples as well as the copper grips with attached wires for high current supply.

2.3.2 T3.2 Warm peening optimization for carburized specimens [KIT; M04-M12]

Optimization of processing parameters regarding peening pressure, peening media and peening coverage started at the end of November and is ongoing.

2.3.3 T3.3 Warm peening optimization for quenched and tempered specimens [KIT; M07-M15]

This task has not yet started.

2.3.4 T3.4 Warm peening optimization for surface induction hardened specimens [KIT; M10-M18]

This task has not yet started.

2.3.5 T3.5 Surface state characterization within the optimization process [STR; M04-M18]

Different plate shaped samples have been used to characterize the first surface state when the machined surface is subjected to high temperature peening. For this purpose, these samples were put on a hot plate which was heated by resistive heating in order to create similar conditions for the plastic deformation as in the later shot tempering processing of cylindrical samples.

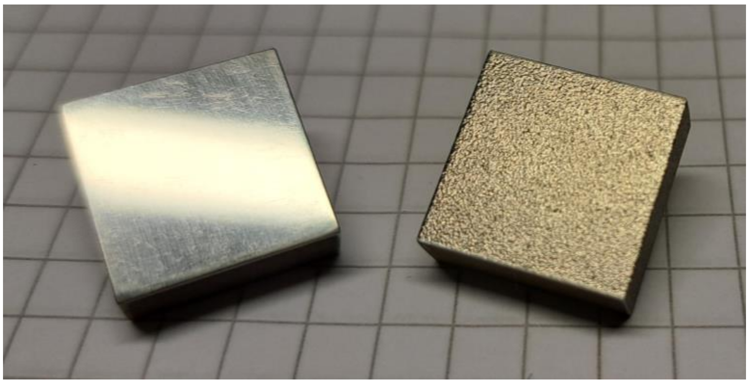


Figure 8: Shot Peening Analysis

Figure 8: Analysis of different covering of the shot peening process at higher temperatures (300 °C) on a hot plate in order to vary the peening parameters for the later shot tempering process.

Regarding the different configurations the conventional peening setup has been finalized at the end of November and the different heating conditions for the Shot Tempering process are ongoing (see Figure 9).

Peening type	Shot size	Almen intensity	Coverage	T	Heating / hold time
Conventional peening	x1	x1	x1	x1	x1
ShotTempering	x1	x1	x1	x5	

Figure 9:Test plan for warm peening optimization

2.3.6 T3.6 Determination of the most adequate warm peening conditions [KIT; M13-M18]

This task has not yet started.

2.3.7 T3.7 Fatigue surface characterization by tribological rolling contact fatigue [CRF; M10-M21]

This task has not yet started.

2.4 WP4 – Evaluation of the fatigue performance achieved by warm peening [KIT]

2.4.1 T4.1 Preparation of specimens with warm peening treatments with the most promising parameter sets [KIT; M13-M24]

This task has not yet started.

2.4.2 T4.2 Interrupted cyclic tests in the HCF range [KIT; M16-M21]

This task has not yet started.

2.4.3 T4.3 Measurement of residual stresses after relaxation tests [STR; M16-M21]

This task has not yet started.

2.4.4 T4.4 Modelling of residual stress stability and derivation of optimized surface state [KIT; M16-M21]

This task has not yet started.

2.4.5 T4.5 Fatigue tests in rotating bending and pure torsion [CRF; M19-M30]

This task has not yet started.

2.5 WP5 – Transfer of results to demonstrator components [CRF]

2.5.1 T5.1 Specification and production of the dummies to be used as demonstrator components [CRF; M25-M30]

This task has not yet started.

2.5.2 T5.2 Validation of the obtained demonstrator component properties [CRF; M28-M36]

This task has not yet started.

2.5.3 T5.3 Surface state characterization of demonstrator components [STR; M28-M36]

This task has not yet started.

2.6 WP6 – Holistic analysis of the attained benefits, implementation and dissemination activities [i2m]

2.6.1 T6.1 Holistic analysis over life cycle, costs and societal impact [i2m; M07-M15/M31-42]

Even though the task has not yet started, discussions have already been held with all partners to indicate which data is required and to point out risks and mitigation measures.

2.6.2 T6.2 Identification of the advantages provided by the new manufacturing process [CRF; M16-M18/ M34-M36]

This task has not yet started.

2.6.3 T6.3 Analysis of other conceivable applications for the warm peening treatments [CRF; M37-M42]

This task has not yet started.

2.6.4 T6.4 Elaboration of the Communication and Dissemination Plan [CRF; M03-M06]

A complete plan has been developed and will be presented at the next monthly meeting.

2.6.5 T6.5 Dissemination and standardization activities [i2m; M01-M42]

The project logo and branding have already been created. Partners have also received templates for deliverables, PowerPoint presentations, Minutes of Meeting (MoM), and a one-pager. The website domain and structure have been finalized, and while the website is still under construction, it will be ready soon. On the website there will be news entries periodically. The social media channels are also in the works. These are the next steps for this task.

A Dissemination Track List was developed during the kick-off meeting, where each partner identified potential conferences, papers, and other dissemination opportunities.

3 Conclusions

In conclusion, the ShotTempering project has successfully laid a strong foundation in its initial six months. All deliverables were submitted on time. The project activities are progressing as foreseen in the Grant Agreement DoA and no deviations or risks were detected by the end of M6. A management framework, and the initiation of critical technical activities have been fullfilled. Significant progress has been made in steel selection, manufacturing, and metallurgical characterization, as well as in communication and dissemination planning.

4 Acknowledgements and disclaimer

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

#	Partner	Partner full name
1	I2M	I2M UNTERNEHMENSENTWICKLUNG GMBH
2	KIT	KARLSRUHER INSTITUT FUER TECHNOLOGIE
3	SIDENOR R&D	SIDENOR INVESTIGACION Y DESARROLLOSA
4	CRF	CENTRO RICERCHE FIAT SCPA
5	STRESSTECH	STRESSTECH GMBH

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Abbreviations and Definitions

Term	Definition
GA	Grant Agreement
WP	Work Packages
PM	Person Month
MoM	Minutes of Meeting
PO	Project Officer
PC	Project Coordinator
PA	Project Advisor
EC	European Comission
MS-Teams	Microsoft Teams
MM	Monthly Meetings
QT	Quenching and Tempering
F2F	Face to Face Meeting
D	Deliverable

List of Figures

List of Tables