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EXPERIENCE FROM THE CONSTRUCTION OF A NEW FAST WIRE SCANNER PROTOTYPE FOR THE CERN-SPS AND ITS OPTIMISATION FOR INSTALLATION IN THE CERN-PS BOOSTER

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ABSTRACT

A new design of wire scanner is under development for the LHC Injector Upgrade project at CERN. A prototype has been designed, built and installed in the SPS accelerator to test the concept in an operational accelerator environment. New technology has been developed and qualified for in-vacuum motor and structural components using 3D metal additive machining. This paper will describe the technology developed for this scanner and the test results to date. This prototype has recently been re-optimised to fit in the limited space available in the PS Booster rings.

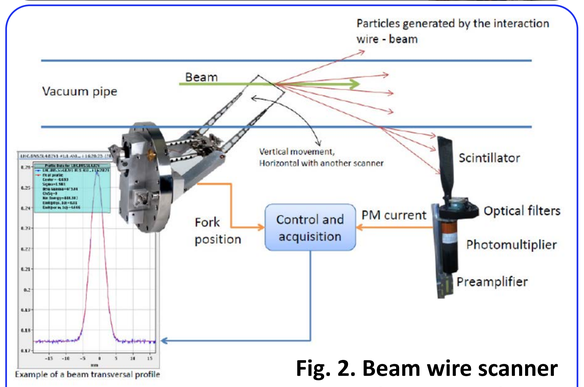

Fig. 2. Beam wire scanner working principle

PROTOTYPE VALIDATION PRIOR TO INSTALLATION

- the scan cycle is composed of two displacements of π rad.
- nominal linear speed of the wire is **20 m.s^{-1}** [3]
- more than **70000** scans were performed during the functional validation of the prototype and actuator.
- moving mechanical components (bearings, forks, shaft) showed no sign of wear or damage.
- control prototyping system Dspace (MatLab/Simulink based) [5, 6].
- setup allows fine tuning of the system parameters.
- nominal speed and expected position are reproduced consistently (speed is very reproducible but not completely flat at top speed).
- further optimisation on system parameters is foreseen.

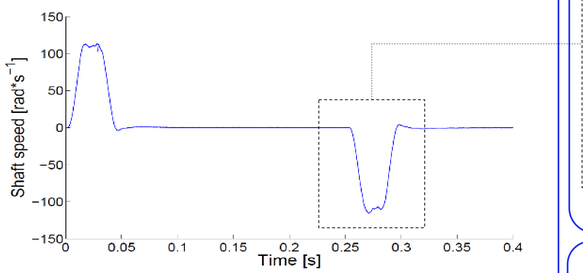

Fig. 4. Shaft speed with 6 superimposed scan cycles

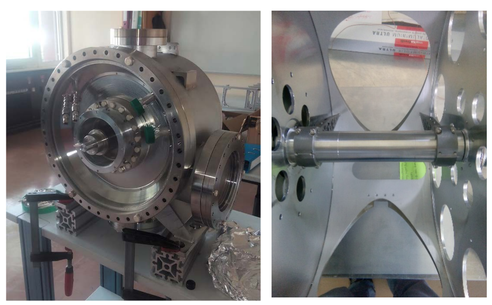

Fig. 5. Prototype disassembly after tests

ELECTRIC MOTOR

- vacuum compatible rotor [2]
- no glue, epoxy or other adhesives for permanent magnets fixation.
- increased air gap for insertion of vacuum chamber wall between stator and rotor.

Motor type	**F**rameless **P**ermanent **M**agnet **S**ynchronous [1]
Permanent magnets material	Sm_2Co_{17}
Rotor core material	Steel
Bake-out temp. of the rotor, ^{0}C	200
Angular speed, rad.s^{-1} (for L_{fork} =182.5 mm)	**133**
Rotor inertia, kg.m^2	1.28E-03
Minimum air gap thickness, mm	0.7
Peak acceleration torque, Nm	55
Ionizing radiation dose, kGy.year^{-1}	1

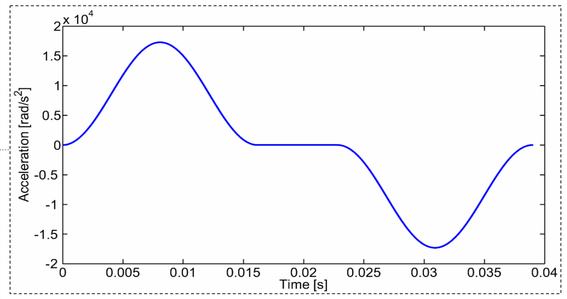

Fig. 3. Acceleration profile [3]

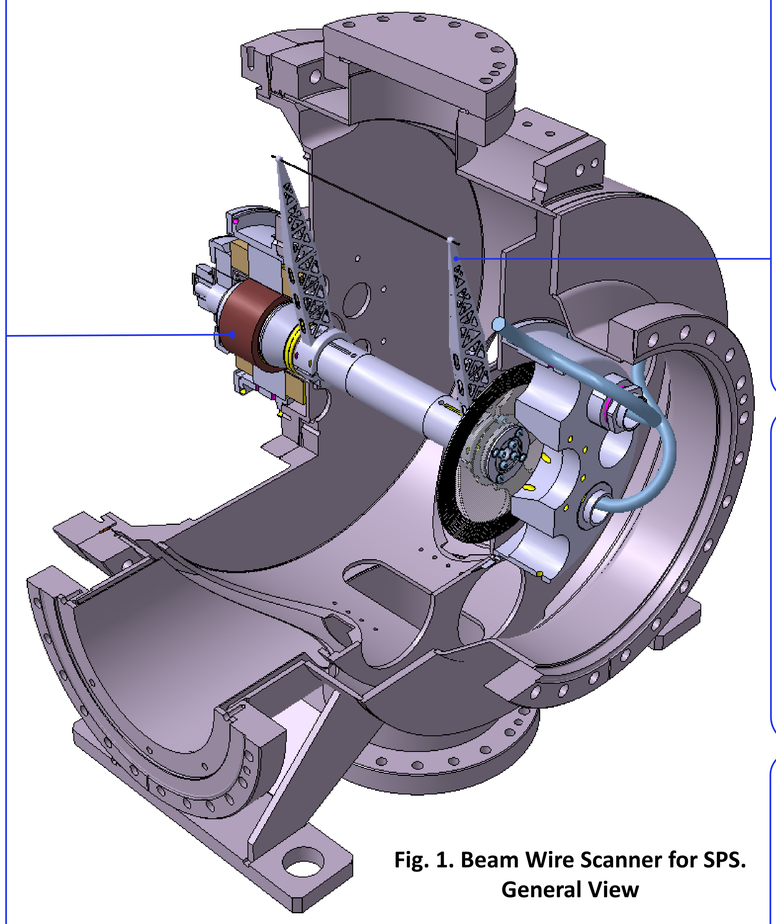

Fig. 1. Beam Wire Scanner for SPS. General View

DESIGN AND MANUFACTURE OF FORKS

Forks serve to hold the wire under tension and support it while it is moved across the beam [4].

Automated topological optimisation was performed:

- 2D then 3D optimisation of the fork shape.
- refinement of the topology in the ANSYS to conform to requirements of stiffness and vibration modes.

Manufacturing

- laser-sintered 3D additive machining (titanium (TiAlV6) powder with a wall thickness of 0.4 mm)
- precision details were post-machined at CERN.

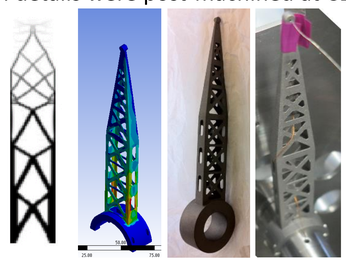

Fig. 7. Design and manufacture process of forks

QUALIFICATION OF MATERIALS FOR VACUUM

all in-vacuum parts should be UHV-compatible

- residual gas analysis and outgassing rate measurements for non-standard materials showed that they are UHV-compatible.
- final measurement of the fully assembled beam wire scanner.
- an additional vacuum pump was added onto the instrument tank to reach the required vacuum pressure.
- further tests are in progress

OPTIMISING THE DESIGN FOR THE PSB

The PS Booster is composed of four superimposed synchrotron rings placed at an inter-axis distance of 360 mm, and have a beam aperture of 80 mm x 120 mm.

- fitting a total number of eight wire scanners.
- access from passage side (easy maintenance)
- same design for horizontal and vertical wire scanner.
- the possibility of putting H and V scanners in different sectors of the machine is under investigation, which would make more space available and also allow for simultaneous scans in both planes.

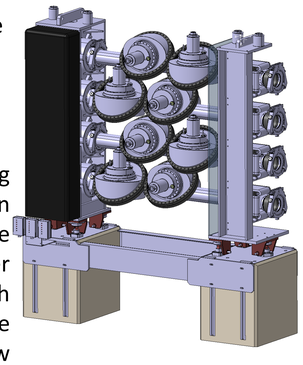

Fig. 7. Integration of the beam wire scanner in PSB

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STATUS AND NEXT STEPS

- 2 prototypes have been built, with one installed for test in the SPS accelerator.
- preliminary testing in the lab have validated the mechanics, control system and performance
- production of a small prototype series is expected in 2016.
- installation of the prototype in the PSB in 2017
- 18 of new scanners will be required during the period 2019-2020.
- robust and cost-effective engineering of both mechanics and control system will be required before series production.