IMPELLER FLOW CHARACTERISATION FOR A HIGH TEMPERATURE VENUS DRILL AND SAMPLE DELIVERY SYSTEM S. Pandey[1] and K.Zacny[2], [1]Doctoral Candidate, School of Engineering and Information Technology, UNSW Canberra at ADFA, 2600 Northcott Drive, ACT, Australia, S.Pandey@student.adfa.edu.au; [2]Director, Exploration Technology, Honeybee Robotics Spacecraft Mechanism Corp., Pasadena 91103 USA, zacny@honeybeerobotics.com

Introduction: Based on the National Research Council (NRC) Decadal Survey (2013-2022) and priorities drawn out by VEXAG in 2014, our work targets the sample acquisition technology development for medium and long term Venus exploration mission plans [1]. VEXAG laid out the 2nd of 3 non-prioritized goals, i.e. 'To determine the evolution of the surface and interior of Venus' correlated with Far term plan within the Exploration Road Map' [2]. One of the core questions asked being what caused the evolutionary paths of Earth and Venus to diverge [1]. Given the thick, opaque and reactive atmosphere, remote sensing limitations shall eventually lead to surface landed probes and mobile platforms conducting elemental and mineralogical characterization of surface and subsurface regolith on Venus. Due to the extremely dense and hot Venetian atmosphere of close to 500 *°C* and corroding gases, previously landed probes have melted within an hour, indicating that future missions have to acquire samples and conduct scientific analysis and relay information within a short constraint of time.[3] The engineering challenge of acquiring regolith samples and bringing it within the pressurized chamber to conduct in situ measurements is acknowledged and addressed. A Drill and Sample Delivery System is being developed for Venus under NASA SBIR Phase I to drill and capture surface and subsurface regolith [4]. The impact of ambient atmosphere (mainly hot supercritical carbon dioxide, hereby referred to as 'air') on the performance of the pneumatically driven components is investigated using finite volume model approach. Given the complexities in conducting actual experiments within such a physical setup, computational flow predictions are sought to optimize the component designs and also improve understanding of gas dynamics at Venus surface. (As sought by VEXAG Venus Technology Plan 2014, under Infrastructure development) [3].

System Description: Figure 1 shows the configuration of the Venus Drill and Sample Delivery System as a part of a surface landed platform. Ambient 'air'[1] is drawn in (1) and directed by a spinning impeller (2) down the double wall drill pipe and enters the center of the drill causing low pressure to develop (3) and in turn 'suction' at the tip of the bit (4). The Venturi effect causes atmospheric air to be drawn down the ports and into the holes in the drill bit. The fluidized regolith then flows up the cavity within the bit into an X-ray Fluorescence Spectrometer (XRF) or an X-ray Powder Diffraction instrument (XRD). Alternatively, the ambient atmosphere being at 96 bar can be utilized to force up regolith into a vacuum reservoir but only for single use. The advantage of utilizing a high spin impeller system enables multiple usage scenarios and also helps direct the air flow efficiently into the drill tube cavity.

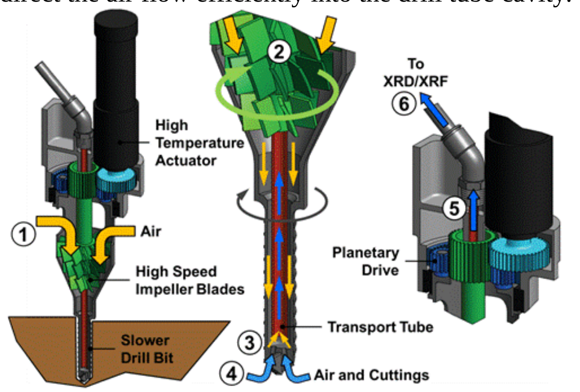

Figure 1: Venus Drill and Sample Delivery System (Honeybee Robotics)

Research Focus: The impeller blade configuration selection depends upon the hydrodynamic characteristics of the incoming flow. It also needs film coating to account for the high temperature and corrosive nature of the flow which affects the achieved pressure ratios. A flow characterization study using a finite volume code is conducted to study the different flow regimes and pressure ratios achieved for a set of impeller blades run at different RPMs. The objective is to arrive at a range of RPMs for a selection of impeller blade configurations that would deliver a desired pressure ratio necessary to lift a prescribed mass of regolith/rock cuttings. A subsequent part of the future work could involve fabricating candidate impeller configurations and conduct comparison tests in a Venus environment chamber.

References:

[1]Robert Herrick (Chair), K.B., et al, *Goals, Objectives, and Investigations for Venus Exploration*. 2014.[2]Doug Stetson, M.G.c.c., Sushil Atreya, Bruce Campbell, Gordon Chin, Lori Glaze, David Grinspoon, Sanjay Limaye, Ralph Lorenz, and Sue Smrekar, *Roadmap for Venus Exploration*. 2014.[3]Pat Beauchamp (Chair), J.C.L.A., et al, *Venus Technology Plan*. 2014 [4]Bar-Cohen Y., X.B., M. Badescu, S. Sherrit, K. Zacny, N. Kumar, T. R. Shrout, and S. Zhang, *High-Temperature Drilling Mechanisms*, in *High Temperature Materials and Mechanisms*, T.F.G. CRC Press, Boca Raton, Florida Editor. 2014. p. 427-426.